

e-SOURCEBOOK



ICT IN AGRICULTURE

**Connecting Smallholders
to Knowledge, Networks,
and Institutions**

UPDATED EDITION

ICT IN AGRICULTURE

Updated Edition

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and Institutions

Updated Edition



WORLD BANK GROUP



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PARTNERSHIP FACILITY

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FOREWORD

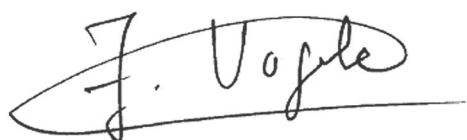
While many societies are transforming through migration to cities, most poor people still live in rural areas and depend largely on agriculture for their livelihood. We have a historic opportunity to reduce poverty and boost shared prosperity while transforming the global food and agriculture sector. Today's fast-evolving information and communication technology (ICT) represents a tremendous opportunity for rural populations to improve productivity, to enhance food and nutrition security, to access markets, and to find employment opportunities in a revitalized sector.

However, realizing this promise requires a long-term commitment to mobilizing timely and relevant resources and expertise, particularly in the face of climate change and food price fluctuations. For this reason, we are pleased to share an updated publication of the popular ICT in Agriculture e-Sourcebook, first launched in 2011.

This resource is designed to support practitioners, decision makers, and development partners who work at the intersection of ICT and agriculture. In this revised e-Sourcebook you will find updated modules on ICT in the work of producer organizations; in research, extension and innovation; and in value chains and markets. The module on gender as a crosscutting theme has also been updated, and a new module on Big Data has been added.

Our hope is that the updated ICT in Agriculture e-Sourcebook will continue to be a practical guide in understanding current trends, implementing appropriate interventions, and evaluating the impact of ICT interventions in agricultural programs. The publication marries cutting-edge expert knowledge in ICT with empirical knowledge on a wide range of agriculture topics, from governance to supply chain management.

The original e-Sourcebook was an endeavor carried out by InfoDev and the Agriculture and Rural Development Department of the World Bank. The update of the ICT in Agriculture e-Sourcebook was led by the World Bank Group's Food and Agriculture Global Practice, with significant contributions from external partners and experts. This effort was funded jointly by the Government of Finland, the Korea–World Bank Partnership Facility, and the World Bank Group. We are grateful for their contributions and we look forward to continuing work that assists countries in meeting their Sustainable Development Goals.



Juergen Voegelé
Senior Director
Food and Agriculture Global Practice
The World Bank Group

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ACRONYMS AND ABBREVIATIONS

2G, 3G, 4G	second-, third-, and fourth-generation [developments in mobile wireless technology]
ACDI/VICA	Agricultural Cooperative Development International/Volunteers in Overseas Cooperative Assistance
AGRIS	International System for Agricultural Science and Technology
AIS	agricultural innovation system
B2B	business-to-business
BSE	bovine spongiform encephalopathy
C	Celsius
CaFAN	Caribbean Farmers Network
CARENAS	Communication and Training Centre for Natural Resources Management and Sustainable Agriculture
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture)
CIC	community information center (Bhutan)
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
CKW	community knowledge worker
DIT	Department of Information Technology (Bhutan)
DFID	Department for International Development (UK)
DNE	Dairy Network Enterprise
DOQ	digital orthophoto quad
e-	electronic
EAFF	Eastern Africa Farmers Federation
EAP	East Asia and Pacific
EARS	Environmental Analysis and Remote Sensing
ECA	Europe and Central Asia
ERP	enterprise resource planning
EU	European Union
FAPRI	Food and Agricultural Policy Research Institute
FEPASSI	Fédération Provinciale des Professionnels Agricoles de la Sissili (Federation of Agricultural Producers of Sissili Province)
FINO	Financial Inclusion Network and Operations
G2P	government-to-person (cash transfer)
GAP	good agricultural practice
Gbps	gigabit per second
GDP	gross domestic product
Ghz	gigahertz
GigE	gigabit Ethernet
GIS	geographical information systems

GLN	global location number
GM	genetically modified
GNSS	global navigation satellite systems
GPRS	general packet radio service
GPS	global positioning system
GSM	Global System for Mobile Communications
GTIN	global trade item number
HACCP	hazard analysis and critical control point
HIC	high-income countries
IBLI	index-based livestock insurance
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	information and communication technology
ICTs	information and communication technologies
IDI	ICT Development Index
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
IFFCO	Indian Farmer's Fertilizer Cooperative Limited
IFMR	Institute for Financial Management and Research (India)
IFPRI	International Food Policy Research Institute
IICD	International Institute for Communication and Development
IITA	International Institute of Tropical Agriculture
IKSL	IFFCO Kisan Sanchar Limited
ILRI	International Livestock Research Institute
IP	Internet Protocol
IPS	Innovative Practice Summary
IRRI	International Rice Research Institute
IT	information technology
ITU	International Telecommunications Union
LAC	Latin America and Caribbean
Lao PDR	Lao People's Democratic Republic
LiDAR	light detection and ranging
m-	mobile
Mbps	megabit per second
MENA	Middle East and North Africa
MFI	microfinance institution
Mhz	megahertz
MNO	mobile network operator
NAIP	National Agricultural Innovation Project (India)
NARO	National Agricultural Research Organisation (Uganda)
NGN	next-generation network
NGO	non-governmental organization
NSDI	national spatial data infrastructure
OECD	Organisation for Economic Co-operation and Development

OS	operating system
PDA	personal digital assistant
PIN	personal identification number
PKGFS	Pudhuaaru Kshetriya Gramin Financial Services
PSTNs	public switched digital telecommunication networks
RFID	radio-frequency identification
RML	Reuters Market Light
Rs	rupees
SA	South Asia
SCM	supply-chain management
SDI	spatial data infrastructure
SIM	subscriber identification module
SMS	short messaging service
SSA	Sub-Saharan Africa
U Sh	Uganda shillings
UA	universal access [to communication networks for ICTs]
UA/USFs	universal access/universal service funds
UK	United Kingdom
UNECE	United Nations Economic Commission for Europe
US	universal service [from communication networks for ICTs]
USA	United States
VANS	value added network services
VAT	value-added tax
VHRI	very high resolution image
VoIP	Voice over Internet Protocol
VSAT	very small aperture terminal
WFP	World Food Programme
WG-DSM	International Working Group on Digital Soil Mapping
WHO	World Health Organization
WiMAX	Worldwide Interoperability for Microwave Access
Y	Yuan
ZNFU	Zambia National Farmers Union

SECTION 1

Overview of ICT in Agriculture:
Opportunities, Access, and
Crosscutting Themes

Module 1 INTRODUCTION: ICT IN AGRICULTURAL DEVELOPMENT

KERRY MCNAMARA (American University), CORY BELDEN (World Bank), TIM KELLY (Infodev, World Bank Group), EIJA PEHU (World Bank), and KEVIN DONOVAN (Infodev, World Bank Group)

INFORMATION AND COMMUNICATION TECHNOLOGY: FINDING A PLACE IN THE AGRICULTURE SECTOR

Information and communication have always mattered in agriculture. Ever since people have grown crops, raised livestock, and caught fish, they have sought information from one another. What is the most effective planting strategy on steep slopes? Where can I buy the improved seed or feed this year? How can I acquire a land title? Who is paying the highest price at the market? How can I participate in the government's credit program? Producers rarely find it easy to obtain answers to such questions, even if similar ones arise season after season. Farmers in a village may have planted the "same" crop for centuries; but over time, weather patterns and soil conditions change and epidemics of pests and diseases come and go. Updated information allows farmers to cope with and even benefit from these changes. Providing such knowledge can be challenging, however, because the highly localized nature of agriculture means that information must be tailored specifically to distinct conditions.

Agriculture is facing new and severe challenges in its own right (see box 1.1). With rising food prices that have pushed over 40 million people into poverty since 2010, more effective interventions are essential in agriculture (World Bank 2011). The growing global population, expected to hit 9 billion by 2050, has heightened the demand for food and placed pressure on already-fragile resources. Feeding that population will require a 70 percent increase in food production (FAO 2009).

Filling the stomachs of the growing population is only one reason agriculture is critical to global stability and development. It is also critical because one of the most effective ways of reducing poverty is to invest in and make improvements in the agricultural sector. Even after years of industrialization and growth in services, agriculture still accounts for one-third of the gross domestic product (GDP) and three-quarters of employment in Sub-Saharan Africa. Over 40 percent of the labor force in countries with per capita incomes in the range of US\$400–1,800 works in agriculture (World Bank 2008). Because agriculture accounts for the vast majority of the poor's livelihood activities, it is also the sector that holds

the most promise for pro-poor economic growth. In fact, agriculture is around four times more effective at raising incomes among the poor than other sectors (World Bank 2008). No less important, improved agriculture also has a direct impact on hunger and malnutrition, decreasing the occurrence of famine, child stunting, and maternal infirmity.

Given these challenges, the arrival of information and communication technology (ICT) is well timed. The benefits of the Green Revolution greatly improved agricultural productivity. However, there is a demonstrable need for a new revolution that will bring lower prices for consumers (through reduced waste and more-efficient supply chain management), contribute to "smart" agriculture, and incentivize farmers (for example, through higher income) to increase their production. Public and private sector actors have long been searching for effective solutions to address both the long- and short-term challenges in agriculture, including how to answer the abundant information needs of farmers. ICT is one of these solutions, and has recently unleashed incredible potential to improve agriculture in developing countries specifically. Technology has taken an enormous leap beyond the costly, bulky, energy-consuming equipment once available to the very few to store and analyze agricultural and scientific data. With the booming mobile, wireless, and Internet industries, ICT has found a foothold even in poor smallholder farms and in their activities. The ability of ICT to bring refreshed momentum to agriculture appears even more compelling in light of rising investments in agricultural research, the private sector's strong interest in the development and spread of ICT, and the upsurge of organizations committed to the agricultural development agenda.

But what exactly is ICT? And can it really be useful and cost-effective for poor farmers with restricted access to capital, electricity, and infrastructure? First, ICT includes any device, tool, or application that permits the exchange or collection of data through interaction or transmission. ICT is an umbrella term that includes anything ranging from radio to satellite imagery to mobile phones or electronic money transfers. Second, these and other types of ICT have gained traction even in impoverished regions. The increases in their affordability,

accessibility, and adaptability have resulted in their use, even within rural homesteads relying on agriculture. New, small devices (such as multifunctional mobile phones and nano-technology for food safety), infrastructure (such as mobile telecommunications networks and cloud computing facilities), and especially applications (for example, those that transfer money or track an item moving through a global supply chain) have proliferated. Many of the questions asked by farmers (including questions on how to increase yields, access markets,

and adapt to weather conditions) can now be answered faster, with greater ease and increased accuracy. Many of the questions can also be answered with a dialogue—where farmers, experts, and government can select the best solutions based on diverse expertise and experience.

The types of ICT-enabled services that are useful for improving the capacity and livelihoods of poor smallholders are growing quickly. One of the best examples of these services

BOX 1.1. Globalizing Food Markets and New Challenges for Smallholder Farmers

Understanding and addressing global agriculture developments—both advantageous and not—are critical to improving smallholder livelihoods, in which ICT can play a major role. The continued increase in globalization and integration of food markets has intensified competition and efficacy in the agriculture sector, and has brought unique opportunities to include more smallholders in supply chains. Yet in the same vein, agriculture faces a range of modern and serious challenges, particularly in developing countries exposed to price shocks, climate change, and continued deficiencies in infrastructure in rural areas.

When commodity prices rise quickly and steeply, they precipitate concerns about food insecurity, widespread poverty, and conflict—more so in countries that import high volumes of staple foods. Globalized food markets also increase the risk that some countries and many smallholders will remain marginalized from the expanding and more profitable agricultural value chains (such as premium foods, which have seen an increase in demand due to an expanding middle class) that rely on technical sophistication to ensure speed, scale, and customization.

Climate change has also played an acute role in keeping smallholders in the underbelly of value chains. Farmers can no longer rely on timeworn coping strategies when all of their familiar benchmarks for making agricultural decisions—the timing of rains for planting and pasture, the probability of frost, the duration of dry intervals that spare crops from disease—are increasingly less reliable. Severe and unexpected weather is shrinking already-limited yields and promoting migration from rural areas and rural jobs. Weather-related events leave developing-country governments, which lack the resources and the private sector investment to provide risk management instruments, to cope with major crop failures and the displaced victims only after the fact.

It is in the context of globalizing agriculture where the need for information becomes most vivid. Smallholders, who still provide a significant portion of the world's food, need information to advance their work just as much as industrial-scale producers. Comparing the two types of farmers—industrial and small-scale—exemplifies the latter's disadvantages. Wealthy industrial producers can use the Internet, phone, weather forecasts, other digital tools, and technologies as simple as vehicles and infrastructure as basic as electricity to glean information on prices, markets, varieties, production techniques, services, storage, or processing; but smallholders remain dependent primarily on word of mouth, previous experience, and local leadership.

The smallholder disadvantage does not stop there. Financial and insurance services are often out of reach and poorly understood. Key intermediaries like producer organizations and rural institutions (including local government) could help alleviate the disadvantage, but in many places, the former are just emerging and the latter are inefficient and nontransparent. Both require a variety of technical and financial support to grow and become inclusive and effective. Many of these challenges and others can be addressed by using ICT effectively.

Source: Authors.

IMAGE 1.1. Soil Data Can Be Collected and Disseminated Using Various Types of ICT



Source: Neil Palmer, CIAT.

is the use of mobile phones as a platform for exchanging information through short messaging services (SMS). Reuters Market Light, for example, services over 200,000 smallholder subscribers in 10 different states in India for a cost of US\$1.50 per month. The farmers receive four to five messages per day on prices, commodities, and advisory services from a database with information on 150 crops and more than 1,000 markets. Preliminary evidence suggests that collectively, the service may have generated US\$2–3 billion in income for farmers (Mehra 2010), while over 50 percent of them have reduced their spending on agriculture inputs.¹

ICT-enabled services often use multiple technologies to provide information (image 1.1). This model is being used to provide rural farmers with localized (nonurban) forecasts

so that they can prepare for weather-related events. In resource-constrained environments especially, providers use satellites or remote sensors (to gather temperature data), the Internet (to store large amounts of data), and mobile phones (to disseminate temperature information to remote farmers cheaply)—to prevent crop losses and mitigate the effects of natural adversities.

Other, more-specialized applications, such as software used for supply chain or financial management, are also becoming more relevant in smallholder farming. Simple accounting software has allowed cooperatives to manage production, aggregation, and sales with increased accuracy. The Malian Coprokazan, involved in shea butter production, began using solar-powered computers with keyboards adapted to the local language to file members' records electronically. Along with electronic administration, the coop plans to invest in global positioning system (GPS) technology to obtain certifications and use cameras and video as training materials to raise the quality of production. From 2006 to 2010 alone, the coop's membership grew from 400 to 1,000 producers (<http://www.coprokazan.org/>).

These examples represent only a minute subset of the information and communication services that can be provided to the agricultural sector through increasingly affordable and accessible ICT. Hundreds of agriculture-specific applications are now emerging and are showing great promise for smallholders, as illustrated in the more than 200 project-based case studies and examples in this Sourcebook. In order to exploit the possibilities, countries have two tasks:

(A) To empower poor farmers with information and communication assets and services that will increase their productivity and incomes as well as protect their food security and livelihoods, and

(B) to harness ICT effectively to compete in complex, rapidly changing global markets (avoiding falling behind the technology curve).

Accomplishing these tasks requires the implementation of a complex set of policy, investment, innovation, and capacity-building measures, in concert with beneficiaries and other partners, which will encourage the growth of locally appropriate, affordable, and sustainable ICT infrastructure, tools, applications, and services for the rural economy.

¹ See Topic Note 9.4 in Module 9.

Of particular importance, ICT is not an end to agricultural development. The excitement generated by ICT as it spreads throughout developing countries has often masked the fact that its contributions to agriculture are both rapidly evolving and poorly understood. It is too early to have a clear idea, supported by rigorous analysis, of how ICT supports agricultural development, and under what conditions. While there is credible evidence of a positive impact, questions remain about how to make these innovations replicable, scalable, and sustainable for a larger and more diverse population. A central goal of this Sourcebook is to analyze and disseminate evidence of ICT's impact on agricultural development and rural poverty reduction, exploring opportunities for long-term and expansive efforts.

THE WAY FORWARD: UNDERSTANDING THE WHY AND THE HOW

Each module in this Sourcebook discusses the key challenges, enablers, and lessons related to using ICT in a specific subsector of agriculture. These are derived from a range of experiences, and summarize the knowledge gained during pilot projects and wider initiatives. While different in type of intervention and approach, a string of themes emerges from the modules. These themes—namely, the why and how of using ICT in agricultural development—demonstrate the great potential of ICT and help to clarify the way forward.

The Why: Drivers of ICT in Agriculture

Five main trends have been the key drivers of the use of ICT in agriculture, particularly for poor producers: (1) low-cost and pervasive connectivity, (2) adaptable and more affordable tools, (3) advances in data storage and exchange, (4) innovative business models and partnerships, and (5) the democratization of information, including the open access movement and social media. These drivers are expected to continue shaping the prospects for using ICT effectively in developing-country agriculture.

Low-Cost and Pervasive Connectivity

The pervasiveness of connectivity—to mobile phones, the Internet, and other wireless devices—is due to a number of factors, including decreases in costs, increases in competition, and expansion of last-mile infrastructure. Several trends, working in tandem, are making ICT devices and services more affordable in ways that also extend access to small-scale producers.

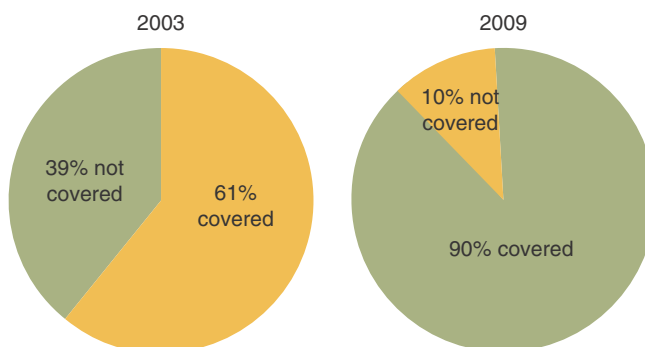
Mobile phones are in the vanguard of ICT use in agriculture. By the end of 2011, over 6 billion mobile phone subscriptions—or

more accurately, subscriber identity module (SIM) cards—were expected to be in use worldwide (Wireless Intelligence 2011). Mobile phone penetration in the developing world now exceeds two subscriptions for every three people, driven by expanding networks in Asia and in Africa. The ability to purchase a low-cost mobile phone is complemented by the expansion of telecommunications infrastructure; most countries now have more than 90 percent of their population served by a cell phone signal, including coverage in rural areas (see figure 1.1). This rapid expansion results from enabling regulations that ensure competition in the telecommunications sector as well as from high demand for mobile phone subscriptions.

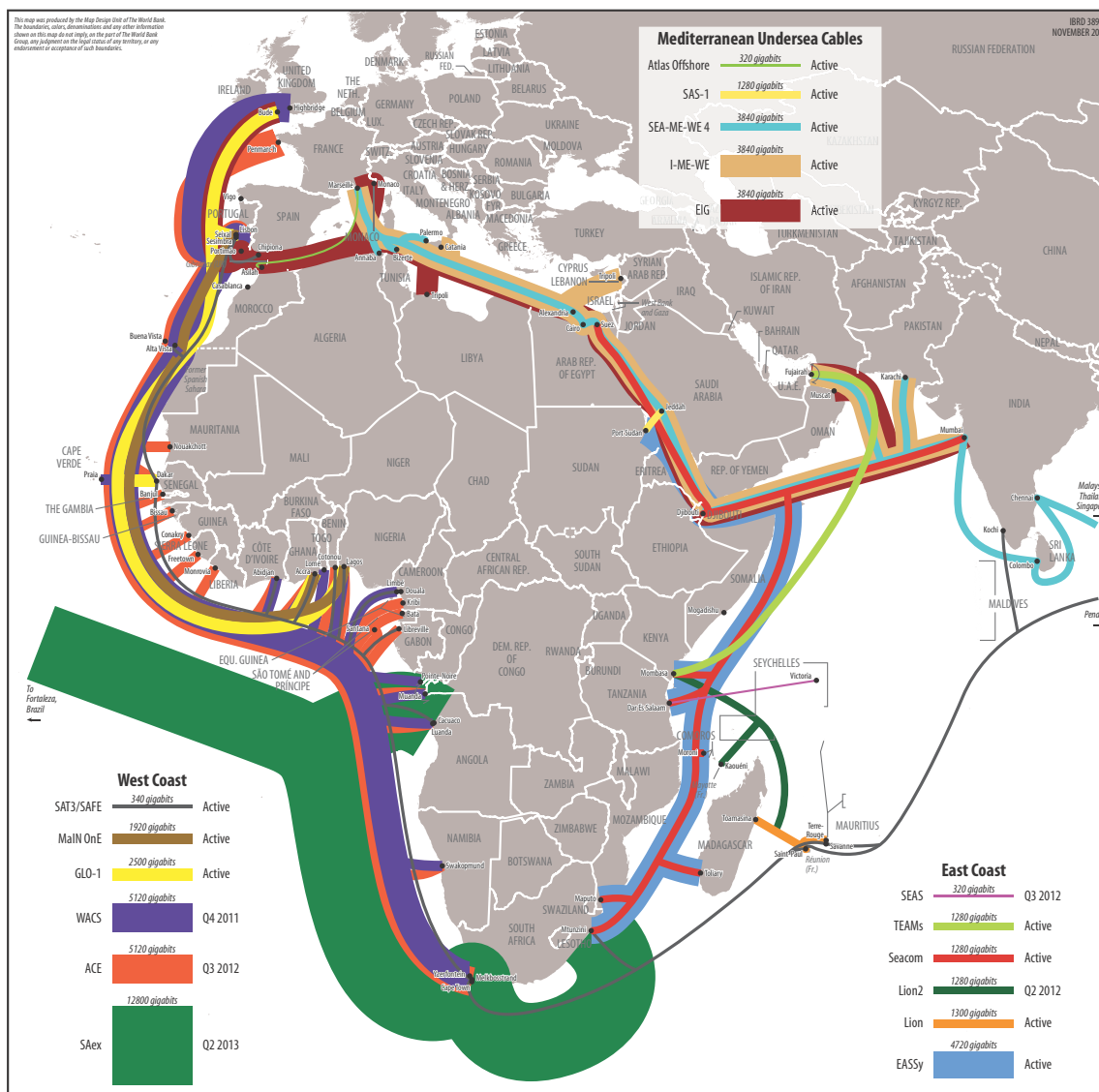
The reach and affordability of broadband Internet is also improving dramatically—though somewhat more slowly—in developing regions. In 2010, the number of Internet users surpassed 2 billion and over half of these users are now in developing countries. Internet connectivity around the world has grown exponentially since 2000, by over 480 percent (Internet World Statistics, 2011). The price of bandwidth has continued to drop as well, driving down the costs of extending connections to isolated communities. In Sub-Saharan Africa, which lags other regions in ICT accessibility, a recent surge of investments in international undersea cables and inland infrastructure to complete those connections is making ICT services substantially more accessible and affordable across Africa (figure 1.2). By 2010, 12.3 terabits per second of backbone capacity were operational in Africa, up from less than 1 gigabit per second at the start of the decade (TeleGeography 2011).

Telecenters or other community-based facilities can provide Internet access in locations where broadband is too expensive

FIGURE 1.1. Percentage of the World's Population Covered by a Mobile Cellular Signal



Source: International Telecommunications Union.

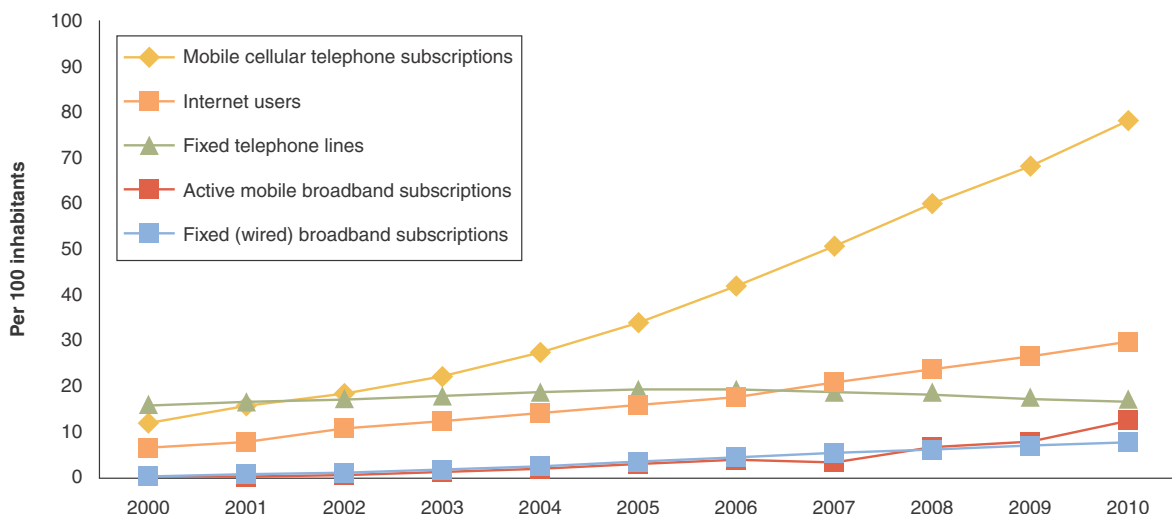
FIGURE 1.2. African Undersea Cables, Those Working and Those in Development

Source: Adapted from Steve Song, <http://manypossibilities.net> and TeleGeography.

for individuals to use on their own. Internet access is also expected to increase through the continued rollout of third- and fourth-generation (3G and 4G) mobile networks that greatly improve the capacity for carrying data. Smartphones, such as iPhones, which include 3G mobile services with remote Internet connection, will increase access to information even to poor farmers. The International Telecommunication Union (2010) reports that at the end of 2010, 143 countries offered commercial 3G services, providing at least 256 kilobits per second of bandwidth and supplying voice and data simultaneously (figure 1.3 shows the slow, but increasing, rate of uptake for mobile broadband) and other ICT tools.

Adaptable and More Affordable Tools

The proliferation of adaptable and more affordable technologies and devices has also increased ICT's relevance to smallholder agriculture. Innovation has steadily reduced the purchase price of phones, laptops, scientific instruments, and specialized software. Agricultural innovation in developed countries has become more applicable to developing-country needs. The intuitive design of many technologies and their capacity to convey information visually or audibly make them useful for people with limited formal education or exposure to technology.

FIGURE 1.3. Global ICT Development, 2000–10

Source: International Telecommunications Union's World Telecommunication / ICT Indicators database.

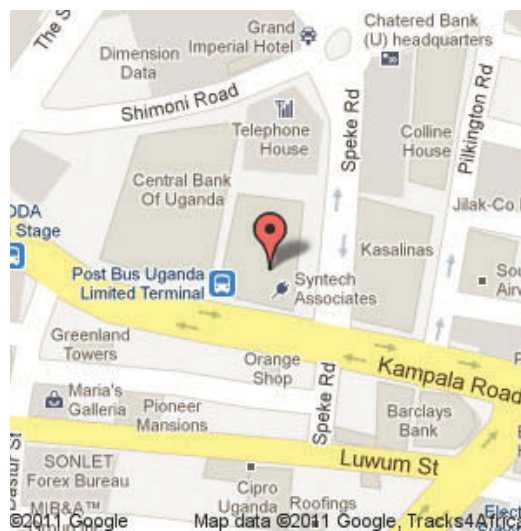
Mobile-based applications are also becoming more suitable for poor and isolated communities, especially through feature phones. Drawing on simple, available technologies such as SMS, service providers can offer mobile banking, other transactional services (selling inputs, for example), and information services (market price alerts). Other publicly and privately provided services, such as extension and advisory services, are delivered over mobiles, which are increasingly not just “phones” but are actually multifunctional wireless devices.

Geospatial information is also becoming easier to access and use as mapping tools, such as Microsoft Earth or Google Maps (image 1.2), bring geographical data information to nonspecialist users. Scientists and development organizations have created substantial sets of georeferenced data on population, poverty, transportation, and any number of other public goods and variables through more affordable, usable geographic information systems available on standard PCs and mobile devices using Web-based tools. Satellite images and similar representations have improved exponentially in quality and detail. These tools and remote sensors use less energy and require less human attention than in previous years. The capacity to overlay geospatial information with climate and socioeconomic data opens many options for analyzing biophysical trends (such as erosion or the movement of pathogens), making projections (about the effects of climate change or the best location of wholesale markets in relation to transportation infrastructure), and selecting particular groups to test new technologies or farming practices (for instance, identifying farmers

who are most likely to benefit from using e-vouchers to purchase fertilizer).

Advances in Data Storage and Exchange

Greatly increased data storage capacity and the ability to access data remotely and share it easily have improved the use of ICT in agriculture. Sharing knowledge and exchanging data have created opportunities to involve more stakeholders in agricultural research—involvement facilitated by an

IMAGE 1.2. Google Map of Kampala, Uganda

Source: Google Maps.

improved e-learning environment and networking capacity. Advances in data storage and sharing have improved the ability to exchange information—for instance, between departments and levels of government—and avoid costs associated with data transmission charges.

Improvements in data storage and sharing have underlying causes. The capacity of hard drives and the speed of microprocessors have continued to rise, making it dramatically cheaper to store data. Cloud computing offers access to numerous shared computing resources through the Internet, including sharable tools, applications, and intelligently linked content and data. These advances address some of the information and communication constraints of agricultural research institutions, government offices, cooperatives, and development organizations. Benefits of enhanced data capacity range from more accurate targeting of agricultural development programs to better preparation for handling surpluses or scarcities at the farm level.

New Business Models and Public-Private Partnerships

The development and use of many types of ICT originated in the public sector but were quickly dominated by the private sector when their profit potential became clear. The public sector maintains great interest in ICT as a means of providing better public services that affect agriculture (for instance, land registration, forest management, and agricultural extension services), as well as for connecting with citizens and managing internal affairs. Private sector involvement in some of these efforts has enhanced ICT's access, affordability, and adaptability for development. Unlike other development strategies, which often struggle to survive or be scaled up because the public sector cannot fund them, development strategies featuring ICT have benefited from growing private sector interest and public demand (image 1.3).

ICT's entrepreneurial nature attracts new partnerships and forms of investment. Mobile phone applications, software design, local language customization, and remote transaction services represent only a fraction of the opportunities for continued innovation. Private companies that have invested in technology and applications are often interested in working with the public sector to provide their products and services to smallholders. Mobile network operators, for example, can invest by providing large text packages at a lower price, collecting premiums, distributing payments, or participating in extending networks to rural areas. Commercial enterprises such as processors, input suppliers, and exporters are also motivated to invest in ICT

because they often lead to increased efficiency and revenue as well as extensions to client bases like isolated farmers.

New forms of business incubation and knowledge brokering are also contributing to ICT in agriculture. The private sector has a keen interest in investing in firms that come out of such incubation schemes, speculating on the ability of an innovative idea to expand into a highly profitable enterprise. Incubators identify additional investors and other suitable partners, including technical experts. In many instances, they develop enterprises through which private and public providers of agricultural services collaborate to deliver products more efficiently to farmers; in developing, sharing, and capitalizing on innovations for agricultural development, they almost always use ICT and often develop new ICT tools.

IMAGE 1.3. Public-Private Partnerships Often Lead to More Sustainable Services for Rural People



Source: Nokia.

Knowledge brokering, whereby a private enterprise provides information for a fee (for example, farmers obtain market, price, crop, and weather information via their mobile phones), is also gaining traction. This business model reduces the burden on the public sector while increasing the abilities of brokers and farmers to profit from information sharing.

Democratization of Information, the Open Access Movement, and Social Media

The democratization of information and science facilitated by ICT is also contributing to agriculture and rural development more broadly. Vast quantities of information held by institutions and individuals are becoming visible, publicly accessible, and reusable through the open access movement. Many governments and organizations—such as the World Bank,

the Food and Agriculture Organization, and the Consultative Group on International Agricultural Research—are aiming to make data, such as national surveys and research findings, publicly available. These actions have not only improved transparency and accountability but have also invited the public, private, and research sectors to participate in solving long-term economic and social problems, including those involving agriculture.

The expansion of open access software also enables grassroots community organizations to share knowledge with one another. Social media, once used purely for entertainment, has great potential to be used for knowledge sharing and collaboration, even in agriculture. Although penetration of the most popular social medium, Facebook, was estimated at just 3 percent in Africa and almost 4 percent in Asia in 2010, compared to 10.3 percent (over half a billion users) globally (Internet World Statistics 2011), recent geopolitical events highlight the effectiveness of social media for sharing information and motivating collective action—two key features of agriculture development.

Finally, crowdsourcing—in which scientists, governments, and development organizations request feedback from farmers and consumers through devices like mobile phones—is also facilitating agriculture development. Farmers can use SMS to send critical local agricultural information like incidences of pests or crop yields that was previously difficult to obtain without expensive surveys by researchers. Using the digital tools available, consumers can also provide information related to changing consumption patterns and tastes to private enterprise.

The How: Lessons Learned So Far

A number of key lessons related to ICT-in-agriculture policies and projects were gleaned during the research for this e-sourcebook. Using ICT to achieve agricultural development goals requires supplementary investments, resources, and strategies. Flexible but strongly supportive policies and regulations, complementary investments in physical infrastructure, support for men and women farmers of different age groups, technological appropriateness, and enabling environments for innovation and new businesses will determine the long-term impact and sustainability of these efforts. These lessons are not conclusive—much remains to be learned—but they serve as sound considerations as investments are made in future interventions.

Concentrate on the Demand, Not on the Technology

The versatility and near-constant innovation that characterize ICT can be a distraction: They can cause interventions to focus more on the technology than on the priorities of the intended clients and the trade-offs imposed by resource-constrained environments. It is important to begin any ICT-in-agriculture intervention by focusing on the need that the intervention is purposed to address—not the need for ICT—but the need for better and more timely market information, better access to financial services, timely and appropriate crop and disease management advice, stronger links to agricultural value chains, and so forth. In some cases, ICT will not be an effective means to meet these needs at all.

Years of agricultural development experience show that projects that involve new technologies require farmers' engagement, right from the start. Interventions that make meager efforts to involve farmers in planning and design result in low uptake, trust, and interest. The same is true for programs or strategies involving ICT for development. A weak focus on farmers' needs at the expense of ICT will ignore ancillary needs for investment in human capacity, community participation, or infrastructure.

Use Appropriate Technologies

The attractiveness of the newest types of ICT can lead to a preference for the latest technologies at the expense of older technologies (such as radio), yet the newest, most elaborate, or most innovative technology is not automatically the most appropriate one. Moreover, an innovative mix of technologies (for instance, radio programs with a call-in or SMS facility for feedback) can be the most cost-effective solution. A well-reasoned assessment of the trade-offs between the added cost of a technology or service and benefits relative to other options (technological and other) is important.

The wide coverage of mobile devices reduces but does not eliminate these trade-offs. In considering the appropriateness of technology, assessing the human capital available for developing and disseminating the ICT device or application is critical. The more complex the technology, the more training and (qualified) extension support it will require. In environments where infrastructure is not conducive to a particular instrument, other means should be used.

Finally, it is important to recognize that these newer technologies do not automatically replace the more traditional forms of communication, knowledge sharing, and collective action

that have evolved within a given community or region. In designing ICT interventions, it is necessary to research and understand local information and communication practices, barriers to ICT-enabled empowerment, and the priority information and communication needs of end users. Using conventional information and communication tools to address the needs of those who cannot access the ICT because of limitations related to literacy, isolation, and social norms is often required.

Focus on Affordable Access and Use, Not Ownership

In designing ICT-in-agriculture interventions, it is vital to bear in mind that “access” refers not only to the physical proximity and accessibility of ICT infrastructure, tools, and services but also to their affordability, use, and usage models that are appropriate for the local physical, environmental, and cultural constraints. The specific mix of individual-user and shared-use/public-access models that is most appropriate and locally sustainable will vary depending on local needs and resources, and will change over time as devices and services diversify further and become even more affordable. As the costs of ICT ownership have come down, the affordability and accessibility divide has improved, especially for individual user services. However, it also may be that in some cases, learning is better facilitated through shared access than individual access facilities.

Actual use of the technology should also be monitored, as a supplied technology does not necessarily imply that it is being used for economic means. Many times, mobile phones and other devices function strictly as a tool for basic communication or entertainment. This is often a result of participants’ low exposure to ideas or methods on how ICT can be used to achieve agriculture or other economic goals.

Be Aware of Differential Effects, Including Gender and Social Differences in Access and Use

Under certain conditions, ICT interventions can worsen rather than alleviate underlying economic, social, and political inequalities, including those between women and men. Rural women face significant disadvantages in accessing information and communication assets and services. Many of the fixed-location ICT projects designed to enhance rural access to information assets and services were or are owned or managed by men. Cultural attitudes and women’s multiple roles and heavy domestic responsibilities often exclude them from these services. The same attitudes and lack of control over

family income can prevent women from owning or even using phones. However, the growing availability and lower cost of mobile phones, as well as other contributing factors, have the potential to meet women’s agricultural needs (image 1.4).

IMAGE 1.4. Determining Levels of Inclusiveness Is a Critical Factor in ICT Interventions



Source: Nokia.

Social access issues extend beyond gender. A full understanding of the local, national, and regional agricultural economy is important for ensuring that ICT interventions do not restrict poor producers’ participation to the low end of agricultural value chains, as other technologies have done. ICT in itself does not guarantee full participation by all social groups. Efforts to be inclusive must focus on the full range of capacities and resources that small-scale producers will need to benefit from an intervention. Questions of social access should be raised consistently when using ICT to improve rural livelihoods. Do sociocultural norms or divisions prevent certain groups from using the technology? Will better-off groups benefit more than poor groups? Will floods of entertainment and spurious information dilute the knowledge needed for sustainable agricultural and rural development? Broad-based rural development depends on monitoring and evaluating outcomes and making adjustments along the way.

Create an Enabling Environment for Innovation in Infrastructure Investment, Business Models, Services, and Applications

Effective design and consistent, transparent implementation of appropriate policies and regulations guiding a country’s investment in and provision of ICT infrastructure, tools, and

services is key to enabling ICT interventions. In creating a supportive environment for ICT innovation and service provision, effective policies and regulations in a number of other key areas are equally important, such as public and private financing of infrastructure, the business environment, support for innovation, and intellectual property. ICT-in-agriculture interventions require a strong, but flexible, regulatory environment; the policy environment is further strengthened by incentives for the private sector to make investments.

Develop Sustainable Business and Investment Models through Partnerships

Public-private partnerships are now considered essential to the long-term viability of most interventions that use ICT in agriculture. The public sector in developing countries particularly may need guidance in providing technological services; a lack of human and financial resources as well as the overwhelming needs of the agrarian population weaken its ability to provide widespread services of acceptable quality.

With private investment, public service provision can be more sustainable. Other partnerships also appear important to sustainability (image 1.5). Technical experts with experience in various subsectors; information technology (IT) teams for technological maintenance, design, and troubleshooting; multilevel policy makers; and farmers and farmers' organizations that can provide local know-how, are also often all needed in one way or another.

IMAGE 1.5. A Collaborative Effort Among Many Actors Is Important for ICT in Agriculture



Source: Neil Palmer, CIAT.

Promote Leadership and Find Champions

Last, but not certainly not least, ICT interventions require leadership. Champions are needed to push projects forward in the development agenda and make them visible and interesting to the stakeholders—farmers, businesses, and others—that need them. These leaders must operate at the national level, where budgetary and strategic decisions are made. They must also operate at local levels, modeling the effective use of a technology and building farmers' trust in its efficacy. Leaders build public confidence in an intervention. Uptake is typically low if confidence in the chosen ICT and its potential impact are minimal. Leaders are needed for the long haul, as interventions that require new infrastructure or policy and institutional reforms take years to complete.

USING THIS E-SOURCEBOOK

The 2011 *ICT for Agriculture e-Sourcebook* was developed jointly by the World Bank's Agricultural and Rural Development Sector and *infoDev*, and benefited from generous funding from the Government of Finland under the Finland/*infoDev*/Nokia program *Creating Sustainable Businesses in the Knowledge Economy*. The updated edition was developed jointly with the Bank's Food and Agriculture Global Practice and *infoDev*, and benefited from the generous support of the Korea-World Bank Partnership Facility, as well as collaboration with the "Innovations in Big Data Analytics" program in the Global Operations Knowledge

Management department of the World Bank. It is designed to support practitioners and policy makers in taking maximum advantage of ICT's potential for improving agricultural productivity and smallholder incomes, strengthening agricultural markets and institutions, improving agricultural services, and building developing-country linkages to regional and global agricultural value chains. It focuses primarily on how ICT can assist small-scale producers and the intermediate institutions that serve them, yet it also looks at how to link smallholders to ICT-enabled improvements in larger-scale farming, markets, and agribusiness to stimulate the broader rural economy.

The Sourcebook provides users with a fairly comprehensive overview of

TABLE 1.1. Themes Treated in Sourcebook Modules

OPPORTUNITIES, ACCESS, AND CROSSCUTTING THEMES	ENHANCING PRODUCTIVITY ON THE FARM	ACCESSING MARKETS AND VALUE CHAINS	IMPROVING PUBLIC SERVICE PROVISION
Access and affordability Mobile applications Gender and ICT services	Increasing productivity Agriculture innovation systems Rural finance Farmer organizations	Market and price information Supply chain management Risk management Traceability and food safety	Rural governance Land administration Forest governance

current and upcoming ICT-in-agriculture applications and how they might improve agricultural interventions or strategies. The Sourcebook is not a primary research product; nor does it claim to be the definitive treatment of a sector that is evolving so rapidly. Its modules are intended to serve as a practical resource for development professionals seeking a better understanding of the opportunities and existing applications offered by ICT as tools for agricultural development.

Overall, each module seeks to provide guidance through real examples for development practitioners in the following areas:

- Providing a landscape of existing ICT applications that assesses applications in their local context.
- Understanding current trends in ICT as they pertain to agriculture and the contributions that ICT can make to enhance agricultural strategies and their implementation.
- Designing, implementing, and evaluating appropriate and sustainable ICT components of agricultural projects.
- Building effective partnerships—public and private—to promote ICT access and innovation for agriculture.
- Including ICT in policy dialogue and planning with country counterparts on agricultural and rural development goals and priorities.

To facilitate learning, the Sourcebook is split into this introductory module plus 14 modules focusing on specific aspects of the agricultural sector in relation to ICT (table 1.1). Each module provides:

- An overview of how ICT is used in each focus area, along with the current trends;
- The challenges, lessons, and key enablers for using ICT;
- A number of Topic Notes that address subjects related to each focus area, pinpointing how ICT can be used to meet specific objectives; and
- Innovative practice summaries (IPS) and other examples that demonstrate success and failure in interventions.

At the beginning of each module, an “In this Module” box briefly describes the content in the module, including the overview, Topic Notes, and innovative practice summaries. The innovative practice summaries are bulleted underneath the description of the Topic Note, and can be viewed directly by clicking on the title. Many of the tools, examples, and projects discussed also include links to websites and other useful resources.

Given the still-limited evidence on how to implement ICT-in-agriculture initiatives, the World Bank plans to further develop its operational practices and country-specific technical assistance as evidence and analysis accumulate.

REFERENCES AND FURTHER READING

- International Telecommunications Union. 2010. International Telecommunications Union's World Telecommunication / ICT Indicators database. <http://www.itu.int/ITU-D/ict/statistics/>, accessed September 5, 2011.
- Internet World Statistics. 2011. *Facebook Users in the World*. June 2011. <http://www.internetworldstats.com/facebook.htm>, accessed September 15, 2011.
- Mehra, A. 2010. “Small Technologies Fuel Big Results in the Developing World.” *Huffington Post*, September 13, 2010. http://www.huffingtonpost.com/amit-mehra/small-technologiesfuel-b_b_715274.html, accessed September 2011.
- TeleGeography. 2011. <http://www.telegeography.com/>, accessed September 23, 2011.
- UNFAO. 2009. *How to Feed the World 2050*. http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf, accessed September 6, 2011.
- Wireless Intelligence. 2011. *Global Mobile Connections to Surpass 6 Billion by Year-End*. <https://www.wirelessintelligence.com/analysis/pdf/2011-09-08-global-mobile-connections-to-surpass-6-billion-by-year-end.pdf>, accessed September 15, 2011.
- World Bank. 2008. *World Development Report 2008: Agriculture in Development*. <http://siteresources.worldbank.org/INTWDR2008/Resources/2795087-1192111580172/WDROver2008-ENG.pdf>, accessed September 10, 2011.
- . 2011. *Food Price Watch*. February. http://siteresources.worldbank.org/INTPREMNET/Resources/Food_Price_Watch_Feb_2011_Final_Version.pdf, accessed September 4, 2011.

Module 2 **MAKING ICT INFRASTRUCTURE, APPLIANCES, AND SERVICES MORE ACCESSIBLE AND AFFORDABLE IN RURAL AREAS**

MICHAEL BARRETT (University of Cambridge) and MIRA SLAVOVA (International Food Policy Research Institute)

IN THIS MODULE

Overview. What is “accessible” and “affordable” information and communication technology (ICT)? What general policy strategies, infrastructure, technology, and business models mediate ICT’s accessibility and affordability? Partnerships between organizations with different specialties, capacities, and profit motives are key to improving access and affordability. The task of regulation policy is to keep pace with technological developments and reduce inequalities within countries while maintaining sound business reasoning within the telecommunications sector. Policy interventions must consider ICT and its users as a socio-technical system through which equitable access to ICT translates into sustainable benefits for rural residents.

Topic Note 2.1: Making ICT Affordable in Rural Areas. In developing countries, infrastructure, appliances, and services influence the delivery of affordable ICT. What wired and wireless infrastructure can improve domestic backbone and “last mile” connectivity in rural areas? What trade-offs exist between quality and quantity of service? What devices appear most adaptable to the needs of rural users? Finally, how can services benefit from synergies among network infrastructure, connectivity modalities, access devices, and content?

Topic Note 2.2: Public Innovations in Universal Access to Telecommunications. It is within the domain of government to provide innovative methods for access to ICT in rural areas. Public agencies help develop infrastructure where incentives for private investment are insufficient; public policy encourages demand for telecommunications through such mechanisms as universal access/universal service funds or support for low-cost devices.

- **Passive Infrastructure Sharing in Nigeria**
- **Turkey’s Oligopolistic Infrastructure-Sharing Model**
- **Dabba’s Experience with Unlicensed Wireless Services in South Africa**
- **Bhutan’s Community Information Centers Adapt to the Geographical and Consumer Context**

Topic Note 2.3: Mobile Money Moves to Rural Areas. In developing economies worldwide, companies deliver financial services and new sources of income outside of conventional bank branches, through mobile phones and nonbank retail agents. Mobile financial and income-generating services cost little and operate on all handsets, making them advantageous on a large scale, even in more remote rural areas.

- **M-PESA’s Pioneering Money Transfer Service**
- **Zain Zap Promotes Borderless Mobile Commerce**
- **Pakistan’s Tameer Microfinance Bank for the Economically Active Poor**
- **Txteagle Taps a Vast, Underused Workforce**

Topic Note 2.4: Delivering Content for Mobile Agricultural Services. New services offer critical information for farmers to improve their livelihoods. The technical aspects of delivering content and services that rural users value are influenced by the partners engaged in providing the service, the regulatory environment, business model, and the networks, infrastructure, and devices available.

- **First-Mover Advantage Benefits Reuters Market Light**
- **Long Experience in Farm Communities Benefits Indian Farmer’s Fertilizer Cooperative Limited (IFFCO) Kisan Sanchar Limited**
- **Farmer’s Friend Offers Information on Demand, One Query at a Time**

OVERVIEW

ICT has a demonstrably positive effect on income growth in developing and developed countries (Röller and Waverman 2001; Waverman, Meschi, and Fuss 2005). In rural areas, ICT can raise incomes by increasing agricultural productivity (Lio and Liu 2006) and introducing income channels other than traditional farm jobs. Current limited evidence from individual farmers and fishers in India supports the conclusion that ICT improves incomes and quality of life among the rural poor (Goyal 2010; Jensen 2007). The idea that wider access to and use of ICT throughout a country will reduce inequalities in income and quality of life between rural and urban residents is compelling. Despite the scarcity of evidence to support this notion (Forestier, Grace, and Kenny 2002), it underlies widespread policy initiatives to ensure equitable access to ICT in all areas.

Creating affordable ICT services in rural areas is a complex challenge. In these areas, the “last mile” of telecommunications infrastructure is provided at a very high cost that may not be justified by the resulting use and effects of the telecommunications network. Affordable access to ICT in rural areas can be frustrated at the supply as well as the demand ends of the service-provision chain. To supply ICT and related services in rural areas, the main challenge is the high level of capital and operating expenses incurred by service providers. On the demand side, rural adoption of ICT in developing countries is curtailed by low availability of complementary public services, such as electricity and education, and by the relative scarcity of locally relevant content.

Recognizing the equity implications of access to ICT, governments have adopted regulatory policies to enable the rollout of ICT infrastructure and the supply of services in rural areas, and they have addressed low rural demand by introducing locally relevant content in the form of e-government and e-agriculture services. The task of regulation policy has been to keep pace with technological developments while maintaining licensing policies geared toward equity; in other words, to reduce inequalities within countries while maintaining sound business reasoning within the telecommunications sector.

This module describes what is meant by “accessible” and “affordable” ICT and discusses the more general policy strategies that influence rural access to ICT. Topic Note 2.1 is a relatively technical review of the infrastructure, networks, devices, and services for delivering ICT affordably in rural areas. Topic Note 2.2 considers the role of public innovation in achieving universal access to infrastructure and appliances. The compounded access problem, consisting of limited rural access to ICT and limited rural access to financial services, is discussed in Topic Note 2.3. The discussion focuses on business models that enable

the mobile microfinance industry to grow. Topic Note 2.4 explores efforts to build on expanding mobile networks in rural areas to deliver value-added livelihood services to farmers (primarily information to reduce agricultural losses and increase income).

“Access” in Relation to Two Broad Concepts in Telecommunications Policy: Universal Access and Universal Service

Within telecommunication policy, “access” can be understood in relation to two broad concepts: universal service and universal access (Gasmi and Virto 2005). “Universal service”¹ (US) is a policy objective primarily used in developed countries. It focuses on upgrading and extending communication networks so that a minimum level of service is delivered to individual households, even in the least accessible areas. US objectives are generally pursued by imposing universal service obligations on network operators. “Universal access,”² a policy objective more typical for developing countries, seeks to expand the geographic access to ICT for the population at large, and often for the very first time. UA obligations provide for a minimum coverage, especially of remote communities, thereby allowing all citizens to “use the service, regardless of location, gender, disabilities, and other personal characteristics” (Dymond et al. 2010). Table 2.1 outlines the characteristics of universal access and universal service in terms of their availability, accessibility, and affordability.

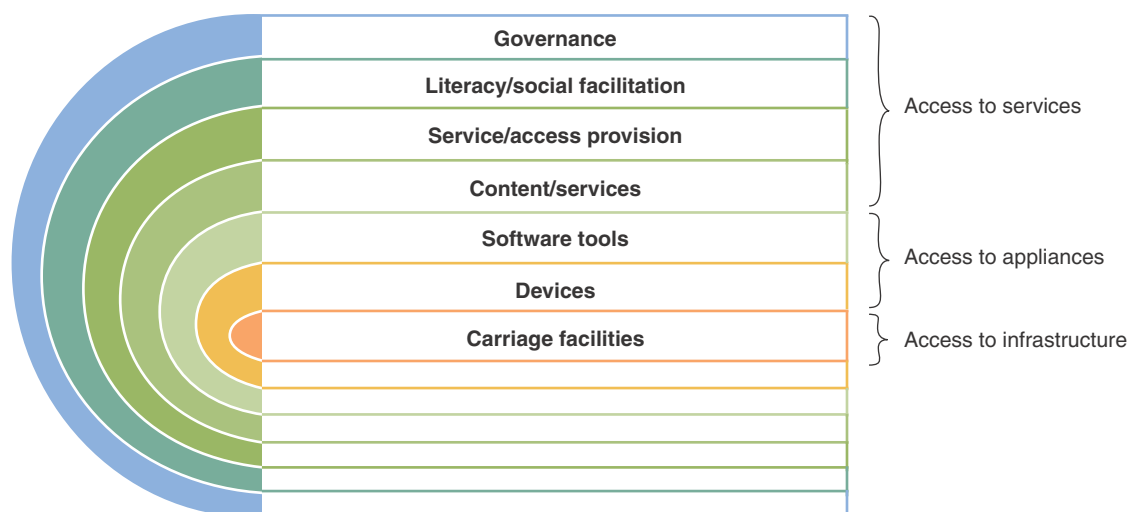
In designing policy interventions to promote equitable access to ICT, the technology and its users must be considered as forming a socio-technical system through which improved ICT access translates into improved rural livelihoods and sustainable benefits for rural residents. Many authors have considered access to ICT holistically, with an aim of understanding different aspects of how access is enabled or impeded, including technological, socioeconomic, and cultural aspects.³ This module uses the Access Rainbow Framework (Clement and Shade 2000),

- 1 “Universal service (US) describes when every individual or household can have service, using it privately, either at home or increasingly carried with the individual through wireless devices. For some services, a goal of full US would be too ambitious at present in a developing country, because the services must be affordable as well as available. Goals may relate to the proportion of the population that can afford private service (i.e., subscriber penetration targets)” (Dymond et al. 2010).
- 2 “Universal access (UA) describes when everyone can access the service somewhere, at a public place, thus also called public, community or shared access. . . . In general there would be at least one point of access per settlement over a certain population size” (Dymond et al. 2010).
- 3 For example, Benkler (2006) focuses on technological aspects and proposes a model of access consisting of a content layer, a service layer, a network layer (physical transportation and logical transmission), and a device layer (logical device operating system, OS, and physical machinery).

TABLE 2.1. Characteristics of Universal Access and Universal Service

ASPECT	UNIVERSAL ACCESS	UNIVERSAL SERVICE
Availability	Focused coverage	Blanket coverage
	Public access (e.g., at a pay phone or telecenter)	Private service on demand
	Free emergency calls	Free emergency calls
Accessibility	Walking distance, convenient locations and hours	Simple and speedy subscription
	Inclusively designed premises (e.g., for wheelchair users); inclusively designed terminals or available assistance (e.g., for the blind or deaf)	Inclusively designed terminals and services (e.g., for blind or deaf people)
	Assistance from an attendant	Assistance through the terminal (e.g., by making calls or viewing help pages for the Web)
	Adequate quality of service (e.g., having few failed call attempts)	Reasonable quality of service (e.g., having few dropped calls)
Affordability	Options of cash and card payment	Cost of average monthly usage is a small percentage of monthly GNI per capita
	Options of cash and card payment	Options of cash, card, and electronic payment
	Payment per use (e.g., for a single call or message or an hour of Internet access)	Flat rate, bundles of services, or low monthly subscription fee

Source: Dymond et al. 2010.

FIGURE 2.1. Access to ICT Infrastructure, Appliances, in Services and the Access Rainbow

Source: Authors, following Clement and Shade 2000.

depicted in figure 2.1, to understand access to ICT. The Access Rainbow Framework demonstrates the multifaceted nature of access to ICT and captures the socio-technical architecture instrumental to it. The framework goes beyond a mechanical understanding of ICT access by including enablers of ICT such as locally relevant content, ICT literacy, proximal ICT use,⁴ and social mechanisms for governing ICT use.

The Access Rainbow provides a framework for discussing access to ICT infrastructure, appliances, and services. The “carriage facilities” layer is a physical technology layer

consisting of installed network capacity, network connectivity, and interoperability standards. In this module, this layer is interpreted as access to ICT infrastructure. Access to ICT appliances is captured by the physical layer of ICT hardware devices and the logical layer of software tools on these devices. With its twofold (hardware and software) nature, access to ICT appliances links the supply of ICT infrastructure with the provision of services targeted at end users. Access to ICT services is a more amorphous concept, consisting of: (1) the ready availability of content (resources), fulfilling users’ roles as citizens, producers, and consumers; (2) the ready availability (to those who are not experts in the technology) of network access and appropriate support services through commercial vendors;

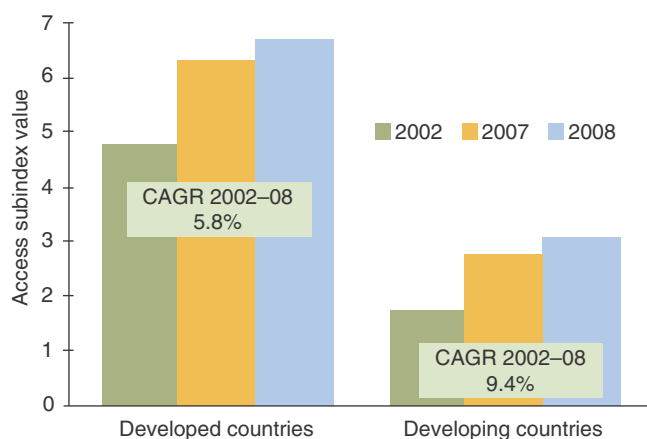
⁴ ICT use intermediated by skilled users in the rural community.

(3) the availability of formal and informal learning facilities for developing network literacy; and (4) the ready availability of channels through which individual users can participate in decisions about telecommunications services, their social inclusiveness, and the public accountability of their provision.

In considering interventions to improve access to ICT, practitioners must consider the complexity of access to ICT infrastructure, appliances, and services. It is important to locate the access layer within which an intervention is anchored and to assess how it relates to contingent aspects of access.

For public policy makers, a comprehensive understanding of the processes determining ICT access is best achieved within a holistic framework, but policy makers may also find some value in quantifying ICT access within countries and drawing comparisons across countries. To measure the digital divide between countries and assess countries' ICT development potential, the International Telecommunication Union (ITU) introduced the ICT Development Index (IDI) as an indicator of countries' level of ICT development. The IDI measures access by considering ICT readiness and five additional indicators: fixed telephony, mobile telephony, international Internet bandwidth, households with computers, and households with the Internet (ITU 2010). Figure 2.2 shows that in recent years (2002–08) developing countries have exhibited considerably greater access values than developed countries, largely owing to explosive growth in mobile telecommunications in developing countries.

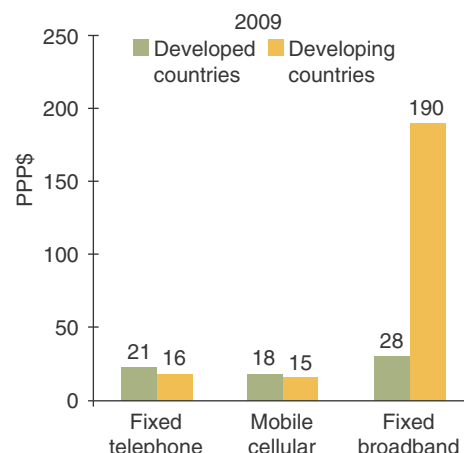
FIGURE 2.2. Access to ICT by Level of Development, Based on the ICT Development Index



Source: ITU 2010.

Note: For each year, the figures use the simple average value of the ICT Development Index (IDI) access subindex over all developed or developing countries. The compound annual growth rate (CAGR) of the IDI access subindex is computed by the formula $(P_n / P_0)^{1/n} - 1$, where P_n = present value, P_0 = beginning value, and n = number of periods. The result is multiplied by 100 to obtain a percentage.

FIGURE 2.3. ICT Price Subbaskets by Level of Development



Source: ITU 2010.

Note: PPP\$ = GNI per capita in current international dollars, obtained using purchasing power parity (PPP) conversion factors.

“Affordability” as a Function of Pricing and Business Model

An affordable universal service is one in which the “cost of average monthly usage is a small percentage of monthly gross national income (GNI) per capita” (Dymond et al. 2010). As a concept, affordability is easier to measure than access. As a measure of affordability, ITU uses the ICT price basket, which includes price indicators for fixed telephones, mobile phones, and fixed broadband service (ITU 2010).⁵ Figure 2.3 clearly shows that by this measure, fixed-line broadband was the single most expensive and least affordable service in developing countries as of 2009. In using this means of assessing affordability, however, it is vital to determine if the contents of the price basket are relevant to the access problem at hand (for example, Topic Note 2.1 questions whether in some contexts the affordability of fixed-line broadband infrastructure merits concern).

The Access Rainbow Framework (introduced in the “Access Concept” section) helps in understanding issues of affordability and sustainability, because it represents the layered system of interdependencies within which technology diffusion, business development, and regulatory policies occur.

5 The fixed telephone subbasket captures the average monthly cost of a basic, local, fixed residential telephone service. The mobile cellular subbasket represents low monthly mobile usage, namely 25 outgoing calls per month (on-net, off-net, and to a fixed line, and for peak, off-peak, and weekend periods) plus 30 SMS messages. The fixed broadband subbasket represents a typical monthly offer based on a 256 kilobit connection and a minimum of 1 gigabyte of data.

For example, the ICT layer carrying the highest value proposition for end users is the content/service layer.⁶ The framework makes it possible to consider the financial viability of all contingent layers (network capacity, availability of appliances, customer support, and so on) and how they may affect the value derived from the content/service layer.

From a regulatory standpoint, the Rainbow approach captures the significance of the separation between layers, most prominently the separation between the carriage and the content layers. Focusing regulatory efforts within layers and enabling competition within and between layers is central to achieving quality end-user services at affordable prices. From a regulatory policy perspective, the layered structure illustrates the trend in policy to enable competition among technologies delivering comparable functionality by following the principles of competition, technological neutrality, and licensing flexibility.

Ensuring competition within each of the layers is a long-standing policy priority, especially where economies of scale are conducive to monopolistic market structure.⁷ Market liberalization and free entry give incumbents incentives to pursue a higher quality of service. For example, starting in 1992 Thailand sought to break up the Communication Authority of Thailand's monopoly over international gateway services by introducing concessions to private companies under build-transfer-operate agreements. The entry of the private sector alongside state-owned enterprises, such as the Telephone Organization of Thailand, led to a remarkable expansion of subscriptions for both fixed and mobile services. Yet the level and the degree of competition in the fixed line and mobile subsectors varied considerably because of the number of concessions and their terms and conditions (Nikomborirak and Cheevasittayanon 2008). Competition in the mobile market yielded improved connectivity and affordability, while the fixed-line subsector stagnated.

The lesson is that the welfare benefits of market liberalization are achieved by implementing complementary policies on competition that enable market pricing and restrict predatory pricing by incumbents facing new entrants throughout the structural layers of the ICT sector. In Thailand, fixed-line concessions were restricted by stipulated fixed-call rates

and upper bounds on the number of subscribers, which skewed the viability of fixed-line rollouts by private concession holders.

In addition to competition, technological neutrality is another leading regulatory policy principle for ensuring the affordability of ICT. Technological neutrality is the principle of refraining from specifying technology requirements within telecommunications licenses. Historically, specifying technology requirements was a means of stimulating domestic equipment manufacturing, but technological neutrality is advisable within the present rapidly evolving IT industry, because regulatory decisions on technology selection can be risky (box 2.1 presents an example from the Republic of Korea).

BOX 2.1. The Risks of Picking Winners in the Rapidly Evolving IT Industry

In the Republic of Korea, the licensing of new technologies arguably led to market growth for domestic equipment manufacturers such as Samsung and LG, yet this strategy may prove more risky in the IT domain. Government support for WiBro, a Korean version of mobile WiMAX (a telecommunications protocol that provides fixed and mobile Internet access), has since been viewed as misguided. By the end of 2008, WiBro had attracted only 170,000 customers for Korea Telecom and SK Telecom combined, a fraction of the government's expected 1.4 million subscribers. Within the Korean market, LTE^a mobile broadband services were emerging as a more viable alternative to WiBro, and both Korea Telecom and SK Telecom announced plans to launch commercial LTE services at the expense of languishing WiBro services.

Source: Author, based on Kim 2009a, 2009b.

(a) Long Term Evolution (LTE) is a preliminary mobile communication standard, formally submitted as a candidate 4G system to ITU-T in late 2009. Commitment to LTE among mobile network operators has been growing steadily.

Because no specific technology standards are designated, technological neutrality widens the scope for competition within each layer of the Access Rainbow. Competing operators choose the technology standards that allow them to deliver services cost effectively. The regulatory policy drift toward technological neutrality is supported by technology developments that lead to increased standards of interoperability (see Rossotto et al. 2010).

The main policy lever for assuring market competition and technological neutrality is flexible licensing policies and the

⁶ Layer number 4 in figure 2.1.

⁷ International Internet gateways and local-loop or "last mile" fixed networks are examples. Local-loop networks are the fixed networks that deliver connectivity from the local exchange to the homes of end users. Because of the high cost of entry in developing these networks, this segment is conducive to a monopolistic market structure.

enforcement of flexible spectrum rights. Strict licenses and spectrum rights can be counterproductive if they restrict services that can be provided or technologies used to provide services (for example, WiMAX licenses have been issued limiting service provision to fixed broadband, to the exclusion of mobile broadband). In addition to limiting technological possibilities, restricted licenses and spectrum rights can also reduce the bidding incentives in spectrum auctions. Technology flexibility can be achieved within each of the interconnected layers of the ICT system through unified licenses and simplified licenses (Rossotto et al. 2010). Box 2.2 describes Singapore's experience with facilities-based and service-based operating licenses.

BOX 2.2. Singapore's Simplified Licenses Encourage Innovative, Cost-Effective ICT Infrastructure

By ensuring that the installation and operation of any network infrastructure in Singapore is covered by a license, the Infocomm Development Authority of Singapore ensures the development of innovative and cost-effective infrastructure. Simplified licenses are issued to facilities-based operators (FBOs) and services-based operators (SBOs) of telecommunications networks. FBOs include companies deploying submarine cables to improve international connectivity infrastructure, companies rolling out fiber-optic cables to improve domestic backhaul connectivity, and companies setting up broadband Internet Protocol (IP) or infrared networks. Wireless networks making demands on scarce spectrum resources are licensed separately and subject to comparative selection or auctioning. The operations of FBOs effectively remain within the carriage layer, but FBOs have the flexibility to deploy and/or operate any form of telecommunication networks, systems, and/or facilities on a technologically neutral basis.

SBOs remain within the service/access provision layer, but they have full flexibility to choose their technology. Individual SBO licenses are intended for companies that plan on leasing international connectivity capacities installed by FBOs. Individual SBO licenses cover services such as international simple resale, public Internet access services, and store-and-forward value-added services. SBO class licenses cover store-and-retrieve value-added network services, Internet-based telephony, the resale of public switched telecommunication services, and other services.

Source: Halewood 2010.

Note: One result of this clear, flexible approach to ICT development is Singapore's extensive e-governance system, described in Module 12.

KEY CHALLENGES AND ENABLERS

The challenges and enablers related to making ICT more widely and affordably available to rural people in developing countries are discussed in the sections that follow. Particular attention is given to the kinds of partnerships, regulations, and policies needed to reach this goal.

Partnerships

Considering the multilayered nature of the problem of ensuring affordable rural access to infrastructure, devices, and services, partnerships between organizations with different specialties, capacities, and profit motives appear to be a key way to improve access and affordability. Partnerships serving as critical mechanisms for improving rural ICT access can take the form of partnerships within the public sector, negotiated public-private partnerships, private agreements between stakeholders in the telecommunications sector, or informal understandings between service providers and stakeholders at the community level.

Enabling such partnerships and maintaining them remains a key government role. For example, the public sector played a considerable role within the M-PESA collaborative partnership (see IPS "M-PESA's Pioneering Money-Transfer Service," in Topic Note 2.3). This role involved financially supporting the collaboration between mobile network operators (MNOs) during software development. In Bhutan, partnerships between departments within government were instrumental in rolling out community information centers in remote areas (see IPS "Community Information Centers: Bhutan," in Topic Note 2.2).

A variety of motives engender private partnerships that improve rural access to infrastructure and services. For example, in the infrastructure-sharing arrangements discussed in Topic Note 2.2, explicit agreements were enacted to share passive infrastructure costs and implement 3G technology. Agreements between commercial and nonprofit partners also make a compelling case for the significance of partnerships in implementing projects to deliver improved rural access to ICT. For example, the Farmer's Friend service could be implemented only through collaboration incorporating Grameen Foundation's understanding of the nonprofit sector, Google's technology expertise, MTN's network coverage, and the local agricultural knowledge of the Busoga Rural Open Source Development Initiative.

Regulation and Policy Challenges

Although ICT's evolution in developing countries has far to go, it has moved significantly forward in the past decade.

The rapid expansion of mobile phone networks and market uptake of Global System for Mobile Communication (GSM) technologies⁸ following liberalization and deregulation are the most frequently cited examples of this evolution.

Informed and effective regulation is necessary for creating an enabling environment that will maximize entrepreneurs' abilities to expand market offerings and minimize the negative effects of competition on consumers. Barriers such as a monopoly operator and excessive licensing regimes in some contexts (for example, requiring local community networks to have licenses) can negatively affect business potential. At the other end of the spectrum, a supportive fiscal and financial environment and entrepreneurs' access to financial services can enable and increase the number of socially oriented services.

Significant regulatory issues in the telecommunications sector include taxes, licensing, liberalization, and competition policies. Taxes on communication services strongly influence ICT's affordability in Africa, for example, given the low average incomes. Import duties on IT equipment, value-added taxes (VAT) (ranging from 5 to 23 percent) on goods and services, and excise taxes on communications services all raise prices, discouraging use. Excessive licensing can also stifle the delivery of various content-based ICT services. Regulations of content broadcasting should be synchronized

with pure data transmission regulations (UNCTAD 2010). In terms of competition, policies fostering the effective management of competitive markets, interconnection regimes, and mobile termination rates can provide incentives to invest in quality of service, differentiation, and innovation.

With the increasing adoption of ICT and growing prominence of ICT-enabled services in consumers' lives in developing countries, it is worth emphasizing the significance of consumer protection regulation for ensuring the effective governance of multilayered ICT access. Recurrent problems include gaps between advertised "headline" broadband access speeds and what subscribers actually experience, lack of transparency in the pricing of mobile voice and data services, lack of effective mobile number portability, and excessive SMS pricing. Consumer-focused regulations should also target improvements in the legibility and ease of comprehension of transactions, made possible through improved ICT access. Consumer protection can pursue such goals through measures for mobile phone number registration, identity verification, confidentiality, and privacy.

Finally, the advent of financial services implemented on mobile phones makes it essential to create an environment that integrates financial regulation and telecommunication regulations. These services are discussed in greater detail in Topic Note 2.3.

Topic Note 2.1: MAKING ICT AFFORDABLE IN RURAL AREAS

TRENDS AND ISSUES

"Fixed-mobile convergence" is the increasingly seamless connectivity among wired and wireless networks, devices, and applications, which permits users to send and receive data regardless of device and location. Convergence is the result of converting content formats (text, images, audio, video), devices for creating and communicating this content, and telecommunications infrastructure to digital standards.

Device convergence allows devices to support different functionalities and different network access technologies. Service convergence means that end users are able to receive comparable services via different devices and technologies for accessing networks. Network convergence means that a single network is able to carry voice and data formats and can support access by different technologies.

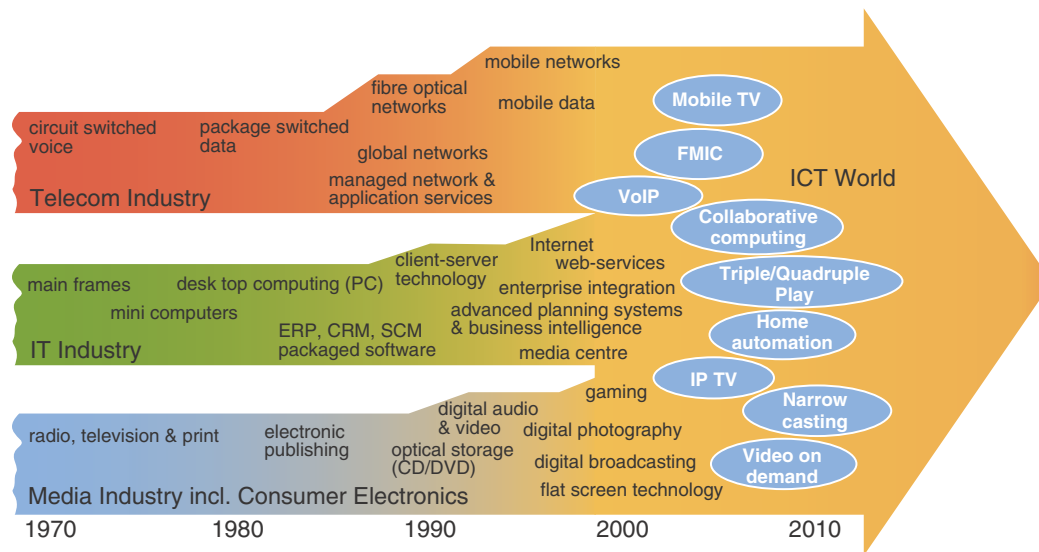
Convergence (as the name implies) blurs the distinctions between the domains of Internet service providers, cable television media companies, fixed-line telecommunication companies, and operators of mobile telephony networks (figure 2.4).⁹ With this context in mind, the discussion that follows examines how technology trends in infrastructure, appliances, and services can influence the delivery of affordable ICT in developing countries.

INFRASTRUCTURE

What are the current wired and wireless options to improve domestic backbone and "last mile" connectivity? As noted, wired telecommunications infrastructure tends to reach rural areas in the wake of complementary rural access infrastructure such as roads and electricity and the expansion of public

⁸ GSM standards for 2G cellular networks serve an estimated 80 percent of the global mobile market, according to the GSM association (<http://www.gsm.org/>).

⁹ Offers that span three out of these four services have become known as "triple play" offers. (Sunderland 2007) points to such offers in Cape Verde and the Caribbean.

FIGURE 2.4. Telecommunications, IT, and Media Industry Convergence

Source: Caneval Ventures, "ICT and Media Industry" (<http://www.caneval.com/vision/ictmediaindustry.html>, accessed July 2011).

services such as education. The lag between the arrival of complementary infrastructure and public services and the establishment of wired ICT infrastructure in rural areas can be considerable, but the introduction of wireless, especially mobile, infrastructure is bound neither by the presence of roads nor by access to the electricity grid.

Rural infrastructure development needs to be considered in light of the different opportunities offered by wired and wireless technologies and the fixed-mobile convergence occurring throughout the ICT sector. Sunderland (2007) notes that fixed-mobile convergence differs in developing countries, where fixed-line teledensity is low, from that in developed countries. As a result, convergence in developing countries largely amounts to convergence in the delivery of Internet access and voice telephony services over wireless networks. For example, in rural Africa, where the teledensity of fixed networks is low and their rollout can be prohibitively expensive, fixed-mobile convergence enables the use of wireless "last mile" infrastructure, while the backhaul traffic is carried on fixed fiber-optic cables because of their high capacity. In small-island developing countries, fixed-mobile convergence allows for international connectivity via satellite rather than undersea cable.

Telecommunications networks comprise a hierarchy of links that connect users at the "edge" of a network to its "core," also called the "backbone" (the high-capacity links between switches on the network). The backhaul portion of a network consists of the intermediate links between subnetworks at the users' end and the core network.

In considering how best to develop affordable telecommunications infrastructure in developing countries, all three connectivity segments of the network need to be taken into account: (1) the international and domestic connectivity that makes up the network's backbone capacity, (2) the domestic backhaul connectivity that enables the intermediate links, and (3) the local loop or "last mile" connectivity that serves end-user access at the edges of the network. (Each of these networks segments is discussed in greater detail in "Domestic backbone and rural backhaul connectivity" and "local loop or 'last mile' connectivity.") The expansion of backhaul connectivity and the provision of "last mile" connectivity pose particular challenges to extending ICT to rural areas in an affordable way (box 2.3).

Wireless infrastructure may be an economical option, but it has certain cost constraints. Buys et al. (2009) show that the probability of the presence of mobile tower base stations is positively correlated with the potential demand (population density, per capita income), as well as with the absence of factors that increase operational and capital expenditures, such as elevation, slopes, lack of all-weather roads, unreliable power supplies, and even insecurity. (See IPS "Passive Infrastructure Sharing in Nigeria," in Topic Note 2.2.)

At the carriage level, network convergence is associated with the transformation from circuit-based public switched digital telecommunication networks (PSTNs) to packet-switched networks using the Internet Protocol (IP) and known as next-generation networks (NGNs). Both PSTNs and NGNs are

BOX 2.3. Balancing Quality and Service in Reaching Rural Areas: Fixed-Line versus Wireless Backhaul

Even though wireless is accepted as an economical option for delivering “last mile” connectivity, backhaul traffic is usually carried via fiber-optic networks because of their high capacity. Connectivity is often limited by the limited penetration of the fixed-line backhaul that supports it. The delivery of connectivity to rural areas lacking fixed-line backhaul involves balancing concerns about ICT access, connection quality, and the expenditures and delays entailed in rolling out fixed lines and supporting infrastructure. The benefits of wireless backhaul technology are worth considering in such cases.

Wireless backhaul is increasingly recognized as an option for combating the expenditures involved in providing fixed-line rural connectivity. Wireless network backhaul solutions can take the form of point-to-point or point-to-multipoint wireless Ethernet bridges or wireless mesh networks. They can use licensed or unlicensed microwave links (see Unlicensed Wireless Use). With throughput from as low as 10 Mbps up to GigE full duplex (with gigabit wireless), a licensed microwave link or wireless bridge can provide sufficient capacity for many rural applications. Because it is compatible with mobile phone standards (GSM, CDMA), the WiMAX standard offers opportunities for rolling out affordable wireless rural backhaul. Advocates of the technology are optimistic about its potential for linking wireless fixed-location base stations to the core network.

Source: Authors.

Note: Mbps = megabits per second; GigE = Gigabit Ethernet; GSM = Global System for Mobile Communication; CDMA = Code Division Multiple Access (CDMA) 2000, a wireless air interface standard; WiMAX = Worldwide Interoperability for Microwave Access.

made up of telephone lines, fiber-optic cables, microwave transmission links, mobile networks, communications satellites, and undersea telephone cables.

The difference between the two kinds of networks lies in their switching mechanisms. Under circuit switching, the connection is established on a predetermined, dedicated, and exclusive communication path for the whole length of the communication session. Consequently, PSTN connectivity is costly. In packet-switching protocols, such as IP, the communicated data are broken into sequentially numbered packets, each of which is transmitted to the destination via an independent path, and then the packets are reassembled. In packet-switching, the potential for congestion, packet loss,

and delay can mar the quality of the connection. A comparison between traditional fixed-line telephone services and voice over IP (VoIP) clearly demonstrates the difference between the two types of networks. NGNs completely separate the packet-switched transportation (connectivity) layer and the service layer, enabling any available fixed-line carriage infrastructure to be used efficiently for any service.

Domestic Backbone and Rural Backhaul Connectivity

As end users’ demand for additional bandwidth grows, insufficient domestic backbone can pose a considerable challenge to the rollout of fixed-line broadband services. In the mobile sector, insufficient backhaul capacity is becoming a limitation, particularly with the increase of rural 3G data use. Government interventions in support of rural backhaul solutions have included the introduction of public-private funding mechanisms (as in Korea and Chile; see box 2.4), construction subsidies (as in Canada), and the rollout of fiber-optic networks connecting public institutions (Rossotto et al. 2010). Complementary regulations can be used to ensure competitive conditions in the provision of domestic backbone and rural backhaul. The policy tools for supporting domestic backbone rollout and rural backhaul connectivity include infrastructure sharing,¹⁰ functional separation,¹¹ and cross-ownership restrictions, allowing for interplatform competition¹² (Dartey 2009).

Local Loop or “Last Mile” Connectivity

The delivery of network access in the “last mile” is the most costly and challenging element of rural deployments. The technology options for delivering wired local loop broadband connectivity include the rollout of xDSL,¹³ cable, and fiber to the home infrastructure. Wireless options include the rollout of mobile (2G, 3G, 4G),¹⁴ wireless broadband (WiMAX, Wi-Fi,

10 “Infrastructure sharing” is a mechanism for reducing capital expenditures and operating expenditures. Passive infrastructure sharing consists of colocating competitors. Active infrastructure sharing consists of sharing the network base station controllers, both circuit-switched and packet-oriented domains, mobile services switching center, GPRS support node, and so on.

11 In “functional separation,” an incumbent operator is required to establish separate divisions for managing fixed-line services and providing wholesale services to retail competitors.

12 Cross-ownership restrictions prevent operators, such as telephony operators, from controlling competitive network infrastructure, such as cable television networks. For example, restrictions may be placed on the simultaneous control of telephony and cable television network infrastructures in a specified area.

13 xDSL refers to all digital subscriber line (DSL) technologies.

14 2G mobile wireless has basic functionality: voice and short messaging service (SMS); 3G has advanced functionality: general packet radio service; and 4G has broadband functionality: long-term evolution (LTE).

BOX 2.4. Chile's ICT Policies for Connectivity and Economic Growth

Chile regards ICT policies as important tools for increasing the nation's economic growth. The government has introduced policies addressing both the supply of and demand for ICT. These policies go beyond infrastructure to include programs for e-literacy, e-government, and ICT diffusion.

Chilean ICT policies consistently distinguish between the domains of the private and public sectors and rely primarily on market forces to dictate the development of the telecommunications sector. For example, the broadband market in Chile has high levels of interplatform competition: Multiple operators offer competing broadband services through different networks. Government involvement is limited to cases where market forces alone fail to provide incentives for growth in the sector. Starting in 2002, for example, government investments focused on improving the connectivity of rural schools, developing fiber backbone infrastructure, and training people in remote areas in computer skills. In 2008, the government embarked on a more ambitious project to extend at least 1 megabit per second connectivity to 92 percent of the population and intensify ICT use in agriculture and tourism. Candidates for delivering this project were selected through a reverse auction. The Chilean government participated by offering a subsidy of US\$70 million and the spectrum in the 3.5 gigahertz band.

The Chilean Universal Access/Universal Service Fund has been praised for its accomplishments. Between 1994 and 2002, by providing public pay phones to more than 6,000 rural locations, the fund reduced the fraction of the population living without access to basic voice communication from 15 percent to 1 percent. The subsidies required to achieve this goal cost less than 0.3 percent of the telecommunications sector's revenue over the same period. The opportunity for existing and new operators to use the subsidized pay phone infrastructure to provide individual telephone lines and value-added services (voice mail, Internet access, and so on) was one key to commercial success. An interconnection rate with access charges capable of surpassing 40 percent of rural operating revenues was the other key to success.

Sources: Mulas 2010; Wellenius 2002.

WLAN),¹⁵ and satellite very small aperture terminal (VSAT) infrastructure. Within cell-based (mobile) wireless standards, all users connect to a single base station, and the transmission bandwidth has to be shared among all users in the cell's coverage area.

Within a short range, wireless broadband transmission is possible at relatively high data rates—from hundreds of megabits (Mbps) to a few gigabits (Gbps)—but services of such high quality are not foreseeable for existing mobile standards. Conversely, mobile technologies have the advantage of reliability within a greater access range. Point-to-multipoint solutions, combining VSAT terminals with wireless broadband local access, are increasingly viable and promising. Unlike cell-based connectivity, satellite connectivity does not distribute the available bandwidth among users; instead, each user is connected independently, so satellite solutions can offer a better quality of service. Yet the low density of wired infrastructure, combined with limited domestic fiber backbones in developing countries, makes wireless a practical option for connectivity in rural areas, despite the limitations imposed on users by sharing capacity.

As this discussion implies, finding the network solution that can ensure affordable ICT in rural areas can be an innovative, challenging, and exhausting process. The choice depends largely on the availability of technology, of rural backhaul, and of complementary infrastructure. It also depends on the flexibility and responsiveness of the regulatory framework to the prevailing technology constraints and opportunities.

Policies related to the development of rural wireless infrastructure require careful study of the trade-offs between affordability and usability. Policy makers must determine where the value lies (in terms of use) in developing the infrastructure. Regulatory policy must consider the trade-offs between reach, speed, frequency, and transmission. For example, the choice to use technology with low transmission power can lead, on the one hand, to a great increase in the available bandwidth per user; but on the other hand, it may require a direct line of sight between the antenna and the user. Consequently, the number of access points needed to cover a fixed area, and therefore the required capital expenditures, will rise considerably.

¹⁵ WiMAX (worldwide interoperability for microwave access); Wi-Fi (wirelessly connecting electronic device); WLAN (wireless local area network).

Several key technology parameters should be considered in decisions about the expansion of rural connectivity and the choice of technological delivery mechanism. They include the availability of spectrum frequencies, number of base stations needed to cover an area of specific size given a fixed operating frequency, achievable connection speed, data transmission rates, and downlink and uplink speeds.

Given the complexity of such decisions, the role of the regulatory environment should be to expand the set of viable technology options. Flexibility in allowing licensed and unlicensed use of operational frequencies can be advisable. Wellenius (2002) describes how Chile identified cost-effective solutions to reduce the gap between urban and remote areas in access to basic communications technology.

The “digital dividend” has been widely hailed as the solution to urban-rural inequities in digital ICT access. The “digital dividend” is the reassignment of operational frequencies that become available following the switch from analog to digital television broadcasting. The Geneva 2006 Agreement sets June 17, 2015, as the final date for protecting currently assigned analog television transmission frequencies. The digital dividend spectrum is found between 200 megahertz (MHz) and 1 gigahertz (GHz). It offers a combination of transmission capacity and distance coverage conducive to the extension of wireless broadband infrastructure in rural areas. Using this spectrum, a few stations can transmit with high power, thereby providing Internet coverage to large rural areas where population is low and demand sparse. The advantage is the low capital expenditure required; the downside is the low bandwidth available to individual users. The process is accepted as inevitable, however, and it provides opportunities for efficient spectrum management in rural areas.

How to reassign digital dividend frequencies efficiently remains open to debate. Some advocate the reassignment of analog transmission frequencies to MNOs, without imposing a requirement that rural infrastructure investments be tied to urban infrastructure investments (Picot et al. 2010). Others propose allocating the digital dividend frequencies to short-range communications. Countries’ experiences with the crossover to digital television have varied and remain difficult to evaluate, as the process is still unfolding (box 2.5 has an example from South Africa).

Some observers (Nedeveschi et al. 2010) have considered CDMA450 a solution to rural connectivity problems (it is

BOX 2.5. Lessons from South Africa’s Experience in Migrating to Digital Television

South Africa developed a digital migration strategy to stimulate growth in its electronics manufacturing sector. The strategy featured a digital switch-on date in 2008 and an analog switch-off date at the end of 2011. The reduced costs of simultaneous analog and digital broadcasting (€750 million for three years) were considered a strong advantage of the ambitious, three-year migration plan. Other expected costs included €800 million for the digital rollout, as well as €2.5–3.5 billion for subsidies to local manufacturers producing digital set-top boxes. In early 2011, the South African minister of communications announced that the switch from analog would be postponed until December 31, 2013. Observers have raised questions about the practicality of the plans and even the postponed date. The lesson is that the certain costs of switchover plans need to be balanced against their uncertain benefits, including the uncertain demand for the released telecommunications spectrum and for additional digital TV services.

Sources: Author, based on Pham 2009; Armstrong and Collins 2011; and Government of South Africa, “Statement by Minister of Communications,” January 14, 2011 (http://www.doc.gov.za/index.php?option=com_content&view=article&id=478:statement-by-the-honorable-minister-of-communications-mr-radhakrishna-l-padayachie-roy-on-progress-made-with-regards-to-the-digital-migration-process&catid=88:press-releases, accessed July 2011).

used for this purpose in Kazakhstan; see box 2.6). CDMA450 is a cellular technology based on the CDMA2000 standard, with an operating frequency of 450 MHz. The technology uses the same air interface as CDMA2000 but operates at a lower frequency and is able to offer the same basket of high-speed voice and data connectivity over a greater range, thereby implying lower capital expenses. In rural settings, CDMA450 has a range of up to 50 kilometers. Owing to a process known as “cell breathing,” however, such ranges are not achievable under cell loads approaching cell capacity. CDMA450 appears to be best suited to mixed urban-rural deployments, in which urban deployments are capacity-centric and rural deployments are coverage-centric. Another disadvantage of CDMA450 is the large antenna required to allow the extended coverage for meeting low rural demand. The major limitation of CDMA450 solutions is the scarcity of mobile devices that can use the 450 MHz frequency (the majority operate at 900–1800 MHz).

BOX 2.6. CDMA450 Technology Connects Rural Kazakhstan

Kazakhtelecom, the biggest telecommunications operator in Kazakhstan, introduced CDMA450 technology in rural areas in the north. The CDMA450 base stations cover 25–35 kilometers and can serve up to 1,000 subscribers. The project, which began in 2008, had installed 399 base stations by 2010, providing connectivity to approximately 1,800 rural settlements. The project intended to roll out 900 base stations throughout the country by 2013, enabling voice and Internet access services at speeds up to 3.1 Mbps.

Sources: Author, based on “Implementation of CDMA-450 in North Kazakhstan,” August 5, 2009, *Cellular News* (<http://www.cellular-news.com/story/38960.php>, accessed July 2011); and “Base Stations WLL CDMA Cover About 80% of Rural Settlements in Kyzylorda Oblast,” Kazakhtelecom press release (http://www.telecom.kz/?muin=1240831664&mchapter=1272548824&lang=eng&n_date=2010-04-29&act=archive, accessed July 2011).

APPLIANCES

From a user’s perspective, device convergence has two main aspects. First, users can access content in different formats (audio, data, location data, pictures, maps, text) and with different dynamic properties,¹⁶ produced by different authors, on the same device. Second, users can take advantage of different options (radio, GSM, Wi-Fi, Bluetooth, satellite) for accessing that content.

The evolution of appliances in the mobile phone market illustrates these two trends. The discussion that follows focuses on portable devices that support multiple functionalities or multiple connectivity options, because they are vast majority of ICT appliances available in the world today.

Portable devices, including but not limited to mobile phones, are starting to give users dual (or multiple) mode flexibility. For example, dual connectivity (Wi-Fi/GSM and Bluetooth/GSM) enables mobile phones to conduct both VoIP and standard mobile calls. Dedicated telephone devices are able to process VoIP phone calls using Session Initiation Protocol, as well as regular phone calls using analog signals. Gains in processing power allow functions with higher technology requirements to work on smaller devices (high-end

smartphones and Netbook appliances). Conversely, bulkier stationary devices such as the desktop computer have evolved functionalities traditionally associated with more portable devices, such as VoIP telephony and on-demand radio and TV broadcasts.

Among rural users in developing countries, the trend is to move from mobile phones with basic voice and text message capabilities to feature phones. Feature phones are low-end phones that access various media formats in addition to offering basic voice and SMS functionality, capturing the functionalities of multiple ICT devices that are also available as stand-alone appliances. Rural consumers prefer the combined devices because of their affordability. Features appreciated by consumers in developing countries include the digital camera, voice recorder, flashlight, radio, and MP3 player. Bluetooth and general packet radio service (GPRS) are the most widely available connectivity options, in addition to GSM. Chinese mobile phone manufacturers tend to be at the forefront of making devices that are particularly affordable and attuned to the needs of rural users in developing countries (box 2.7).

The demand for features tends to vary depending on the availability of complementary rural services. For example, radio is a feature very commonly targeted at the rural market, owing to the traditional significance of radio broadcasting in rural areas. Nonetheless, the choice of radio devices by rural residents is largely determined by the availability of electricity. The radio feature of mobile phones tends to consume the device’s battery fairly fast. Rural residents off the electricity grid find this feature uneconomical, because the costs of recharging services provided by local entrepreneurs are not negligible. Rural residents at locations off the electricity grid in Ghana report paying 0.50 cedis per charging, comparable to the price for 1 kilogram of plantains or oranges.¹⁷ In agricultural areas such as northern Ghana, solar-powered and windup charging devices have durability and maintenance issues (although they appear useful elsewhere; see IPS “Long Experience in Farm Communities Benefits IFFCO,” in Topic Note 2.4).¹⁸ By comparison, traditional, battery-powered, dedicated radio receivers appear to be a more affordable choice.

SERVICES

Services entail much more than access to hardware; they encompass affordable access to locally relevant rural content

¹⁶ Such as “online” and “offline” content; “online” content is communicated but not recorded or reusable (such as a radio broadcast), whereas “offline” content is recorded and reusable, once it has been communicated (such as audio podcasts, SMS messages, or voice mail).

¹⁷ See Esoko (<http://www.esoko.com>).

¹⁸ Details available from the authors.

BOX 2.7. Mobile Phones with Features Attract Rural Users in China and Beyond

Chinese mobile phone producers are concentrated in the city of Shenzhen, Guangdong Province. They, as well as their products, have become known as *shanzhai*.^a At least two innovative features associated with *shanzhai* devices have wider relevance to rural consumers' use of, and preferences for, devices in developing countries.

The first feature is that they allow users to store multiple (physical) SIM cards within the device, which allows them to switch between carriers without having to reboot the device. This feature responds to the price sensitivity of rural consumers in developing countries, who switch between carriers to take advantage of preferential termination rates for the carrier of their calling destination. Because the choice of mobile network operator can be limited in rural areas, consumers have strong incentives to take advantage of cost-saving opportunities when they exist. This demand-driven innovation has made no inroads into the products of popular mobile phone manufacturers, which are reluctant to undermine the business models of mobile network operators worldwide. Consumers who cannot purchase these devices can achieve the same results through street-level hack services offering software to configure from 6 to 16 SIM card identities on one physical SIM card, enabling users of unlocked mobile phones to switch conveniently among carriers.

A second feature of devices from Chinese mobile phone manufacturers (relevant to convergence in the "infocom" sector) is the addition of analog television reception. This feature is found in phones with large LCD screens like those of smartphones.

The features in these devices illustrate ways that the global mobile phone industry could choose to respond to the demands and constraints of rural consumers—but has not. The preference of rural consumers in developing countries for access to television over radio is well established but constrained by poor access to the electricity grid. Unlike dedicated radio receivers, television sets have not evolved to operate on dry cell battery power alone, and mobile phone devices with analog television functionality are the exclusive option for rural populations. Given that television remains an effective means of delivering agricultural extension messages, the lack of support for these and other innovative features introduced by Chinese phone manufacturers represents a missed opportunity in rural communication.

Sources: Authors; Chipchase 2010; Abbey-Mensah 2001.

(a) *Shanzhai* signifies Chinese imitation and pirated brands and goods, particularly electronics (<http://en.wikipedia.org/wiki/Shanzhai>, accessed July 2011).

through connectivity providers, content creators and disseminators, information intermediaries, social facilitators, information literacy educators, and the governance channels steering the performance of these services.¹⁹ Concerns with rural content have traditionally been alien to public policies aimed at universal service and universal access, but the convergence of the mass media and telecommunications sector, as well as the rise of the information society, make such concerns increasingly prominent and crucial to unleashing a virtuous cycle of ICT adoption and use in rural areas. The delivery of content-based agricultural services is discussed in Topic Note 2.4.

The service layer reflects the synergies (or lack thereof) among network infrastructure, connectivity modalities, access devices, and content. The dynamics of the worldwide content marketplace point to the dying out of traditional communications business models, which centered on tariffs anchored in

use time, quantity of data transferred, or communications distance covered. Such models increasingly are replaced by more flexible subscription models and models centered on realized interactions and transactions, paid for via micropayments. In developing countries, where consumers are more price sensitive and less willing to pay, the trend toward micropayments poses a considerable challenge to content and value-added service providers. The challenge is compounded by the marginal success of government and donor efforts to provide content-driven rural services in developing countries.

Traditionally, rural information services focused on providing broadcasting ("push") content, such as rural radio programming, but the ubiquity of mobile devices enables the sourcing and sharing ("pull") of rural content. The presence of mobile technology as an authoring tool in rural areas presents an untapped opportunity to engage rural users in authoring content, thereby increasing the demand for existing rural infrastructure. Mobile devices, in combination with broadcasting technologies such as radio, enable rural residents to

19 See the earlier discussion of the layered nature of access ("Access Concept") and the Access Rainbow Framework.

participate in public discourse and influence decision making. In reviewing communication and media needs at the community level in Ghana, (Dartey 2009) points out that call-in radio programs have become widely popular. Such programs allow Ghanaians to express their opinions on issues of local concern.

The provision of rural ICT-based services in developing countries has a few discernible characteristics. One recurrent characteristic in successful business models is found at the literacy/social facilitation level of the Access Rainbow Framework. Successful business models manage to leverage social networks and social value (UNDP 2008). Engaging rural residents as individuals rather than as beneficiaries appears to be essential in delivering a worthwhile value proposition. Allowing rural residents to be trainers, to facilitate access to content, and to provide local support and maintenance appears to be a successful business strategy for the delivery of rural services (image 2.1).

IMAGE 2.1. Cell Services in Rural South Africa



Source: John Hogg, World Bank.

Even though the diffusion of personal mobile phones has eroded the business logic behind well-documented models such as the Grameen Village Phone (an owner-operated GSM payphone) (Futch and McIntosh 2009), the significance of social value remains a key building block of business models aimed at delivering rural ICT-based services. As pricing plans have changed over the past few years, the mobile payphone has become less profitable as a business asset. Even so, the impersonal nature of mobile payphones is instrumental to addressing concerns related to equal access. From the standpoint of public service provision, equal access to public phones continues to be significant, especially for women who

cannot afford their own phones or are not permitted to use the personal phones of family members (Burrell 2010). The sharing and collaborative use of personal mobile phones can enhance social ties but may also cement social inequalities.

Another trend to be noted is the divergence in focus and targets of local (especially rural) demand-driven information services relative to supply-driven services. Content-focused service innovations tend to respond to local needs within the entertainment, social networking, game, and music domains. If managed carefully, such services can be legitimate drivers of ICT use for demand-driven services in education, public awareness, health, and agriculture. Introducing immediately popular content is a way to attract and retain users. Once the user base is established, there is room for introducing more practical content, such as mobile banking (box 2.8).

BOX 2.8. MXit Blends Entertainments and Practical Content in South Africa

Founded in 2003, MXit is a pioneering mobile media and social networking company based in South Africa. Initially, community issues and causes formed a strong focus for the networking it facilitated. Subsequently, it has expanded to cover entertainment (music downloads, multiplayer games, TV polls), dating, classifieds, education, counseling (drugs, youth helpline), and mobile banking.

The primary MXit product is software allowing mobile users to use instant messaging to participate in community forums on different topics. The software can be installed for free, and there is no subscription and no charge for messaging. By using IP-based (GPRS, 3G) connectivity, MXit allows instant messaging at a cost per character hundreds of times smaller than the cost of an equivalent SMS message. These costs are covered by revenues from advertising (wallpapers, promotions, brand portals) and content sales (skins, music, classifieds).

Sources: Chigona et al. 2009; Prows 2009; Ramachandran 2009.

Currently, prepaid subscription models appear to be the standard operational mode for providing services in developing-country markets. Yet, as Topic Note 2.4 indicates, this strategy may be impractical for rural content providers, given the risks involved in subscription renewal and the high fixed costs of generating relevant rural content.

Topic Note 2.2: PUBLIC INNOVATIONS IN UNIVERSAL ACCESS TO TELECOMMUNICATIONS

TRENDS AND ISSUES

With technology moving toward fixed-mobile convergence, the provision of minimum services (other than telephony) and public access to ICT devices has fallen within the mandate of universal service regulations. This note examines the public sector's changing and recently expanding role in providing affordable access to ICT infrastructure, appliances, and services, including the growing use of universal access/universal service funds.

Changing Role of the Public Sector

Public involvement in the telecommunications sector evolved in a nonlinear way (Gómez-Barroso and Feijóo 2010). An early monopolistic stage after the Second World War was succeeded by a series of crises in the 1970s as services came to be considered a “public matter” demanding closer government involvement. In the 1980s, the public sector started giving way to the private sector, which was considered better equipped to deliver value and efficiency.

The public sector's current role in telecommunications can be described as promoting the information society. Governments act as facilitators and enablers of universal access to telecommunications, and the public sector has reemerged as an active participant in the sector. In both developed and developing countries, public agencies are regarded as partners in funding infrastructure in areas where the incentives for private investment are insufficient; they are also regarded as partners by virtue of their role in encouraging demand for telecommunications. In developing countries, local governments and international development partners actively facilitate access to ICT at all levels (infrastructure, appliances, and services).

It is within the domain of local government and public administration to provide innovative methods for access to ICT in rural areas. Effective partnerships and public support are capable of overcoming obstacles at different access layers. Until recently, the public sector was not considered an investor in telecommunications, but under the increasing pressure of the recent international financial crisis, governments looked to ICT as fiscally sound investments relative to other public stimulus options. Investments in broadband and next-generation networks are proving to work as countercyclical tools for creating jobs and as building blocks of long-term economic recovery (Qiang 2010).

Broadening Mandate of Universal Access / Universal Service Funds

The main vehicles for improving access to ICT in rural areas have been the universal access/universal service funds (UA/USFs) established in the 1990s. The funds originally offered an opportunity for funding and access to ICT solutions in underserved areas (Hudson 2010). Dedicated at first to increasing the penetration of landline telephone services, the funds now support mobile network development and Internet services in most countries.²⁰

In some countries, such as Ghana and Mongolia, funds are disbursed to aid the provision of rural public access telephony and Internet facilities. Although the expansion of mobile networks has reduced the urgency of public access to voice telephony, arguments based on gender inequality and perceptions of social obligation still favor the provision of public access (Burrell 2010). In allocating UA/USF funds to services other than voice telephony, some governments specify additional criteria, such as the nearby presence of public-access facilities (telecenters, libraries, Internet cafes, and so on).

Since cost-effective technologies for delivering rural access to ICT are evolving constantly, it is essential that UA/USFs do not limit their technological scope and maintain technological neutrality. It is advisable for UA/USFs' tender requirements to specify coverage, bandwidth, quality of service, target price, and so on—but not technology. Rural areas where the profitability of telecommunications services is low can be of limited commercial interest to telecommunications companies. Consequently, the UA/USF levy can run the risk of becoming a simple direct tax on the operator, and a strategic approach is needed to deliver ICT services and “unlock” the potential of UA/USFs (especially in Africa) (UNCTAD 2010).

Public Support for Low-Cost Devices

Unlike public support for the provision of infrastructure, public support for the provision of low-cost devices has experienced considerable criticism. The most prominent instance

²⁰ The objectives of UA/USFs can be at very different stages of development and maturity. Hudson (2010) reviews key lessons related to UA/USFs' management, professional capacity, size of funding, and expanding mandate. Stern, Townsend, and Stephens (2006) recommend the accelerated, simplified, and diversified use of UA/USFs. UNCTAD (2010) discusses in detail the challenges and opportunities for financing ICT in rural areas of developing countries through UA/USFs.

BOX 2.9. India Exemplifies Evolution in the Public Provision of Low-Cost Devices

India's union minister for human resource development announced that the government would continue to support development of a low-cost device with computing and communication capabilities. The cost of the tablet device, commonly known as the "Sakshat" ("before your eyes"), currently stands at US\$35, but it is projected to decline to US\$10 through continuing research and development cooperation with private manufacturers. The government is committed to first provide the technology to 110 million schoolchildren.

The Indian program clearly demonstrates how the scope of public initiatives providing access to low-cost devices has evolved, largely as a result of the comprehensive approach of the One Laptop per Child project. Government initiatives aimed at the development of low-cost technology devices include the active participation of technology development partners (for example, the Indian Institute of Technology Rajasthan) as well as further development and investment in communication layers other than the appliance itself. The Indian Ministry for Human Resource Development is simultaneously tackling the problems of device/hardware affordability and content creation by ensuring that electronic content for the devices is generated under the National Programme on Technology Enhanced Learning.

Sources: Author, based on "India to Unveil £ 7 Laptop," *The Guardian*, February 2, 2009 (<http://www.guardian.co.uk/world/2009/feb/02/india-computer-cheapest>, accessed July 2011); "India Unveils World's Cheapest Laptop," *The Guardian*, July 23, 2010 (<http://www.guardian.co.uk/world/2010/jul/23/india-unveils-cheapest-laptop>, accessed July 2011); "Low Cost Access-Cum-Computing Device Unveiled by Shri Kapil Sibal," *The Hindu*, July 23, 2010 (<http://www.thehindu.com/news/resources/article529944.ece>, accessed July 2011).

was government involvement in the One Laptop per Child project (Burke 2006; Hollow 2009; Kleine and Unwin 2009). Yet government efforts to provide low-cost devices persist and are evolving (box 2.9).

INNOVATIVE PRACTICE SUMMARY

Passive Infrastructure Sharing in Nigeria

"Passive infrastructure sharing" is the sharing of nonelectronic infrastructure, equipment, and services at mobile network base stations, including the site space, buildings, towers, masts, and antennas; power supply, back-up batteries, and generators; security; and maintenance. Passive

infrastructure sharing is distinguished from "active infrastructure sharing," which can involve the shared use of electronic infrastructure such as network components (for example, access node switches), radio transmission equipment, and core network software systems (Ghosh, Aggarwal, and Marwaha 2009). Although active infrastructure sharing can raise concerns among mobile network operators, passive infrastructure sharing has become established as a reliable mobile network expansion strategy, particularly for expensive rural sites with high transmission and power costs.

Nigeria has been named one of the telecommunications markets with the most promising potential for growth. Even so, the National Communications Commission has identified several issues as detrimental to this growth, including poor public power supply, poor security, and high operational costs (Onuzurike 2009). Gupta and Sullivan (2010) found unreliable electricity and insecurity to be the main challenges to operating mobile networks. These challenges were much more prominent in Nigeria compared to other West African countries with more reliable access to the electricity grid (such as Ghana, Cameroon, and Côte d'Ivoire). Gupta and Sullivan (2010) calculated that costs of fuel for generators, including a minimum of 20 percent of fuel lost to theft, amounted to 60–90 percent of the costs of running network sites in Nigeria. Base station costs in Nigeria add up to US\$200,000–250,000, 3.5 times higher than in India (US\$ 60,000–70,000). Some of these limitations are at last being overcome through passive infrastructure sharing.

Helios Towers Nigeria (<http://www.heliostowers.com/homepage>) significantly decreases the impact of such issues. In 2005 Helios Towers became Africa's first independent mobile tower company, enabling wireless network operators to share infrastructure. The organization buys nonelectronic infrastructure at the cell site from telecommunications providers, such as towers and power supplies, or develops new infrastructure where none exists. Telecommunications companies rent space at the towers and access to other elements of the communications infrastructure, sharing it with other providers.

Helios Towers estimates that clients colocating on one of their towers can save over US\$200,000 in capital expenditures and up to 20 percent in operating expenditures. Helios Towers also provides wireless operators with power, round-the-clock security and access (shelters have typically been subject to vandalism), and other services such as installation and maintenance. According to its website, the company's large-scale and numerous sites allow it to offer a guarantee of 99.9 percent uptime for service users, compared

to a 70 percent industry average. Network operators thus improve the quality of service for customers and can pass the associated cost reductions on to them.

The economies of scale that Helios Towers and companies like it generate enable them to provide access in areas where it would not be financially advantageous for other companies, such as network operators, to do so. Access is increased in rural areas, for example, or areas where power supplies previously were poor.

Helios Towers' first site went live in June 2006, and since then the company has expanded to include over 1,000 four-operator sites across Nigeria's six geopolitical zones. Through them, MTN Nigeria provides services in 223 cities and towns, more than 10,000 villages and communities, and a growing number of highways across the country. In August 2004, MTN had coverage in all 36 states and the Federal Capital Territory Abuja, and their signal reached 80.9 percent of Nigeria's total population, living in 58.33 percent of its landmass.²¹ Similarly, through Helios Towers, Zain Nigeria²² (MTN Nigeria's largest competitor) currently covers over 1,500 towns and 14,000 communities across all six geopolitical zones. Zain was the first telecom operator to serve all of the zones.²³ Considerable overlap in the coverage offered by these and other network operators provides significant advantages to end users: The resulting competition lowers tariffs and enhances choice.

The National Communications Commission supported this new business model and developed a regulatory framework for potential colocators. This framework suggests how to share infrastructure to promote fair competition and infrastructure sharing among the telecoms' licensees. It effectively enables organizations such as Helios Towers to operate with state support and gives network operators a strong incentive to align with such a powerful ally.

The business model developed by the growth of tower management companies such as Helios Towers has helped erase

problems faced by operators in operating and managing wireless infrastructure. As Onuzuruike (2009) notes, tower management companies usually enjoy scalable and long-term recurring revenues with contracted annual escalations. They also benefit from low churn rates and low operating and capital costs. Hence they are able to ensure the fair treatment of new entrants while satisfying incumbents (by purchasing their infrastructure and allowing the operators to outsource at a lower cost), at the same time providing more comprehensive service to end users.

Helios Towers depends on wireless operators buying into its service. The company is able to offer a basis for partnership that makes their proposition highly attractive to corporate clients: infrastructure sharing lowers the risk represented by investment in network expansion and upgrades. The company counters the rising price of site rentals by sharing this cost among partners; site owners, in response to the rising demand for provision in underserved areas, have increased their rents, and local government restrictions on new tower construction owing to health and environmental hazards have only increased the attractiveness of passive infrastructure sharing.

To retain its many partners (aside from MTN and Zain, they include EMTs, Starcomms, Reliance Telecoms, and Visafone) and provide comprehensive nationwide service, Helios offers services to the full range of wireless operators: GSM, CDMA, and WiMAX operators utilizing 2G, 3G, and 4G technology platforms. It is also prepared to build towers where there are none, even when it is not financially advantageous in the short to medium terms, to improve its network and remain the dominant supplier. As a result, operators can expand into rural markets and other underserved areas while keeping their costs—and, crucially, their tariffs—low.

INNOVATIVE PRACTICE SUMMARY

Turkey's Oligopolistic Infrastructure Sharing Model

The Turkish mobile telecommunications market is dominated by Turkcell, Vodafone Turkey, and Avea (a wholly owned subsidiary of Turk Telekom, the largest telecommunications company in Turkey). Following an agreement announced by Turkcell and Turk Telekom in August 2009, the two companies (and, to a lesser extent, Vodafone) have made strides to reduce the costs of introducing 3G mobile broadband technology in Turkey through passive infrastructure sharing.²⁴

21 See <http://www.mtnonline.com/index.php/about.html>, accessed July 2011.

22 In 2010 Bharti Airtel of India completed the acquisition of the Zain Group in a US\$10.7 billion deal (Pan 2010), which included ownership of Zain's assets in Africa (network operations in Burkina Faso, Chad, Democratic Republic of Congo, Republic of Congo, Gabon, Kenya, Ghana, Malawi, Madagascar, Niger, Nigeria, Tanzania, Sierra Leone, Uganda, and Zambia). In these countries, Zain operations are currently known as Bharti Airtel. This section maintains references to Zain Nigeria.

23 Coverage information publicized online (<http://www.ng.zain.com/System/AboutUs/tabid/59/Default.aspx>) by Zain Nigeria, prior to its acquisition by Bharti Airtel.

24 "3G in Turkey: By Sharing Infrastructure?" Developing Telecoms, August 12, 2009 (<http://www.developingtelecoms.com/3g-in-turkey-by-sharing-infrastructure.html>), accessed July 2011.

They have signed contracts with Huawei, ZTE, and Ericsson for this purpose.

This highly interesting development in infrastructure sharing involves competition from both ends of the partnership. Unlike in Nigeria, where Helios Towers enjoyed unparalleled relationships with both Zain and MTN, here the infrastructure managers must fight to retain convivial relationships with their clients. This competitive landscape reflects the business model promoted by Turkey's regulatory framework.

Turkey's ICT sector lags its European counterparts in some areas, with declining numbers of fixed telephone lines (27.3 percent of the population in 2000, compared with 24.6 percent in 2007) and slow penetration of the Internet market (from 2.2 percent in 2000 to 6.3 percent in 2007) but rapid growth in mobile subscriptions (rising from 23.9 percent penetration in 2000 to 83.9 percent in 2007) (Rossotto et al. 2010, 229–30). This sector profile reflects Turkey's young population: 92.9 percent are under the age of 64 (Rossotto et al. 2010, 230). This demographic suggests the huge potential of wireless broadband in Turkey, which is why international players such as Vodafone, Huawei, and Ericsson are keen to invest heavily in the country and compete among themselves for market dominance. Because contracts were exchanged only recently (2009), it is still difficult to evaluate the impact of the technology or the competitive business model under which it is provided.²⁵

Regulatory reform of the Turkish telecommunications industry has been a concern. Rossotto et al. (2010) report that regulators seek to promote a fully competitive market sector through plans modeled loosely around the EU framework. Although Turk Telekom (privatized in 2005) dominates the telecommunications industry with its 93 percent market share, this dominance is being most convincingly challenged in mobile communications. Turkcell and Vodafone both enjoy greater market share in this subsector, thanks to the regulatory efforts made to ensure fair competition.

Despite these efforts at promoting competition, a market share analysis demonstrates that the market is moving toward an oligopolistic structure in terms of competition among mobile network operators as well as among infrastructure managers such as Ericsson. This shift is reflected

in the highly competitive business models of infrastructure providers, which enable more and later entrants to the market (such as ZTE). The price-competitive business model has also enabled customers to receive services at lower prices: Ericsson, Huawei, and ZTE must streamline their own profits to offer the MNOs maximum cost savings (to gain market share); and Turkcell, Vodafone, and Telekom Turk must pass on a significant proportion of these savings to customers (again, to achieve greater market share).

Although the partnership structure that has evolved in Turkey is less convivial than that in Nigeria, it has still been key to implementing 3G technology. The agreement between Turkcell and Telekom Turk to jointly reduce infrastructure costs has been particularly instrumental in avoiding another false start in bringing 3G to Turkey (Rossotto et al. 2010).

The competition among key players in the infrastructure provision industry has ensured comprehensive coverage of the different routes and technologies into mobile broadband; Ericsson's Converged Package Gateway, for example, is suitable for operators "providing high performance broadband LTE services, CDMA operators moving to LTE, and operators wanting to provide mobility between LTE, 3GPP and 'non-3GPP' access networks such as wireless LAN or Wimax."²⁶ ZTE and Huawei provide similarly encompassing services.

INNOVATIVE PRACTICE SUMMARY

Dabba's Experience with Unlicensed Wireless Services in South Africa

One obstacle to expanding wireless technologies is the unlicensed use of wireless services. The main problem associated with unlicensed multipoint wireless services is interference arising from the operations of other wireless networks within an area. Interference often causes unlicensed wireless services to have much higher error rates and interruptions than equivalent wired or licensed wireless networks (for example, copper telephone, coaxial cable, and mobile networks). For these reasons, unlicensed multipoint services often grow slowly and lose customers; their operators may be required to rethink their business model.

Interference problems have yielded several responses. An organizational response has been to establish voluntary

25 "Ericsson to Build 3G Network for Turkcell," Ericsson, March 11, 2009 (<http://www.ericsson.com/news/1296824>, accessed July 2011).

26 See <http://www.ericsson.com/ourportfolio/telecom-operators>, accessed July 2011.

spectrum coordination organizations, entirely independent of government, to coordinate the actions of unlicensed wireless network operators and minimize disruptions through the maintenance of an operator frequency and sources database. Cooperation with the voluntary coordination body is enforced through peer pressure by cooperative operators on uncooperative operators.²⁷

A technology-centered approach to the interference issue is the development of adaptive and mesh network technologies. Adaptive networking improves performance by developing dynamic interference and fault detection and reconfiguration protocols. Mesh networking optimizes quality over routing and the possible paths for the delivery of service to customers. Neither technology is yet capable of delivering high-speed, low-latency, business-class, and reliable local loop service, however.²⁸

As partners of the Village Telco service in South Africa, the company Dabba and the Shuttleworth Foundation in the Orange Farm Settlement provide telephone and mobile access through VoIP wireless routers. Founded by Rael Lissous in 2004, Dabba reprogrammed Wi-Fi routers as base stations and used open source firmware to make up the components of a telecommunications network. Following complaints to the Independent Communications Authority of South Africa by the incumbent operator, Telkom, that Dabba was interfering with its licensed service provision, Dabba's equipment was seized in February 2009. Dabba has since returned to work with a new business partner, Cisco, the international networking and communications expert.

Dabba is an example of innovation to avoid the high costs typically associated with telecommunication service provision to rural and unserved areas. Wi-Fi enables access to large areas at a low cost, as hot spots with amplifiers can cover ranges of up to 8 kilometers, allowing Dabba to serve entire townships with minimal outgoing expenses. In the densely populated townships, this has proved a winning formula for providing telecommunications to large numbers of people and for passing on the low costs to the end user.

Dabba offers free calls within the local network and pay-as-you-go cards for users who wish to place distance calls (avoiding subscription fees).

Initially, Dabba exploited the new regulatory freedom provided by an August 2008 High Court Ruling, which found that anyone in possession of a Value Added Network Services (VANS) license (which Dabba held) was entitled to "self-provide" and compete in the formerly oligopolistic market (Esselaar et al. 2010). The market grew from four players to potentially hundreds overnight. Dabba took this relative freedom beyond its regulatory limits, however, and was found to be using ISM (industrial, scientific, and medical) Wi-Fi bands, for which it was not licensed, and using equipment that was not type-approved.²⁹

Such unlicensed use perhaps derived from Dabba's business model, with its ever-pressing need to reduce operating costs. Dabba adds value for consumers by offering them the least expensive rates (free local calls, pay-as-you-go distance calls, no subscriptions). Cheap service compensates for the lower quality of service that Dabba's technologies sometimes provide. Although this model enabled Dabba to grow quickly in its pilot area, where customers had little to lose by joining the network, it generated enormous pressure to operate cost-effectively.

This pressure has abated through Dabba's new partnership with Cisco. Cisco has provided new equipment and support and has provided 100,000 rand to initiate an ICT entrepreneur program, enabling Dabba to expand into two new townships.³⁰ Dabba has also received additional support from the Shuttleworth Foundation, which underwrites all of their work. Dabba can now pursue its original business model while remaining more firmly within South Africa's regulatory framework.

The lightweight Ubiquiti equipment employed since Cisco's involvement is inexpensive. It uses solar energy and battery packs connected by locally made antitheft brackets to reduce costs further. This setup, combined with the use of Wi-Fi and wireless mesh networks, makes Dabba well-suited to provide coverage for small, local groups and

27 BANC (Bay Area Network Coordination), the first voluntary coordination body, was founded in 2003 by NextWeb, Etheric Networks, GateSpeed, and a handful of other companies. BANC comprised the majority of operators in California's Bay Area and used peer pressure to get uncooperative operators to conform. BANC was subsequently deployed in Los Angeles. Despite its efforts, some members of BANC switched to licensed operations because of the high costs of interruptions, and the system foundered.

28 The source for this paragraph is http://en.wikipedia.org/wiki/Wireless_local_loop.

29 "ICASA Defends Wi-Fi Equipment Confiscation in South Africa," *Balancing Act*, Issue 443, February 27, 2009 (<http://www.balancingact-africa.com/news/en/issue-no-443/internet/icasa-defends-wifi-e/en>, accessed June 2011).

30 "Low-Cost Phone and Voice Operator Bounces Back with Entrepreneur Support from Cisco," *Balancing Act*, Issue 451, April 23, 2009 (<http://www.balancingact-africa.com/news/en/issue-no-451/top-story/low-cost-phone-and-v/en>, accessed June 2011).

townships, whereas large, centralized projects could not provide services that most users could afford. Dabba has renewed its operations so recently, however, that its impact remains unclear.

INNOVATIVE PRACTICE SUMMARY

Bhutan's Community Information Centers Adapt to the Geographical and Consumer Context

Bhutan's Department of Information Technology (DIT) has established a series of community information centers (CICs) to provide sustainable, commercially viable ICT services in rural areas. DIT provides all of the equipment for offering CIC services, and the local community provides an individual who is employed to promote and maintain those services. Services available at the CICs include basic and advanced computer training, non-Internet-based games, digital reproduction, the Internet, telephone facilities, government information and forms, and lamination and scanning.

In line with the government's ninth five-year plan, the CICs represent an updated effort to provide rural Bhutan (just over 79 percent of the population) with some telecommunications connectivity. Bhutan's mountainous, forested terrain (forests occupy nearly three-quarters of its land area)³¹ have made wired Internet and telephone connectivity prohibitively expensive for operators and end users. The CICs reduce the costs for the end user, who pays on demand only for the services required, and public access through CICs renders service provision more attractive by expanding the customer base. Individuals who could never afford their own personal connection to the telecommunications network may still prove a significant source of income to the CIC, especially when such individuals are considered in the aggregate (villages average 43 households).³²

The CIC initiative is still in its infancy; the decision to move from government-owned facilities to commercial, locally managed centers was made in late 2008. Microsoft's baseline surveys suggest that when access to telecommunications was available, "the population was adept at using the devices and their usage permeated . . . the community."³³

They also suggest that Bhutan's relatively young population is an indication of the potential impact of the telecommunications sector.

A key factor enabling development of the CICs is that they not only receive strong government support but also are in fact government led and organized and in effect self-regulating. As long as local managers produce a profit and offer the services detailed in the government guidelines, they are free to operate their CICs as they see fit. Running the centers is thus rendered attractive to local entrepreneurs.

This business model of local autonomy underwritten by government support is crucial to the CICs' success. Some villages are so remote (in extreme cases, several days' walk from the nearest road) that only locals can understand the market conditions.³⁴ By international standards, Bhutan's national media (particularly its newspapers) are weak, and rural service users are likely to have higher levels of trust in local business managers. However, central intervention will be necessary to subsidize the high costs of accessing some rural areas, which is crucial if telecommunications are to reach the population at large. The partnership between local and players and government strikes a favorable balance.

The Government of Bhutan plans to provide a hub-and-spokes network, enabling it to overcome the difficulties associated with placing infrastructure in mountainous and remote terrain. It seeks to provide a network of broadband connection through fiber-optic cables from the capital and out to the 20 districts (*dzongkhag*) and village groups (*gewog*). The connection from districts to village groups and on to the villages will be provided by wireless technologies such as GSM. These "spokes" lead to the CICs.³⁵

LESSONS LEARNED

The enabling factors and lessons surrounding regulation, business models, partnerships, and infrastructure for these initiatives in Nigeria, Turkey, South Africa, and Bhutan are summarized in tables 2.2 and 2.3.

31 Tobgyl (n.d.,3).

32 Tobgyl (n.d.,4).

33 Bhutan Department of Information Technology, "Microsoft Unlimited Potential Baseline Survey on Socio-economic Demographics and Information Needs," (<http://www.dit.gov.bt/content/microsoft-cic>, accessed July 2011).

34 Tobgyl (n.d.,4).

35 Ministry of Information and Communications (Bhutan), "Vision for Information Society" (<http://www.maic.gov.bt/pdf/Vision%20for%20information%20Society.pdf>, accessed July 2011), p. 10.

TABLE 2.2. Key Enabling Factors for Innovations in Rural ICT Provision in Nigeria, Turkey, South Africa, and Bhutan

ASPECT	HELIOS TOWERS, NIGERIA	INFRASTRUCTURE SHARING, TURKEY	DABBA WIRELESS SERVICES, SOUTH AFRICA	COMMUNITY INFORMATION CENTERS, BHUTAN
Regulation	<ul style="list-style-type: none"> • Support from Nigerian ICT regulatory body • Framework to suggest how to share infrastructure to promote fair competition and infrastructure sharing between telecoms' licensees backs Helios business model 	<ul style="list-style-type: none"> • Telecommunications sector recently focused on regulatory reform and promoting a fully competitive market structure • Allows companies like Vodafone and Turkcell to thrive; enables new companies to enter the market 	<ul style="list-style-type: none"> • Changes to VANS licensing opened a formerly restrictive telecommunications market to new players such as Dabba, allowing them to "self-provide" if they did not cause interference to licensed networks and used type-approved equipment 	<ul style="list-style-type: none"> • Government-led and organized, hence effectively self-regulating service • Local entrepreneurs free to act as they feel most appropriate, provided they make a profit and offer the services detailed by government guidelines (within the framework of other laws)
Business Model	<ul style="list-style-type: none"> • Scalable and long-term recurring revenues, low churn rates, and operating costs: allow NMOs to achieve savings through outsourcing while retaining profit themselves 	<ul style="list-style-type: none"> • Oligopolistic model has led to price competition, giving consumers connectivity at increasingly lower prices • Network managers such as Ericsson must pass more of their own savings on to MNOs 	<ul style="list-style-type: none"> • Low-cost/lower-capabilities model: Offers customers a lower-commitment approach to telecommunications • Free Internetwork calls and pay-as-you-go card for distance and international calls 	<ul style="list-style-type: none"> • Local autonomy underwritten by government support enables the CICs to combat the remote nature of some locations and the lack of inbuilt trust in national communication systems (due to a weak national media)
Partnerships	<ul style="list-style-type: none"> • Large numbers of corporate clients, rendering Helios dominant network: financial capability to expand throughout Nigeria and become most comprehensive network 	<ul style="list-style-type: none"> • Agreement between major mobile telecommunications operators to share infrastructure costs in the implementation of 3G technology • On-record support for passive infrastructure sharing from multiple players 	<ul style="list-style-type: none"> • Cisco has offered equipment and financial support • Has paid to initiate an entrepreneurship scheme, enabling Dabba to expand into two new townships 	<ul style="list-style-type: none"> • Partnership between government departments and villages (<i>gewog</i>) to provide national service in remote areas • Microsoft involved in planning and development, bringing experience and expertise in systems implementation
Network and Infrastructure	<ul style="list-style-type: none"> • Helios offer services to the full range of wireless operators: GSM, CDMA, and WiMAX operators using 2G, 3G, and 4G platforms • Willing to build new towers where there are none 	<ul style="list-style-type: none"> • Comprehensive service provided due to network management companies' desire to remain competitive: Variety of entries provided to mobile broadband service 	<ul style="list-style-type: none"> • Lightweight Ubiquiti equipment is low cost and uses solar energy and battery to reduce costs further • Wi-Fi and wireless mesh networks well suited to provide coverage for small, local groups and townships 	<ul style="list-style-type: none"> • Hub-and-spokes network, with fiber-optic broadband connection to the districts (<i>dzongkhag</i>) passed on through wireless technologies to the <i>gewog</i>, and eventually individual villages. combat problems of wired access in difficult terrain

Source: Authors.

TABLE 2.3. Lessons Learned from Rural ICT Provision in Nigeria, Turkey, South Africa, and Bhutan

HELIOS TOWERS, NIGERIA	INFRASTRUCTURE SHARING, TURKEY	DABBA'S WIRELESS SERVICES, SOUTH AFRICA	COMMUNITY INFORMATION CENTERS, BHUTAN
<ul style="list-style-type: none"> • Outsourcing can lower costs: Economies of scale enabled Helios Towers to make a profit in difficult areas and enabled MNOs to enter previously unserved areas • Service provision is a vital part of product provision: Helios has offered security assurance and 24-hour access, alongside its towers and connectivity, to assuage fears affecting MNOs' own operations (e.g., vandalism) 	<ul style="list-style-type: none"> • Companies must adapt to the existing market structure: Attempts to produce fully competitive markets have stalled in the face of Turkey's dominantly oligopolistic system • Powerful players can lead to consumer savings: Turkey's telecommunications industry is oligopolistic in multiple and vital sectors, forcing all to use economies of scale to provide savings to clients 	<ul style="list-style-type: none"> • Consider regulatory issues: Dabba lost valuable time and equipment investment by working outside of regulatory approval • Employ local expertise: Antitheft brackets produced in the network's area and other locally made equipment have helped keep costs down 	<ul style="list-style-type: none"> • Geography matters: Bhutan may have to accept that nationwide connectivity is not financially feasible in the short to medium terms, due to the remoteness of some villages and rough terrain • Adapt the service to consumer needs: Studies have shown that the people of Bhutan have found little need for technologies such as facsimiles; implementers should offer technologies in such a way that their consumer added value is immediately apparent

Source: Authors.

Topic Note 2.3: MOBILE MONEY MOVES TO RURAL AREAS

TRENDS AND ISSUES

One consequence of improved access to ICT infrastructure, appliances, and services in rural areas may be that rural people will gain better access to financial services and additional sources of income (image 2.2). The telecommunications and microfinance industries have grown rapidly in recent years and are overcoming the traditional challenges of reaching rural and formerly underserved areas. This topic note specifically examines the business models and enabling factors that are making new sources of financing and income accessible in rural areas.

Mobile banking is a logical consequence of the growth of telecommunications and microfinance. In developing economies worldwide, companies have sprung up to deliver financial services outside of conventional bank branches, through mobile phones and nonbank retail agents. A particularly well-known service is M-PESA. Operated by Safaricom in Kenya, M-PESA allows users to transfer money through their mobile phones, without having to register or qualify for a bank account.

M-PESA does not operate in a vacuum; easypaisa in Pakistan, G-Cash in the Philippines, and Bancosol in Bolivia are just a few enterprises that provide some form of mobile financial services to the un- and underbanked poor. One rural bank, Green Bank, has calculated the substantial savings from using mobile technology: By switching from field-based to text-based collection, it reduced its interest rates from 2.5 to 2 percent and its service charges from 3 to 2.5 percent, yet profits rose by US\$16 for every US\$400 loan (Kumar, McKay, and Rotman 2010).

The rise of mobile income sources is another trend behind the demand for mobile financial services. In recent years conditional cash transfer programs in many countries have provided government payments to economically and socially disadvantaged households, especially the economically active poor, conditional on measurable actions (for example, enrolling girls in school, obtaining consistent prenatal care, or using agricultural inputs). Telecommunications technology is transforming governments' capacity to deliver these additional sources of income quickly, reliably, and at a lower cost. It is also allowing farmers to access commercial banks and critical services—including credit, savings accounts, and remote transfers—despite distance and a lack of local banking facilities.

IMAGE 2.2. Ghana's Telecommunications Infrastructure Expands the Use of Mobile Money



Source: Arne Hoel, World Bank.

Such ventures are united by the goal of enabling the economically active poor to use telecommunications technology to help themselves. Mobile financial and income-generating services, such as M-PESA, Zain Zap, easypaisa, and txteagle, discussed in this note—cost little and operate on all handsets, making them advantageous on a large scale, even in more remote rural areas where previous efforts made few inroads. Advances such as smartcards, fingerprint-sensitive ATM machines, and market kiosks equipped with electronic point-of-sale devices have also made such programs vastly easier to implement (and more likely to reach the intended beneficiaries).

INNOVATIVE PRACTICE SUMMARY M-PESA's Pioneering Money Transfer Service

Based on a pilot funded in part by public funds from the UK Department for International Development, Vodafone and Safaricom launched M-PESA in Kenya in February 2007 in partnership with Sagentia.³⁶ The M-PESA pilot focused on microloans and repayments, but research indicated that consumers primarily would use the service for person-to-person money transfers.

Following the pilot, M-PESA launched with a person-to-person business model, whereby customers can buy e-money

³⁶ "M" for "mobile; "pesa" for "money" (Swahili).

from agents throughout Kenya. Any commercial space may become an agent, making this model particularly effective in rural areas. Mobile phones are used to perform financial transactions, such as sending money to others, paying bills, and even withdrawing cash from an ATM (without needing a bank account). E-money can be cashed in with agents who receive a commission for the services they provide and for registering customers.

M-PESA's great innovation has been to provide a service accessible to the unbanked populations of emerging economies at a low cost. M-PESA costs users about one-third as much as using a money-transfer company such as Western Union, and it is still cheaper than banks. Such companies cannot match M-PESA's low rates because their operating costs are higher (Omwansa 2009:6).

M-PESA now has over 10 million customers in Kenya, and services have been introduced in Tanzania and Afghanistan (called M-PAISA in the latter); a number of other deployments are planned across Africa and Asia.³⁷ Success has so exceeded expectations that M-PESA has faced system capacity and cash flow problems. Cash flow problems have arisen internally (as agents are paid to register customers, who take time to become profitable) and at the point of use (agents run out of both e-money and cash). The problem particularly affects rural areas, where people receive remittances from urban workers and withdraw them as cash. To counteract this problem, larger agents now act as "super-agents," selling e-money and cash to smaller agents.

A Flexible Regulatory Environment

Flexible regulation has been critical to M-PESA's success. Working with the UK Treasury, the Central Bank of Kenya set up special provisions for M-PESA to launch its product with limited risk to the consumer but without being linked directly to a bank and with relatively low levels of regulation. Subsequently the Central Bank provided informal monitoring as opposed to formal regulation. By the time banks and competitors realized M-PESA's potential and began to demand its regulation, the firm was already well established and respected. At the urging of the banks, the Central Bank conducted a thorough audit of M-PESA and found it to be fulfilling all its consumer obligations; the Central Bank has therefore continued enabling this special regulatory environment.

The importance of this flexible "proportional risk" system of regulation is evident in M-PESA's stalled attempts to operate in India, where regulators insisted on a connection with a licensed bank. In Afghanistan, regulations to prevent money laundering have constrained M-PAISA's development as a money transfer service, and it operates predominantly as a microfinance service. The need for identification details detracts from M-PAISA's simplicity and thus its appeal.

A Business Model That Sidesteps the Banking Sector

The M-PESA business model is characterized by low margins and high volumes, whereas banks traditionally need relatively high margins from far fewer people with bank accounts. Independence from the banking sector opened up a huge untapped market for M-PESA; 90 percent of Kenyans did not have a bank account. Although only registered users can initiate transactions, anyone may receive money from M-PESA and withdraw it as cash. This positive nonuser experience was crucial to the user network's growth. This business model has allowed M-PESA to become the dominant and most attractive network. M-PESA's low costs have enabled it to challenge money transfer companies and banks, even where they are present. Yet, over time, many M-PESA users graduated to having bank accounts, and M-PESA is now integrated with the banking system.

Partnerships Facilitate Marketing and Technical Operations

M-PESA's collaborative nature is fundamental to its success. Vodafone, as well as providing the initial funding, holds a coordinating role. Safaricom has provided a brand that many Kenyans trust, and its nationwide airtime reseller distribution network easily transformed into a network of dedicated M-PESA agents, enabling more rapid market penetration. Vodacom undertakes Safaricom's role in Tanzania (and is its sister company); in Afghanistan, Roshan, a large MNO, has been vital in developing the service. Sagentia (IBM, as of September 2009) provided key technical expertise. The use of public funds during the development stage is regarded as crucial for maintaining interest in the telecommunications sector during the pilot, which took longer than expected.

Networks, Appliances, and Infrastructure

Registering with M-PESA requires proof of identity, a SIM card, and submitting a PIN. In addition to providing security, another key success factor was the added convenience of the customer being able to retain his or her

³⁷ Safaricom statistics, June 2010 (<http://www.safaricom.co.ke/index.php?id=1073>, accessed June 2011).

phone number. Since applications are on SIM cards, they do not depend on the functionality of handsets, a factor crucial in making M-PESA financially accessible: M-PESA works on even the most basic and inexpensive handsets. In Tanzania, M-PESA uses USSD technology, which does not require a SIM card to be replaced and allows transactions to be completed in real time without any application stored on the phone.

M-PESA has a widespread and dense network of agents. Kenya had 7,000 M-PESA agents in April 2009 but only 750 bank branches, allowing M-PESA to reach significantly more people, especially rural people, than competitors.³⁸ The advantage obtained by being first in the market allowed M-PESA to build the dominant network in its pilot country and become the most attractive network for new customers and businesses (as with companies such as eBay).

INNOVATIVE PRACTICE SUMMARY **Zain Zap Promotes Borderless Mobile Commerce**

Zain Zap is a mobile phone-based banking service.³⁹ As M-PESA's largest competitor, Zain Zap allows clients to transfer money via mobile phones but requires each user to have a bank account. Although registering with Zap is more complicated than registering with M-PESA, Zap offers potential access to a greater number of services. In partnership with banks in Kenya, Tanzania, and Uganda, Zap provides platform access to financial services to people without a nearby bricks-and-mortar bank.

Zain Zap has differentiated itself from M-PESA by innovating along international lines, operating across Kenya, Tanzania, and Uganda without subjecting users to additional fees, administration, or regulation. It forms part of a wider Zain network, called One Network, which provides international mobile coverage without the expensive rates usually associated with cross-border communication. Before Zap, Celtel (now Zain) introduced a competing product soon after the launch of M-PESA, but the product's very different pricing structure caused it to be withdrawn due to low demand.

38 See M. Barrett, M. H.S.A. Kim, and Karl J. Prince (2009), "M-PESA Power: Leveraging Service Innovation in Emerging Economies." Case study and teaching note, available through www.ecch.com.

39 Since the 2010 acquisition of Zain Group's African assets by Bharti Airtel, the Zain Zap platform has been rebranded as Airtel Money. Bharti Airtel mobile network operators from Africa maintain their participation in the One Network, alongside Zain mobile network operators in the Middle East.

In 2010, Zap expanded to Niger and Sierra Leone, and it has a pilot scheme in Malawi. Zain claims that Zap is now the most comprehensive mobile commerce service in Africa, with over 150 million customers. This claim suggests significant impact in some of the world's most unbanked populations, particularly in rural areas without physical bank facilities. Zain eventually plans to roll out Zap in all 24 countries in Africa and the Middle East where it has mobile networks. If regulation permits this growth, Zain's infrastructure leaves it better placed for such expansion than M-PESA.

Thriving within Regulatory Constraints

Zain's expansion has been checked by regulatory constraints; Zain operates in Lebanon and Zambia without One Network because it has not yet received governmental approval in these countries. However, Zain makes good use of its various partners to ensure that national and international banking regulations are met, and the company seems happy to operate within this framework. Zain works with the National Bank of Malawi and NBS Bank in Malawi, Eco-bank in Niger, and Zenith Bank in Sierra Leone. In Kenya, Tanzania, and Uganda, Citibank and Standard Chartered Bank work in partnership with Zain.

A Business Model Seeking to Balance Availability and Accessibility

Zain's business model treads a fine line between widespread availability and accessibility. Its interaction with banks and its provision of mobile banking opportunities to all its dispersed customers allow greater possibilities for the business to grow in rural areas, as small-scale business owners gain access to financial services they previously lacked. Zain's only source of revenue comes from a fixed fee for every transfer made through Zap, however. It does not attempt to make money on deposits or withdrawals but recommends a fee to agents, who are then free to charge as much as they like. This practice could lead to very high prices for customers, especially until other agents appear.

Partnerships with Big Banks and Big Clients

Non-Zain mobile operators can buy a place in the service: In November 2009, the Arab Republic of Egypt's Mobinil joined, adding 24 million customers to the platform. This practice aids international expansion and allows for the inclusion of local expertise in the business model. As well as partnering with large-scale banks, Zain has also signed deals with large corporate clients such as Coca-Cola and Kenya Airways to allow users to pay for these companies' products through their mobile phones.

Networks and Infrastructure

The primary factor in Zap's successful development is that it belongs to Zain's One Network, the world's first borderless mobile service. According to Zain's corporate website, One Network offers over 90 million of Zain's (and partner mobile operators') customers relatively inexpensive rates, free of high roaming charges for cross-border communications. One Network not only aids rapid expansion by giving Zap a pretargeted customer base, it also offers consumers large incentives to join Zain's network and use its services (over others, such as M-PESA).

INNOVATIVE PRACTICE SUMMARY Pakistan's Tameer Microfinance Bank for the Economically Active Poor

Tameer Microfinance Bank describes itself as "one of the first nationwide, private sector, non-NGO transformed, commercially sustainable microfinance institutions in Pakistan."⁴⁰ A majority share is held by Telenor Pakistan. Tameer has produced an innovative hybrid of M-PESA and Zain Zap's services for the economically active poor in Pakistan.

With its new easypaisa service, Tameer matches M-PESA's ability to reach the unbanked. Currently, easypaisa is available to pay utility bills, but it plans to expand into sending and receiving money within Pakistan and receiving money from abroad. As with M-PESA, customers do not need a bank account and can access the service from a variety of portals, including their mobile phones. Tameer also operates as a bank much as Zain's Zap platform does, although not through partnerships with other banks. Since it became the first bank to gain a branchless bank license in Pakistan (2008), it has been able to offer loans, deposits, overdrafts, insurance, and domestic remittances.

Tameer's innovations are notable for their focus on entrepreneurs and the self-employed. Their aim is to actively generate income in underserved, frequently rural, areas, often by freeing customers from moneylenders and their prohibitive interest rates. Prior to Tameer's penetration of the market, such moneylenders were generally the only option for small-scale businesses in need of cash. Tameer loans have been used to buy new equipment, buy raw materials when they are cheapest, enlarge or purchase new property, and provide insurance against business failure. As such, they represent

a strong opportunity for income generation in underbanked areas. Though Tameer largely operates through bank branches at present (despite its branchless banking license), and thus favors urban areas, the rise of its easypaisa service looks set to counteract this imbalance.

Since its commencement, Tameer has disbursed more than 3.5 billion rupees (Rs), with an active portfolio of Rs 1.4 billion and over 80,000 loan customers. The total customer base of Tameer is over 170,000; it employs 1,100 staff.⁴¹

A Business Model Benefits from Microfinance Regulation

As CEO Nadeem Hussain noted, one of the major enabling factors for Tameer was the SBP 2001 Microfinance Ordinance, which regulates the creation of commercial microfinance banks. Tameer argues that unless microfinance is financed through commercial sources, it will remain in the realm of development aid and its growth will be limited.⁴² For this reason, the Consultative Group to Assist the Poor has been involved with branchless banking regulation in Pakistan from the beginning. Regulation has allowed the use of retail stores as agents.

Regulation also made it possible for bank and telecom operators to enter into a business model conducive for commercial success. The two partners offer those services that each is best placed to deliver: Telenor acts as a distribution arm for branchless banking, organizes channel management and retail setup, and hosts the technology and operation of a call center that provides customer service and complaint handling. Tameer is responsible for operating accounts, creating ledgers, reconciliation, fund settlement, risk, and compliance and fraud investigations.⁴³

Partnerships

In May 2010, Tameer joined with Pakistan Telecommunication Company Limited (PTCL), Pakistan's largest national telecom solution provider. PTCL will provide network connectivity to all of Tameer's outlets. This provision of centralized connectivity has been one of the key enabling factors in easypaisa's success and, crucially, has allowed it to provide easily accessible, low-cost services.

40 Tameer Microfinance Bank (<http://www.tameerbank.com/about.htm>, accessed April 2010).

41 Easypaisa (<http://www.easypaisa.com.pk/about-tameerbank.php>, accessed April 2010).

42 Easypaisa (<http://www.tameerbank.com/ceomsg.htm>, accessed April 2010).

43 Mir (2010).

Networks and Infrastructure

Tameer's large agent network allows customers to access services in a number of ways: via mobile phone, easypaisa authorized shops, Telenor franchises, Telenor sales and service centers, or Tameer Microfinance Bank branches. Like M-PESA, Tameer uses USSD, so customers do not need new SIM cards to store the application. This lowers the cost of signing up for the service even further. Tameer does offer new SIM cards for purchase, however, on which the Tameer application has already been uploaded.

INNOVATIVE PRACTICE SUMMARY

Txteagle Taps a Vast, Underused Workforce

A large, global, and reasonably educated workforce remains underused because of poverty and isolation, especially in rural areas. With the rapid penetration of telecommunications in developing economies, Txteagle believes this situation can change, particularly as more economies launch payment platforms like M-PESA. Txteagle is a mobile phone-based SMS server application that takes tasks from corporate clients (such as Nokia and Google), breaks them down into multiple microtasks, and sends them out for completion to registered users. Targeted users are the rural poor in developing economies, who, through their mobile phones, supplement their incomes with these microtasks. Tasks include translation, image sorting, and audio transcription. Txteagle is similar in some respects to Amazon's Mechanical Turk, which also divides up tasks, but differs in that it distributes them by mobile phone, a technology with a higher penetration rate.

Txteagle operates primarily in East Africa, where it relies on technologies such as those developed by M-PESA; but it also sends work to users in Asia and the developing economies of the Americas. In areas not covered by payment platforms such as M-PESA, users are paid in airtime credited to their mobile phones.

Txteagle's impact is unclear because the company is still in its start-up phase. Given the growing number of subscribers to wireless phone technology (more than 1 billion people in the developing world had a mobile phone in 2006),⁴⁴ technologies such as txteagle have the potential to enjoy great success. If txteagle can maintain and expand its systems capacity, it has the potential to extend its workforce in Africa,

Asia, and the Americas, as the market for mobile phones expands rapidly in such areas as rural China and India.

An Outsourcing Model Outside the Regulatory Flow

Txteagle operates fairly unconstrained by regulation because it is classified as a financial creditor, rather than as any form of banking or microfinance institution. This setup gives txteagle a great deal of flexibility in its business model and where it operates, enabling rapid international expansion. As clients become more diverse, this operational flexibility will become a key asset, as txteagle will need workers with different languages and skill sets.

Txteagle's business model enables outsourcing at a lower cost because of savings in office-based costs and its access to a previously isolated workforce. Low costs and a guarantee of quality (clients pay only for adequately completed work) attract corporate clients.

Adapting to Partners' Needs

Txteagle partners with a number of providers of wireless services, such as Safaricom in Kenya, Telefónica México in Mexico, MTN across Africa and the Middle East, and Viva in the Dominican Republic. As it relies on these partners to provide its service, txteagle is eager to adapt to their needs, from configuring the txteagle platform to operate only during off-peak times, to providing assistance to their customer support teams. This situation has led to worries that txteagle could prove exploitative unless well regulated.

Network and Infrastructure

A key enabling factor in txteagle's business model is its Accuracy Inference Engine (AIE), which, once tasks have been broken into microtasks, can monitor user performance. The AIE platform is a set of computational routines that can dynamically predict which available workers will be most likely to complete the given task successfully, correctly infer when the job has been satisfactorily completed, and differentially pay workers in proportion to their level of contribution, all to within a 99 percent confidence interval of accuracy.⁴⁵ The firm also uses a database that monitors and records user performance. As the system learns more about the capabilities and expertise of its individual users, it updates the algorithms used to assign tasks to make the service as efficient as possible.

44 Tryhorn (2009).

45 Txteagle (<http://txteagle.com/technology/aie>, accessed April 2010).

LESSONS LEARNED

Mobile phones have the potential to provide low-cost banking wherever there is network coverage, but the use of mobile banking services has been held back because mobile banking services and microfinance institutions often play quite different roles that prevent them from leveraging their full potential. There is a wide variety of mobile services; some do not involve banking licenses and are therefore nonbank implementations, while others may involve banking partners. Mobile banking companies such as M-PESA primarily work with money transfers and payments, using some of the most advanced infrastructure available. By contrast, microfinance institutions tend to focus on credit and savings, and use less advanced technologies. A marriage between the two can produce commercially attractive coverage of the market, as seen with Telenor and Tameer Microfinance Bank, but such partnerships can be difficult to source and sustain. Indeed, in the future, traditional banks may also find themselves trying to deliver these services.

The emergence of competition in the sector (such as between M-PESA and Zain Zap) has begun to erode differences in the roles of mobile banking services and microfinance institutions, however. In May 2010, M-PESA joined with Equity Bank in Kenya to produce its most integrated product yet: a low-cost, low-entry microsavings account called M-Kesho. It hopes to provide its 9.4 million users with accessible bank accounts, which will allow them to hold savings and take out microinsurance and microloans, all managed from their mobile phones.

The competition between Zain Zap and M-PESA in particular highlights interesting considerations for the future. With network-based firms such as eBay and Wikipedia, the more dominant a single network becomes, the more attractive it becomes to new users (because it is the most comprehensive), and it compounds its success. Should either Zain Zap or M-PESA win the battle for dominance in Kenya, the winner could offer a more comprehensive and more widely accessible service. The ensuing lack of competition could raise prices, however, cutting off access to the poorest sectors of the community. The regulation of competition between these networks will determine the shape of the industry—and of commerce in Kenya—in the future.

M-PESA has benefited from relative regulatory freedom to become a comprehensive mobile financial service provider and harness the negotiating power of Equity Bank. If such innovations are to spread, regulators must walk a fine line

between allowing the freedom for such ventures to become commercially attractive and the constraints to ensure that they do not exploit the people they aim to help. Chile's congress has only just approved a law demanding network neutrality, guaranteeing that Internet service providers cannot interfere with content accessed by Internet users. As Chile is among the most progressive of the Latin American and other developing economies in its governance of Internet use, its position demonstrates the great strides regulators must take in this emerging area, if mobile and Internet technologies (such as mobile banking) are to become widely and equitably accessible.

One of the biggest challenges for regulators is to find a balance between delivering the financial services that meet inclusion targets and at the same time combat fraud and terrorism. The temptation is always to overregulate, to err on the side of safety. The World Bank has been working to create guidelines for services such as money transfer to encourage them to operate under tough regulation.

Apart from these regulatory issues, service users have demonstrated the wider applicability of the technologies involved by manipulating them to their own advantage. Bancosol in Bolivia, for example, has implemented a partial use of the technology by providing SMS information services before committing to full mobile banking. The Rural Bankers' Association of the Philippines has made GXI's G-Cash service possible in rural areas by grouping 60 rural banks to act as agents and to use G-Cash to pay their employees. Alone, these banks were too small to be commercially interesting to the mobile service, but through collective action they have become a significant business proposition.

Customers have found moneymaking opportunities in these financial services of which their founders did not dare to dream. M-PESA's users have translated access to secure money transfers into innovative income-generation opportunities, often in rural areas. By transferring primarily to M-PESA-based payments, users enjoy the safety of being able to travel without cash and have reduced service times (customers no longer fumble about with change). The growth of the network of agents has created large numbers of jobs, many in the rural areas where M-PESA, and institutions like it, flourish.

Tables 2.4 and 2.5 summarize the key enablers of the innovative financial service models described here and the lessons derived from their experience.

TABLE 2.4. Key Enabling Factors for Innovations in Mobile Financial and Income Services Worldwide

ASPECT	M-PESA (EAST AFRICA, SOUTH ASIA)	ZAIN ZAP (AFRICA AND MIDDLE EAST)	TAMEER MICROFINANCE (PAKISTAN)	TXTEAGLE (AFRICA, ASIA, LATIN AMERICA)
Regulation	<ul style="list-style-type: none"> • Lack of regulation of new technology in Kenya: Establishes self in regulation vacuum • Willingness to adapt when regulation necessitates: More closely resembles a microfinance service in Afghanistan 	<ul style="list-style-type: none"> • Works with banking partners to ensure international financial regulations are met • Seems happy to work within regulatory framework, rather than seek to bypass it, as rivals have done 	<ul style="list-style-type: none"> • Microfinance Ordinance allowed the creation of commercial microfinance banks: Allows for wider growth • Allowed use of retail spaces as agents 	<ul style="list-style-type: none"> • It is classified as a financial creditor rather than a banking or microfinance institution, so it can operate fairly free of regulation
Business model	<ul style="list-style-type: none"> • Initial independence from banking sector and bricks-and-mortar banks allowed provision of a low-cost service • Allow nonuser trial: M-PESA becomes dominant network 	<ul style="list-style-type: none"> • Users must have a bank account: Potential to provide more diverse services than rivals • Users send funds across country boundaries without paying additional fees • Fixed fee for transfers; other fees set by agents: Potential for large profits encourages businesses to become Zap agents. 	<ul style="list-style-type: none"> • Easypaisa concentrates on paying bills, with expansion into money transfer • Clients do not need a bank account, but Tameer offers diverse financial services as it is itself a bank • Focus on entrepreneurs and self-employed 	<ul style="list-style-type: none"> • Use of mobile technology to reach previously untapped market: Relatively educated rural poor • Offers additional source of income to isolated workers and opportunity for corporate clients to save money in their outsourcing
Partnerships	<ul style="list-style-type: none"> • Backed by large MNO: Vodafone • Local brand equity and distribution network from Vodafone subsidiary: Safaricom • Use of local companies (e.g., Roshan in Afghanistan) 	<ul style="list-style-type: none"> • Signed deals with large corporate clients to encourage user growth • Non-Zain MNO can buy into One Network, increasing provision 	<ul style="list-style-type: none"> • Tameer is itself a bank and so is not reliant on deals and partnerships with other banking institutions • Partnership between a bank and a telecom operator: Allows services to be provided and distributed in-house 	<ul style="list-style-type: none"> • Works with local wireless services (e.g., Safaricom in Kenya and Viva in the Dominican Republic) • Signs up large corporate clients such as Google
Network and infrastructure	<ul style="list-style-type: none"> • Widespread and dense network of agents: Uses first-mover advantage to become dominant network • SIM card functionality: Customer can use existing phone (more affordable service) 	<ul style="list-style-type: none"> • Use of Zain's One Network: Infrastructure and distribution network already widely available in multiple countries 	<ul style="list-style-type: none"> • Large agent network: Customers can access services from their mobile phone, easypaisa authorized shops, Telenor franchises, Telenor sales and service centers, or Tameer Microfinance Bank branches 	<ul style="list-style-type: none"> • SIM card functionality: Works on the most basic handsets • Accuracy Inference Engine monitors individual performances and assures quality control to corporate clients

Source: Authors.

TABLE 2.5. Lessons Learned from Mobile Financial and Income Services in Rural Areas

M-PESA	ZAIN ZAP	TAMEER MICROFINANCE	TXTEAGLE
<ul style="list-style-type: none"> • Consider regulatory issues: M-PESA has struggled to take hold in countries where regulation has proved tighter than in Kenya • Be adaptable: M-PESA changed its business model when money transfer proved more popular than microfinance in the pilot phase • The move toward also providing bank accounts is another sign of flexibility and may help solve regulatory problems 	<ul style="list-style-type: none"> • Strategies need to be implemented to combat first-mover advantage: Zain has had to offer more services and work with big name brands to combat M-PESA's dominant network in Kenya • Customer service is vital: Zap has lost customers to M-PESA due to its more complicated sign-up procedure and the poor service and large fees levied by some agents 	<ul style="list-style-type: none"> • Entrepreneurs make good clients: Tameer has found a new and loyal market in Pakistan by focusing on this group (previously forced to rely on extortionate moneylenders) • Rural areas can be profitable: Tameer has rolled out easypaisa to meet the needs of the rural workforce, recognizing that rural areas hold large numbers of the commercially minded self-employed 	<p>Not so much what has been learned, but what it is vital to learn:</p> <ul style="list-style-type: none"> • The move away from "charity" to helping people help themselves should not be a move toward the exploitation of a still-vulnerable group: Deference to corporate clients and local MNO partners should not mean that workers are paid unfairly for their contributions or abandoned when microtasks, such as those provided by txteagle, run out

Source: Authors.

Topic Note 2.4: DELIVERING CONTENT FOR MOBILE AGRICULTURAL SERVICES

TRENDS AND ISSUES

The value of knowledge in the world economy has grown with increased technological innovation in distributing information and greater incorporation of information in economic activity. As developed economies become increasingly knowledge and service based, developing economies (agricultural or industrial) must be capable of communicating in and using the language of knowledge if they are to be economically active on a global scale.

The spread of telecommunications technologies over the past decade has outpaced the spread of Internet technologies, which require more costly infrastructure, particularly for rural users. In India, for example, mobile technology has reached over 30 times as many people as the Internet.⁴⁶ Because much of India, like many developing economies, remains predominantly agricultural, thought has turned to using mobile technology for the benefit and service of agriculture (image 2.3). Rural economies lose billions of dollars each year because critical information is inaccessible: information on production practices, information on impending extreme weather or epidemics, or information that could enable farmers to transport crops more effectively to markets and sell them at better prices.

Reuters Market Light (RML) offers farmers information on crops, diseases, and market prices, as does the subsidiary group of the Indian Farmer's Fertilizer Cooperative, Kisan Sanchar Limited. This trend toward mobile services for

farmers is seen throughout developing economies. Prominent examples include the Agricultural Market Information Systems in Bangladesh, Farmer's Friend (a Google product) in Uganda, and Ovi Life Tools by Nokia. The latter started off in partnership with RML in India but wanted to offer a wider range of information. It now provides education and entertainment services and has rolled out in Indonesia and China as well as India.

This sourcebook describes a number of efforts to benefit from mobile telecommunications in agriculture. Two of the examples discussed below are also discussed in Module 3 (RML) and Module 6 on AIS (Farmers' Friend), yet they are reviewed here to highlight technical considerations in delivering content and services that rural users value. IFFCO Kisan Sanchar Limited and RML have been implemented through a variety of platforms and business models, with voice- and text-based platforms being the primary competing modes of delivery. Farmer's Friend differs from those services by using Google's experience as a search engine to provide an on-demand service and a database that may be searched in the same manner as the Internet.

INNOVATIVE PRACTICE SUMMARY

First-Mover Advantage Benefits Reuters Market Light

Reuters Market Light (RML) is a subscription-based SMS service providing Indian farmers with information that helps them increase productivity, maximize revenue, manage risk, and reduce waste. The service, launched in late 2007, provides localized and personalized information on commodity prices, crop cultivation (covering 17 crops), and the weather.⁴⁷ Mobile telecommunication was the obvious platform for providing this service, as India has one of the fastest-growing mobile markets in the world, with over 427 million mobile connections. By contrast, there are only 37.5 million landline connections and 13.5 million Internet subscribers.⁴⁸

The predominance of agriculture (which employs slightly more than half of India's 523.5-million-strong workforce) gives Reuters a large potential audience. As of February 2010, it had more than 200,000 subscribers in 15,000 villages across 10 states. Supply chain and information failures cause Indian farmers to receive

IMAGE 2.3. Girl Uses Phone in Community Meeting in India



Source: Simone D. McCourtie, World Bank.

46 Prakash and Velu (2010).

47 "Reuters Market Light Wins Award for Innovation," Thomson Reuters Press Release, April 6, 2010 (http://thomsonreuters.com/content/news_ideas/articles/financial/RML_wins_award, accessed June 2011).

48 Prakash and Velu (2010).

about half of the value of their crops that their Western counterparts do (20–25 percent). If the service helps farmers to resolve these problems, the potential benefits for farmers are large.

Regulation: Freedom to Develop Its Business Model

RML used its first-mover advantage in India to become a trusted network—a necessary strategy, given that their main competitor, IKSL, is active in rural areas through its links with the IFFCO farmer cooperatives. Active support from the government has given RML relative freedom to develop its business model.

The subscription-based business model allows RML to derive a steady and regular flow of income, allowing for future planning toward expanding the service. The lack of reliable address databases prevents sales staff from locating farmers and consolidating the customer base. Another drawback is that the subscription fee makes RML expensive relative to on-demand services (like those provided by Farmer's Friend in Uganda, discussed later). A survey of 1,000 households in 100 villages by the South Asia Sustainable Development Agriculture Department of the World Bank found that only around half of RML users planned to renew their subscription. Of those who had not signed up for the service, 95 percent cited cost factors as the reason (G. Dixie, personal communication).

In response, RML has enabled post offices across the states covered by Reuters to provide the information service to unregistered users. This adjustment in its distribution platform makes the service available to those who do not own a mobile phone as well as those who wish to try the service before they commit. The postal network has been crucial for RML's presence in rural areas and the growth of its user network.

Partnerships with Multiple Operators Offer Scalability

RML's regulatory freedom is complemented by partnerships with multiple operators, which frees the system's content from dependence on any single network and is crucial to the scalability of the business. The links with the post office are a valuable asset for RML's distribution network. RML is discussing a more formal association with the Indian Council of Agricultural Research or Punjab Agricultural University, which contribute some of the service's crop information.

Network, Appliances, and Infrastructure

RML is “network agnostic,” meaning that it is not constrained by the limitations of any one MNO, and its service has SIM rather than handset functionality. Information is provided by SMS and therefore can be accessed from the most basic handsets, even those only possessing text capabilities. This delivery format contrasts with that of RML's former partner, Nokia, whose Life Tools uses voice recordings instead of text-based

communications and thus requires mobile phones to be GPRS enabled (adding to their cost and decreasing their accessibility).

INNOVATIVE PRACTICE SUMMARY

Long Experience in Farm Communities Benefits IFFCO Kisan Sanchar Limited

IFFCO Kisan Sanchar Limited (IKSL), another information service for farmers, is a joint venture between the telecom network operator Airtel and the Indian Farmers Fertiliser Cooperative Limited (IFFCO, from which the initiative takes part of its name). In addition to crop advice and the weather, IKSL provides advice on animal husbandry, rural health initiatives, and the availability of products such as fertilizer. Unlike RML, IKSL's information arrives via voice rather than text message.

Users access the service through traditional wired technology based at kiosks at rural cooperative societies throughout India. The kiosks are supplemented by mobile technology: Mobile phones are sold bundled with the Airtel mobile network, which essentially converts the phones into personalized communication kiosks. Members of the service receive five free voice messages a day with agricultural information and advice; they also have free access to a dedicated agricultural help line. IFFCO has around 40,000 societies, is present in 98 percent of India's villages, and brings a receptive audience to the enterprise. This extensive coverage and wide farmer base give IKSL the potential to make a significant impact on agricultural communities.

IFFCO is clearly attuned to making its products and services accessible to rural people. Mobile phones are accompanied by a hand-cranked charger. This innovation is crucial, given the scarcity and cost of power in much of rural India. IKSL's wired information kiosks can be operated through pedal power. These adaptations ensure that the service is not a drain on a highly limited resource and should permit its wider use.

Regulation for Quality and Compliance with Standards

IFFCO is subject to high levels of regulation owing to its dominant presence in the fertilizer trade, which is regulated by the government. To ensure compliance with the standards set for IFFCO as an organization, IFFCO's offshoots are regulated by an in-house Representative General Body made up of members of the Board of Directors and representatives of the larger member societies in every state/territory.⁴⁹ To ensure quality, Kisan Sanchar is assessed by experts from the agricultural universities, and peer reviews are conducted by panels of scientists.⁵⁰

⁴⁹ See <http://www.iffco.nic.in/ffc/web.nsf>.

⁵⁰ “Content Management” (<http://www.iffco.nic.in/iksl/ikslweb.nsf/ef05d07df0ecee65652575040037b375/733c79d21f573e15652577a7002b2cd4?OpenDocument>, accessed July 2011).

A Business Model to Deliver More Diverse Agricultural Information to an Extensive Rural Base

IFFCO has branched out from its original business as a fertilizer cooperative into many other areas, and it has a great deal of experience in growing new businesses in rural India. The partnership between IFFCO and another large company, Airtel, has been crucial to success. As one of the largest MNOs in India, Airtel can provide cellular connectivity to areas where it is not financially advantageous (an example is the Aruku Valley in the Visakhapatnam District). Access at cooperative societies, facilitated by IFFCO, is also crucial to the success of IKSL, because new users can try the service before they commit to it, allowing for the growth of the network. This capacity ensures that IKSL achieves maximum coverage and consumer awareness.

In this way IKSL's business model carefully navigates between the steady income of a subscription service and the value added for the consumer by offering flexibility. Users pay Rs 47 to activate the mobile service, which lasts a lifetime, and then 50 paise per minute for calls between IFFCO members (the rate is slightly higher for calls to nonmembers). Membership comes with five free daily messages, as noted.

IKSL's information is more diverse than that available from by RML, although it is still centered on agriculture (for example, farmers can obtain information on fertilizer and farming equipment and limited information on rural health care). In offering a more comprehensive service, IKSL may be attempting to combat the first-mover advantage of its nearest rival.

Network, Appliances, and Infrastructure

The innovation is SIM rather than handset dependent but does not work on the most basic handsets unless they are updated. IKSL hopes the kiosks will counteract this problem. The prices of the phones used in the pilot—made by Sinocell and sold for about Rs 4,000—would deny the poorer segments of the population access to the technology; but Alcatel, Philips, and Samsung have developed less expensive models that may solve this problem. IKSL also has the potential to develop a suitable phone. The voice recordings are provided in all local languages where the service is provided, a key enabling factor in the challenge to increase access.

INNOVATIVE PRACTICE SUMMARY

Farmer's Friend Offers Information on Demand, One Query at a Time

Farmer's Friend is a Ugandan mobile phone application from Grameen Foundation's AppLab. Working with MTN Uganda as its MNO and using the Google SMS search platform, it provides information on demand for farmers. In addition to weather

forecasts and agricultural advice, Farmer's Friend forms part of a wider initiative that includes health tips, a clinic finder, a Google trading service for agricultural commodities, and other products.

This innovation differs from RML and IKSL in that it is not prepaid; the system is a search engine, and the user pays for each query at the point of purchase. Customers text their query and location and receive a nearly instant reply. The service is currently free from Google, but customers are charged by their network operator for each query. Pilots demonstrate significant uptake of the AppLab's services: the 10 SMS applications that were trialed generated more than 54,000 inquiries among their 8,000 respondents.

Farmer's Friend also generates employment among farmers, some of whom are hired to collate data and pictures of sick plants on local farms. They provide Grameen with more comprehensive information and the potential to offer for better advice.

Farmer's Friend launched at the end of June 2009. Like many efforts initiated recently in rural areas, its impact is not yet apparent. The service has the potential to achieve significant penetration in rural areas because it can leverage MTN's network of over 10,000 village phone and other shared phone operators, as well as all privately owned mobile phones.

Regulation

Farmer's Friend's regulatory framework is derived from that of its parent organizations. Google adheres to U.S. Safe Harbor Privacy Principles, is registered with the U.S. Department of Commerce's Safe Harbor Program, and works with appropriate local regulatory authorities, primarily local data protection authorities.⁵¹ The service self-regulates through its guidelines and maintains that it is "ready to assist any government that wishes to seriously work to create an enabling environment."⁵² Grameen Foundation has criticized the very loose regulatory framework surrounding Farmer's Friend.

A Business Model Designed to Increase Access

Farmer's Friend's business model is specifically designed to increase access. The service works on the most basic handsets. The organization's membership in a much wider platform (which includes Google Trader and health advice) ensures a broader base of awareness in the community and further opportunities to develop brand loyalty. The pay-on-demand system increases access because the financial commitment is far smaller than with subscription models; RML membership

51 For details on the Safe Harbor certification program and privacy principles, see www.google.com/privacy/privacy-policy.html.

52 <http://www.grameenfoundation.org/recommendations-creation-pro-microcredit-regulatory-framework>, p.6.

lasts an average of five months (Preethi 2009). Farmer's Friend users can return to the service at any time.

An Array of Strong Commercial and Noncommercial Partners

A key enabling factor of the initiative has been its marriage between strong commercial and nonprofit partners. The nonprofit Grameen Foundation increases access to technologies. As well as using the search expertise of Google and the network coverage of MTN Uganda (Uganda's largest MNO), Grameen receives agricultural information from the Busoga Rural Open Source Development Initiative, a local NGO that collects farming expertise from networks of farmers. Weather reports are provided by Uganda's Department of Meteorology.

Networks, Appliances, and Infrastructure

As noted, the services work on the most basic handsets and are not handset specific, but users need to be part of the MTN Uganda network. To widen its distribution network, Grameen is trying to establish Village Phones in rural Uganda. As mentioned in this overview, this service, successfully used by Grameen in Bangladesh, involves public pay phones run by local entrepreneurs. An entrepreneur obtains a loan

to buy the equipment and profits from reselling the services the phone offers. Farmer's Friend expects to establish 5,000 Village Phone operators over time. Each is expected to serve as many as 2,000 people, greatly enhancing Farmer's Friend's prospects for growth. (See IPS "Community Knowledge Worker Initiative in Uganda" in Module 4.)

LESSONS LEARNED

Table 2.6 recapitulates the factors enabling farmers to receive agricultural information through the increasingly accessible mobile phone services in rural areas—whether the information arrives through personal or shared phones. The lessons learned so far from the new services are summarized in table 2.7.

REFERENCES AND FURTHER READING

- Abbey-Mensah, S. 2001. "Rural Broadcasting in Ghana." Presented at the International Workshop on Farm Radio Broadcasting, February 19, FAO, Rome. <http://www.fao.org/docrep/003/x6721e/x6721e12.htm>, accessed July 2011.
- Armstrong, C., and R. Collins. 2011. "Digital Turmoil for South African TV." *International Journal of Digital Television* 2 (1): 7–29.
- Benkler, Y. 2006. *The Wealth of Networks: How Social Production Transforms Markets and Freedom*. New Haven, CT: Yale University Press.

TABLE 2.6. Key Enabling Factors for Delivering Agricultural Information to Farmers in India and Uganda

ASPECT	REUTERS MARKET LIGHT, INDIA	IFFCO KISAN SANCHAR LIMITED, INDIA	FARMER'S FRIEND, UGANDA
Regulation	<ul style="list-style-type: none"> Actively supported by the Indian government: Operates with relative regulatory freedom 	<ul style="list-style-type: none"> IFFCO regulated by Indian government and expert assessment from agricultural universities IFFCO regulates all of its suborganizations to ensure they comply with its own standards 	<ul style="list-style-type: none"> Derives regulatory framework from parent organizations Google works with U.S. Department of Commerce and local regulatory authorities
Business model	<ul style="list-style-type: none"> Subscription-based service: Regular local information for farmers, steady income for RML The potential to try the service in post offices before subscribing has been crucial in the growth of the user network Service provided in multiple languages 	<ul style="list-style-type: none"> Voice rather than SMS information provision More diverse information than rival RML: Also provides advice on animal husbandry and products such as fertilizer Wireless technology supplemented by kiosks in cooperatives and commercial areas: Increases distribution and market penetration 	<ul style="list-style-type: none"> On-demand rather than subscription service. Service is free from Google, but users are charged by their MNO Rather than simply receiving advice, users can make queries based on specific needs Supplemented by village phone operators in areas with few mobile phones: Income generation for vendor and wider use
Partnerships	<ul style="list-style-type: none"> Subsidiary of large, powerful company, Thomson Reuters: strong financial backing in implementation stages Crop advisory tips are derived from trusted sources (e.g., Indian Council of Agricultural Research) 	<ul style="list-style-type: none"> IFFCO uses experience of growing new businesses in rural India Airtel (one of the largest MNOs in India) creates wide coverage by setting up towers at sites provided by IFFCO cooperatives and by providing connectivity in areas where it is not financially advantageous to do so: Combats first-mover advantage of RML 	<ul style="list-style-type: none"> Marriage between strong commercial and nonprofit partners: Farmer's Friend enjoys multiple brand equities and financial backing in implementation stages Partnership with Busoga Rural Open Source Development Initiative uses networks of farmers to provide localized information: Encourages user support
Network and infrastructure	<ul style="list-style-type: none"> Network agnostic: allows for maximum coverage, as not restricted to one operator Information is provided by SMS, so it works on the most basic handsets, even those with only text functionality (unlike competitor Nokia's Life Tools, which requires mobile phones to be GPRS enabled to receive voice messages) Single, automated platform for customer services 	<ul style="list-style-type: none"> Free, dedicated help line for service users SIM rather than handset dependent, so has the potential for extensive uptake: SIMs must be updated Widespread cooperative-held kiosks help provide service to poorer customers and allow for trial: Helps grow user network IFFCO has cooperative presence throughout rural India: Strong agent network allows IKSL to become dominant 	<ul style="list-style-type: none"> Part of wider information platform, which includes health tips and a trader function: Diverse capabilities offer greater potential for frequent use and opportunities to develop brand loyalty Queries access information database: Provides Internet-style capabilities where no such platform exists Work on the most basic mobile phones (including SMS only): Greater market penetration potential

Source: Authors.

TABLE 2.7. Lessons Learned in Delivering Agricultural Information to Farmers in India and Uganda

REUTERS MARKET LIGHT, INDIA	IFFCO KISSAN SANCHAR LIMITED, INDIA	FARMER'S FRIEND, UGANDA
<ul style="list-style-type: none"> • Subscription services can be problematic: 64% of users feel RML helps them achieve higher prices, but only around half plan to renew their subscription • Higher costs decrease access: 95% of those who have not bought into the service state that this is because of its cost. Subscription fees increase costs relative to on-demand services • Database management is crucial: Problems with finding subscribers by their listed addresses and the difficulty of reaching them in their rural locations have negatively affected subscriptions to RML 	<ul style="list-style-type: none"> • Access is a balancing act: The use of voice technology in a variety of local languages combats the problem of illiteracy, but at the same time increases the required capability (and therefore cost) of the handsets providing the service • The use of branded handsets in the trials of the innovation have increased this problem • Alternatives must be provided: IKSL has sought to combat access issues through the use of kiosks held by the farmers' cooperatives (offshoots of IFFCO) in villages: Less expensive wired technology supplements the convenience of wireless developments 	<ul style="list-style-type: none"> • Diverse capabilities offer greater potential to develop brand loyalty: Farmer's Friend's position within a wider information service provided by Grameen and Google affords it greater publicity. As customers use one service to positive effect, they become aware of and begin to trust the other, related services • On-demand payment can prove effective: Though providing less stable revenue, the lower cost commitments involved for users allow them to come back to the service at any time • Strong financial backing plays a key role: All three of the initiatives are backed by large-scale commercial and nonprofit organizations, which are able to support the innovators in their rollout phases, provide brand equity, and provide key technical expertise

Source: Authors.

- Burke, W. M. 2006. "Information Technology for Developing Countries: One Laptop per Child." *Perspectives on Global Issues* 1 (1). <http://www.perspectivesonglobalissues.com/0101/OneLaptop.html>, accessed August 2011.
- Burrell, J. 2010. "Evaluating Shared Access: Social Equality and the Circulation of Mobile Phones in Rural Uganda." *Journal of Computer-Mediated Communication* 15: 230–50.
- Buys, P., S. Dasgupta, T. S. Thomas, and D. Wheeler. 2009. "Determinants of a Digital Divide in Sub-Saharan Africa: A Spatial Econometric Analysis of Cell Phone Coverage." *World Development* 37 (9): 1494–505.
- Chigona, W., A. Chigona, B. Ngqokelela, and S. Mpofo. 2009. "MXIT: Uses, Perceptions, and Self-justifications." *Journal of Information, Information Technology, and Organizations* 4: 1–16.
- Chipchase, J. 2010. "Mobile Banking Uptake: Sim Card vs. Phone. Ownership vs. Use." *CGAP technology blog*, July 14. <http://technology.cgap.org/2010/07/14/mobile-banking-uptake-sim-card-vs-phone-ownership-vs-use/>, accessed July 2011.
- Clement, A., and L. R. Shade. 2000. "The Access Rainbow: Conceptualizing Universal Access to the Information/Communication Infrastructure." In *Community Informatics: Enabling Communities with Information and Communications Technologies*, edited by M. Gurstein, 32–51. Hershey, PA: Idea Group Publishing.
- Dartey, D. Y. 2009. *Communication for Empowerment in Ghana: An Assessment of Communication and Media Needs at the Community Level*. Accra: United Nations Development Programme.
- Dymond, A., S. Oestmann, K. Whiting, C. Smithers, C. Milne, and R. Milne. 2010. "Module 4: Universal Access and Service." In *ICT Regulation Toolkit*, edited by InfoDev. <http://www.ictregulationtoolkit.org/en/Sections.html>, accessed July 2011.
- Esselaar, S., A. Gillwald, M. Moyo, and K. Naidoo. 2010. "South African ICT Sector Performance Review 2009/2010." In *Towards Evidence-Based ICT Policy and Regulation: Volume 2, Policy Paper 6*. Cape Town: Research ICT Africa.
- Forestier, E., J. Grace, and C. Kenny. 2002. "Can Information and Communication Technologies Be Pro-Poor?" *Telecommunications Policy* 26 (11): 623–46.
- Futch, M., and C. McIntosh. 2009. "Tracking the Introduction of the Village Phone Product in Rwanda." *Information Technologies and International Development* 5 (3): 54–81.
- Gasmi, F., and L. Recuero Virto. 2005. "Telecommunications Technologies Deployment in Developing Countries: Role of Markets and Institutions." *Communications and Strategies* 58: 19.
- Gómez-Barroso, J. L., and C. Feijóo. 2010. "A Conceptual Framework for Public-Private Interplay in the Telecommunications Sector." *Telecommunications Policy* 34 (9): 48795.
- Ghosh, A., V. Aggarwal, and N. Marwaha. 2009. "Telecom Infrastructure Industry in India." ICRA Rating Feature, ICRA. <http://www.icra.in/Files/Articles/2009-March-TelecomInfra.pdf>, accessed July 2011.
- Goyal, A. 2010. "Information, Direct Access to Farmers, and Rural Market Performance in Central India." *American Economic Journal: Applied Economics* 2 (3): 22–45.
- Gupta, D., and J. Sullivan. 2010. "Bharti Airtel Limited Africa: More Challenges Than Reflected; Comprehensive Feedback." JP Morgan: Asia Pacific Equity Research. https://mm.jpmorgan.com/stp/t/c.do?i=16238-5&u=a_p*d_481495.pdf*h_21ovi1ej%0D%0A, accessed July 2011.
- Hollow, M. 2009. "Initial Reflections on the Ethiopia XO 5000 Programme." Royal Holloway University of London. <http://www.gg.rhul.ac.uk/ict4d/workingpapers/HollowXO5000.pdf>, accessed July 2011.
- Hudson, H. E. 2010. "Defining Universal Service Funds: Are They Accelerators or Anachronisms?" *InterMedia* 38 (1): 16–21.
- ITU (International Telecommunication Union). 2010. *Measuring the Information Society*. Geneva: ITU.
- Jensen, R. 2007. "The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector." *Quarterly Journal of Economics* 122 (3): 879–924.
- Kim, T-H. 2009a. "Korea Facing More Pressure to Give Up WiBro." *Korea Times*, July 12. http://www.koreatimes.co.kr/www/news/biz/2011/02/123_48344.html, accessed July 2011.

- . 2009b. "KCC Chief Ambivalent About WiBro." *Korea Times*, July 15. http://www.koreatimes.co.kr/www/news/biz/2009/07/123_48534.html, accessed July 2011.
- Kleine, D., and T. Unwin. 2009. "Technological Revolution, Evolution, and New Dependencies: What's New About ict4d?" *Third World Quarterly* 30 (5): 1045–67.
- Kumar, K., C. McKay, and S. Rotman. 2010. "Microfinance and Mobile Banking: The Story So Far." *CGAP Focus Note* 62 (July): 13–14.
- Lio, M., and Meng-Chun Liu. 2006. "ICT and Agricultural Productivity: Evidence from Cross-Country Data." *Agricultural Economics* 34 (3): 221–28.
- Mir, A. 2010. "Tameer Microfinance Bank and Telenor Provide Insights on Easypaise." *TelecomPK*, January 6. <http://telecompk.net/2010/01/06/tameer-microfinance-bank-and-telenor-provide-insights-on-easypaise/>, accessed July 2011.
- Mulas, V. 2010. "Broadband in Chile." In *Strategic Options for Broadband Development*, edited by C. M. Rossotto, T. Kelly, N. Halewood, and V. Mulas, 121–47. Washington, DC: Global Information and Communication Technology (GICT), Ministry of Communication and Information Technology (MoCT), Arab Republic of Egypt, National Telecommunications Regulatory Authority (NTRA) 121–47.
- Nedevschi, S., S. Surana, B. Du, R. Patra, E. Brewer, and V. Stan. 2010. "Potential of CDMA450 for Rural Network Connectivity." Electrical Engineering and Computer Science, University of California, Berkeley. <http://tier.cs.berkeley.edu/docs/wireless/cdma450.pdf>, accessed July 2011.
- Nikomborirak, D., and S. Cheevasittayanon. 2008. "Telecom Regulatory and Policy Environment in Thailand: Results and Analysis of the 2008 TRE Survey." SSRN eLibrary. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1555591, accessed July 2011.
- Omwansa, T. 2009. "M-PESA: Progress and Prospects." Paper prepared for the Mobile World Congress, Barcelona, February 16–19.
- Onuzuruike, E. 2009. "Telecom Infrastructure Sharing as a Strategy for Cost Optimization and Revenue Generation: A Case Study of MTN Nigeria/Zain Nigeria Collocation." Master's thesis, Blekinge Institute of Technology. http://www.bth.se/fou/cuppsats.nsf/28b5b36bec7ba32bc125744b004b97d0/8ab522d9c73deb98c125769a0037ccce!OpenDocument&Highlight=0,telecom*,infrastructure*,sharing*,accessed%20July%202010.
- Pan, H. 2010. *Telecom Mergers & Acquisitions Monthly Newsletter*. Information Gatekeepers Inc, June.
- Pham, N. H. 2009. "Digital Switchover Strategies Challenge and Lessons Learned." Paper presented at ITU BDT Seminar, Transition from Analogue to Digital Broadcasting: Correlation between Technical, Economic and Social Costs and Advantage, ITU, Saransk, Russian Federation, June 16–18. https://www.itu.int/ITU-D/tech/digital_broadcasting/SaranskJune2009/Presentations/Day2/Saransk_June2009_Day2_3.pdf, accessed July 2011.
- Picot, A., F. Jondral, J. Elsner, and N. Grove. 2010. "Why the Digital Dividend Will Not Close the Digital Divide." Paper presented at the 4th International Conference on Economics and Management of Networks, Sarajevo, September 3–5.
- Prakash, S., and C. Velu. 2010. "Reuters Market Light: Business Model Innovation for Growth." Centre for India and Global Business. http://www.india.jbs.cam.ac.uk/opinion/pieces/downloads/2010/prakash_reuters.pdf, accessed July 2011.
- Preethi, J. 2009. "Reuters Market Light Goes to Himachal." Medianama, April 17. <http://www.medianama.com/2009/04/223-reuters-market-light-goes-to-himachal-pan-india-with-nokia-txt-vs-gprs-vs-voice/>, accessed July 2011.
- Prows, B. 2009. "Mobile Social Networks with Herman Heunis of MXit." *MobileBeyond blog*, August 26. <http://mobilebeyond.net/mobile-communications-and-communities-in-south-africa-mxits-herman-heunis/>, accessed August 2011.
- Qiang, C. Z.-W. 2010. "Broadband Infrastructure Investment in Stimulus Packages: Relevance for Developing Countries." *Info* 12 (2): 41–56.
- Ramachandran, S. 2009. "MXit Mixes Mobile Networks with Social Conscience." *Business Week*, August 20. http://www.businessweek.com/technology/content/aug2009/tc20090820_669558.htm, accessed August 2011.
- Röller, L.-H., and L. Waverman. 2001. "Telecommunications Infrastructure and Economic Development: A Simultaneous Approach." *American Economic Review* 91 (4): 909–23.
- Rossotto, C. M., T. Kelly, N. Halewood, and V. Mulas, eds. 2010. *Strategic Options for Broadband Development*. Washington, DC: Global Information and Communication Technology (GICT), Ministry of Communication and Information Technology (MoCT), Arab Republic of Egypt, National Telecommunications Regulatory Authority (NTRA).
- Stern, P., D. Townsend, and R. Stephens. 2006. "Telecommunications Universal Access Programs in Latin America: Lessons from the Past and Recommendations for a New Generation of Universal Access Programs for the 21st Century." Draft paper prepared for the Forum of Latin American Telecommunications Regulators (Regulatel), the World Bank (including the Public Private Infrastructure Facility (PPIAF) and the Global Program on Output Based Aid (GPOBA), and the United Nations Economic Commission for Latin America and the Caribbean (ECLAC).
- Sunderland, E. 2007. "Fixed-Mobile Convergence." Discussion paper for the ITU Global Symposium for Regulators, Dubai World Trade Center, Dubai, February 5–7.
- Tobgyl, T. C. n.d. "Case Study: Bhutan: Wireless IP-Based Rural Access Pilot Project." ITU. <http://www.itu.int/osg/spu/ni/futuremobile/technology/bhutanecase.pdf>, accessed July 2011.
- Tryhorn, C. 2009. "Developing Countries Drive Explosion in Global Mobile Phone Use." *The Guardian*, March 2. <http://www.guardian.co.uk/business/2009/mar/02/mobile-phone-internet-developing-world>, accessed August 2011.
- UNCTAD (United Nations Conference on Trade and Development). 2010. "Financing Mechanisms for Information and Communication Technologies for Development." UNCTAD Current Studies on Science, Technology and Innovation, Geneva.
- UNDP (United Nations Development Programme). 2008. *Creating Value for All: Strategies for Doing Business with the Poor*. New York: UNDP.
- Waverman, L., M. Meschi, and M. Fuss. 2005. "The Impact of Telecoms on Economic Growth in Developing Countries." *Vodafone Policy Paper Series* 2: 10–24. http://www.vodafone.com/content/dam/vodafone/about/public_policy/policy_papers/public_policy_series_2.pdf, accessed July 2011.
- Wellenius, B. 2002. "Closing the Gap in Access to Rural Communications: Chile 1995–2002." World Bank Discussion Paper 430, World Bank, Washington, DC.

Module 3 **ANYTIME, ANYWHERE: MOBILE DEVICES AND SERVICES AND THEIR IMPACT ON AGRICULTURE AND RURAL DEVELOPMENT**

KEVIN DONOVAN (*InfoDev, World Bank Group*)

IN THIS MODULE

Overview. What has been the impact of mobile phones on agriculture and rural development? This module describes current knowledge, innovative practices, opportunities, and challenges in using mobile phones to benefit agriculture. Based on what has been learned to date, it provides principles for practitioners seeking to use the mobile platform to improve farmers' livelihoods.

Topic Note 3.1: Key Benefits and Challenges Related to Mobile Phones and Agricultural Livelihoods. Mobile phones may help to increase income, improve the efficiency of markets, reduce transaction costs, and offer a great opportunity for innovative interventions, especially in service delivery. Yet to realize the full potential of enhanced communication of market information, the use of mobile phones must be coupled with additional investments (in roads, education, financial services, and so forth). Mobile services and applications also need to provide compelling value. They must be affordable and have useful content. Finally, mobile phones may not confer their benefits in an equitable fashion or be used in other socially and economically beneficial ways. Context matters. Technology cannot be airdropped into a situation and guarantee positive results.

- **Weather Forecasting Reduces Agricultural Risk in Turkey**
- **Mobile Phones Are the Center of Esoko's Virtual Marketplace**

Topic Note 3.2: Two Typologies and General Principles for Using Mobile Phones in Agricultural Projects. Two frameworks help for understanding and designing initiatives that use mobile phones for achieving development goals. One typology focuses on the services that operate through mobile phones to improve aspects of agricultural livelihoods. A second focuses on the various forms that mobile applications might take to develop the agricultural sector. A number of principles improve the chances of sustainable impact: understand users and the technology; engage in participatory, iterative project design; identify partners with the appropriate knowledge, collaborative capacity, and alignment of goals; ensure that the technology is widely accessible; develop a viable business plan to ensure sustainability; and use monitoring and evaluation to develop a better understanding of outcomes, which would help in designing new interventions.

- **Mobile Service Gives Chilean Farmers a Local and Global Information Edge**
- **For Reuters Market Light, the Wider Network of People Matters**
- **Nokia Life Tools Uses Simple Technologies to Deliver New Functionality**

OVERVIEW

In July 2010, the number of mobile phone subscriptions surpassed the 5 billion mark (figure 3.1), further establishing mobile phones as the most popular form of global connectivity.¹ In their various designs and capabilities, mobile phones

can be found in the pockets of the wealthy and poor alike. Even in rural areas, mobile phones are growing in number and sophistication. Recent figures suggest that although only 81 million Indians (7 percent of the population) regularly use the Internet, price wars mean that 507 million own mobile phones. Calls cost as little as US\$0.006 per minute, and Indian operators are said to sign up 20 million new subscribers per month (*The Economist* 2010).

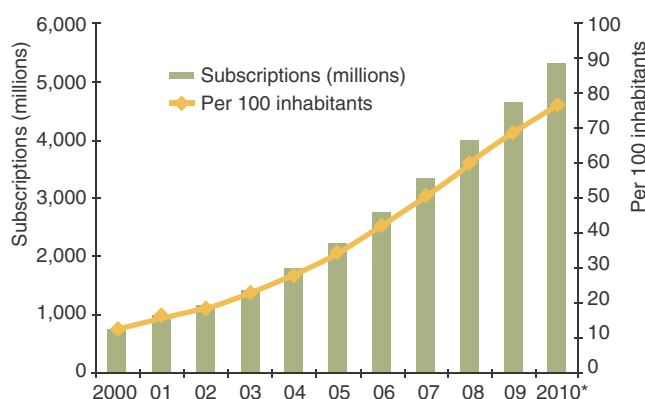
¹ According to <https://www.wirelessintelligence.com/>.

Figures for access to mobile phones are higher than ownership figures. A survey in Uganda found that 86 percent of those asked claimed to have access to a mobile phone, although only one-quarter of farmers said they actually owned one (Ferris, Engoru, and Kaganzi 2008).

This module highlights the impact of mobile phones on agriculture and rural development by outlining current knowledge and describing innovative practices. The discussion complements information in Module 2 on technical aspects of increasing mobile phone use in rural areas and agriculture. It also serves as a preface to numerous other descriptions of mobile phone applications throughout this Sourcebook.

The rise of the mobile phone has been one of the most stunning changes in the developing world over the past decade. The increasing ubiquity of these phones in developing countries presents both opportunities and challenges, especially for critical sectors such as agriculture. Like other technologies before it, the mobile phone is likely to be the subject of inflated expectations and hopes. To caution against the hype, this module also explores barriers to using mobile phones to benefit agriculture and provides recommendations for practitioners seeking to use the mobile platform to improve farmers' livelihoods.

FIGURE 3.1. Global Mobile Cellular Subscriptions, Total and per 100 Inhabitants, 2000–10



*Estimates

Source: ITU World Telecommunication/ICT Indicators database.

Why Mobile Phones?

Mobile phones are but one form of ICT. Personal computers, laptops, the Internet, television, radio, and traditional newspapers are all used to promote improved rural development. So why focus on mobile phones?

The most obvious answer is the sheer scale of adoption. In the ten years before 2009, mobile phone penetration

rose from 12 percent of the global population to nearly 76 percent. A series of innovations drove this adoption, especially in developing countries, which had 73 percent of the world's mobile phones in 2010.² Like other digital technologies, mobile phones benefit from Moore's Law, which states that computational power doubles approximately every two years. The newest smartphones are far more sophisticated than the more affordable models populating poor regions, but those simple phones are still leaps and bounds ahead of devices that were cutting edge a decade ago—and they are entirely relevant to agriculture.

An additional reason for focusing on mobile phones is that regulatory design has improved in recent decades, boosting competition among telecommunications companies. Competition has spurred significant innovation in business models. For example, in most of the developing world, in contrast to practices in some wealthy countries, only the person making the phone call pays. Moreover, mobile phone airtime is available in prepaid bundles, allowing poor customers to avoid lengthy contracts and manage their expenditure in a discrete, granular manner. For those at the bottom of the pyramid, where income is indeterminate and managing finances is very important, this model is a key driver of access and use. (For additional discussion and examples of regulation and business models as key enablers of mobile telecommunications, see Module 2.)

These supply-side improvements have met strong demand from customers around the globe. Like all networked technologies, mobile phones exhibit network effects, making them more valuable as more devices are in use. Also, in contrast to landlines, the mobility and personal nature of this technology have a strong appeal to users. Being connected means being reachable (Ling and Donner 2009). The mobile phone adds a layer of security, allowing someone to reach loved ones or assistance following an accident. It also allows for microcoordination of activities, limiting the need for planning and the cost of changing plans on the fly (Ling 2004). Finally, as anyone who has made a phone call while waiting for the bus or checked his or her phone during a meeting knows, mobile phones allow for multitasking.

What this proliferation means is that while mobile phones may be a substitute or complement for landlines in rich countries, they are more frequently the first form of telephony for many of the world's poor. Through allowing communication at a distance, mobile phones allow users to overcome limits of time and space.

2 See ITU (<http://www.itu.int/ITU-D/ict/statistics/>).

Why Agriculture?

In many countries, agriculture accounts for the overwhelming majority of rural employment. The manifold benefits that accompany improvements in agricultural productivity are well known: Farmers' incomes rise, food prices fall, and labor is freed for additional employment. In some instances, productivity improvements have proven elusive, as climate change and uncertain commodity prices have worsened agrarian conditions for many rural communities. Development practitioners have rightly focused on the difficult situations of many farmers, especially smallholders, who have little room for error and even less protection from social safety nets. Technical innovation, most prominently demonstrated in the Green Revolution, has been key to improving agricultural markets in the developing world. Mobile phones, despite their recent entry into agrarian communities, are already helping those communities improve their agricultural activities.

THE VIRTUOUS CIRCLE OF MOBILE PHONES AND AGRICULTURE

Advances throughout the mobile phone ecosystem tend to act as a positive feedback loop. This "virtuous circle" of innovation enables a number of benefits, even for smallholder farmers:

- **Access.** Mobile wireless networks are expanding as technical and financial innovations widen coverage to more areas.
- **Affordability.** Prepaid connectivity and inexpensive devices, often available second hand, make mobile phones far cheaper than alternatives.
- **Appliances.** Mobile phones are constantly increasing in sophistication and ease of use. Innovations arrive through traditional trickle-down effects from expensive models but have also been directed at the bottom of the pyramid.
- **Applications.** Applications and services using mobile phones range from simple text messaging services to increasingly advanced software applications that provide both livelihood improvements and real-time public services (box 3.1).

Through this expansion process, formerly costly technologies quickly become everyday tools for the bottom of the pyramid. Additional opportunities for more frequent and reliable information sharing will open as technological advances lead to additional convergence between mobile phones and the Internet, GPS, laptops, software, and other types of ICT.

BOX 3.1. What Is a Mobile Application?

A mobile application is a piece of software on a portable device (such as a mobile phone handset, personal digital assistant, or tablet computer) that enables a user to carry out one or more specific tasks that are not directly related to the operation of the device itself. Examples include the ability to access specific information (for instance, via a website); make payments and other transactions; play games; send messages; and so on. The application (app) might come preinstalled, but more usually is downloaded (for free or for payment) from a wireless network from an online store and may require a live connection to function effectively. Simple apps may make use of the built-in, low-speed data communication facilities of digital mobile phones, such as short messaging service (SMS) or unstructured supplementary service data (USSD). On many low-cost phones, applications are available through Java software. More complex apps use the Internet protocol-based data communication facilities of higher-speed networks on third- or fourth-generation mobile phone networks. The broad range of applications available includes:

- **Stand-alone software apps downloaded onto a device,** such as an iPhone app. As of April 2010, third-party developers provided 185,000 apps, and more than 4 billion had been downloaded since the iPhone was launched in July 2008, based on Apple's presentation at the iPhone OS 4 media preview event.
- **Applications that require an elaborate ecosystem to support them,** such as Safaricom's M-PESA application for mobile payments in Kenya. M-PESA (which operates in a number of countries) has some 15,000 agents and over 9 million users.
- **Applications built upon a specific platform that is itself an application.** For instance, the MXit instant messaging platform, which began in South Africa, now supports 250 million messages per day. It provides tools for users to develop their own applications running on the platform.

Source: Author.

The topic notes that follow review numerous ways that private industry, government bodies, and nonprofit organizations are using mobile phones in agriculture. Many of these programs are relatively new, and conclusive results are difficult to ascertain. Most show promise, but there are reasons for caution and the barriers to surmount. Topic Note

3.1 focuses on what is known so far about the benefits, challenges, and enablers related to using mobile phones to improve agriculture and rural welfare. Topic Note 3.2 describes two typologies that can help practitioners understand the various roles and rationales surrounding the use

of mobile phones for agricultural development technologies and help them determine whether and how to incorporate them in the design of new initiatives. The Topic Notes are followed by Innovative Practice Summaries that highlight the approaches taken so far.

Topic Note 3.1: KEY BENEFITS AND CHALLENGES RELATED TO MOBILE PHONES AND AGRICULTURAL LIVELIHOODS

TRENDS AND ISSUES

The proliferation of mobile phones across the globe has impinged on agriculture in various ways. These phones are being used to help raise farmers' incomes, making agricultural marketing more efficient, lowering information costs, reducing transportation costs, and providing a platform to deliver services and innovate. Whether the potential of these trends can be realized more widely, especially in rural areas and in an equitable way, is uncertain. Every aspect of the technology is changing rapidly; the public sector, private sector, and private citizens are constantly experimenting with new applications for it; and governments are grappling with any number of strategies to ease the digital divide. This note summarizes what is known so far about the benefits, challenges, and enabling factors associated with mobile phones in relation to several aspects of agricultural livelihoods.

Helping Farmers Raise Their Incomes

In some instances, access to mobile phones has been associated with increased agricultural income. A World Bank study conducted in the Philippines found strong evidence that purchasing a mobile phone is associated with higher growth rates of incomes, in the range of 11–17 percent, as measured through consumption behavior (Labonne and Chase 2009). One reason for this finding is that farmers equipped with information have a stronger bargaining position within existing trade relationships, in addition to being able to seek out other markets. A study of farmers who purchased mobile phones in Morocco found that average income increased by nearly 21 percent (Ilahiane 2007).

Mobile phones seem to influence the commercialization of farm products. Subsistence farming is notoriously tenuous,

but smallholder farmers, lacking a social safety net, are often highly risk averse and therefore not very market oriented. A study in Uganda found that market participation rose with mobile phone access (Muto and Yamano 2009). Although better market access can be a powerful means of alleviating poverty, the study found that market participation still depended on what producers had to sell: Perishable bananas were more likely to be sold commercially than less-perishable maize.

Mobile phones can serve as the backbone for early warning systems to mitigate agricultural risks and safeguard agricultural incomes. In Turkey, local weather forecasts transmitted through SMS provided very timely warnings of impending frosts or conditions that favored pests.

Mobile platforms may also have potential for enabling rural people to find employment. In Uganda, Grameen AppLab partners with government and NGOs to employ farmers to collect information (for more on Grameen, see Module 3). This method, which relies on local people to transmit data to more centrally located research and extension staff, is much less costly and can provide much more timely information than traditional disease surveys.

Txteagle provides employment for relatively educated users (see “Txteagle Taps a Vast Underused Workforce” in Module 2), and even the very poor in rural areas could eventually benefit from access to a mobile job board. Farmers could advertise when they need additional labor for harvesting or other high-intensity tasks via mobile phone, creating a simple advertising portal. Workers could find jobs without wasting time and money traveling. A group called BabaJob is developing such a service in India, where recruiters and workers submit listings by SMS, but it remains in the developmental stage.

Making Agricultural Marketing More Efficient

At a fundamental level, markets are about distributing information. They do so through prices, which serve as a unifying signal to participants to allow for the coordination of dispersed producers and consumers. Underlying this powerful mechanism, though, is the assumption that everyone knows the market prices for commodities, which is not the case in much of the developing world. Farmers have little information about market prices in urban areas of their own countries, let alone internationally. The result of this information asymmetry is price dispersion—the same goods sell for widely different prices in markets merely a few kilometers apart.

Mobile phones, in addition to other types of ICT, can overcome this problem by informing both producers and consumers of the prices offered for agricultural products in various locations. A number of studies have shown that when mobile phones are introduced to farming communities that previously lacked any form of connectivity, prices unify as farmers learn where they can sell for a better price. (See Module 9 for more information on marketing through ICT.)

A striking example comes from the Indian state of Kerala (box 3.2). As mobile networks were rolled out in coastal

regions, fishers who were previously ignorant of daily prices in different markets were able to contact various ports to find the best offer for their catch. The result was demonstrable welfare gains for fishers because fish were sold where they were more highly valued. Waste decreased and prices equalized throughout the regional ports; there were even small gains in consumer welfare (Jensen 2007).

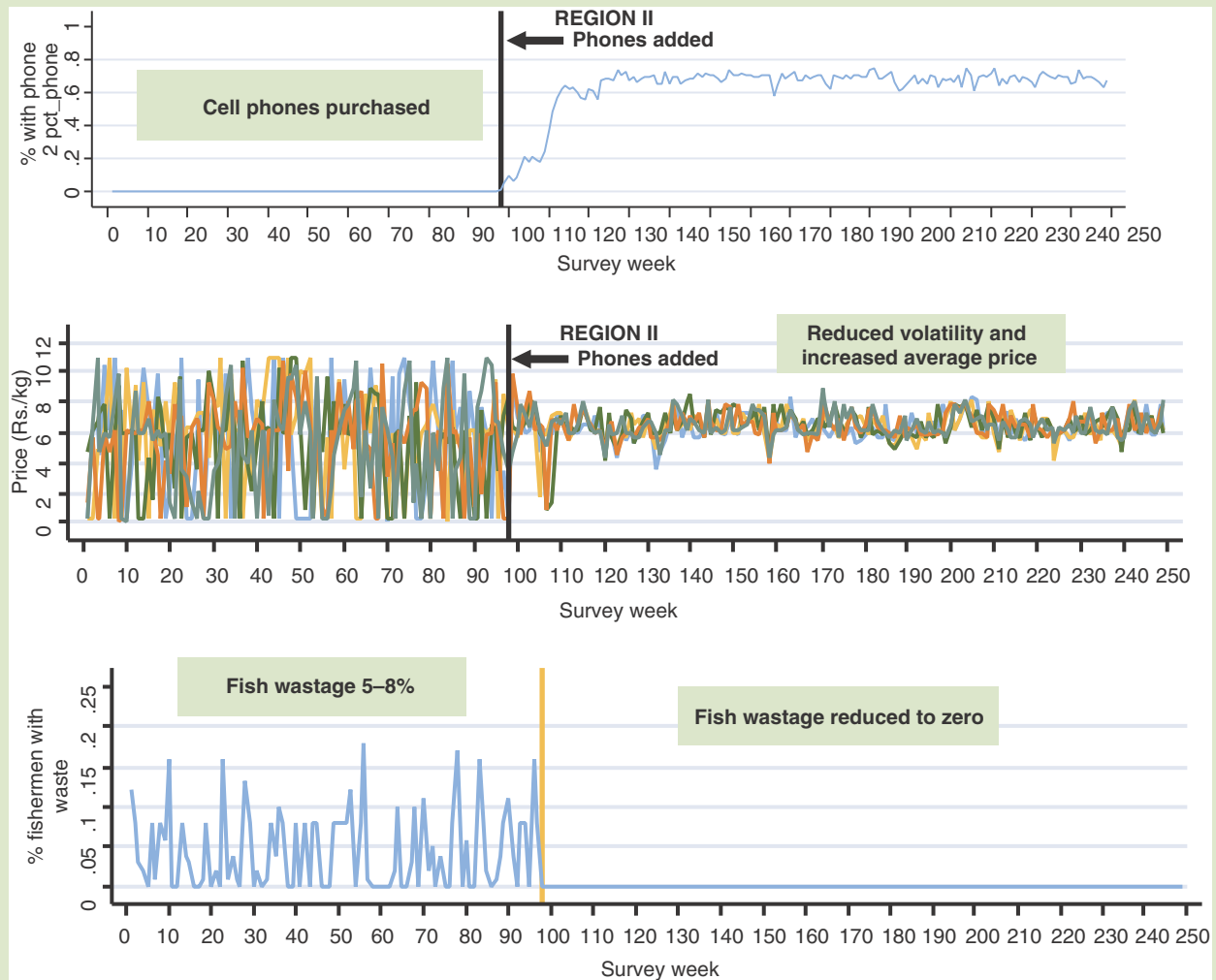
Other studies have confirmed this effect. Despite having the lowest mobile phone penetration in Sub-Saharan Africa, Niger has seen important effects on agricultural markets from mobile phone diffusion. As mobile networks have expanded, grain price differences have decreased by 20 percent, traders' search costs have decreased by 50 percent, scarce resources have been better allocated, and consumers have paid, on average, 3.5 percent less for grain, which is equivalent to 5–10 days of grain consumption annually (Aker 2010a). A small study in Morocco found that farmers with mobile phones increasingly dealt directly with wholesalers or larger-scale intermediaries rather than smaller intermediaries (Ilahiane 2007). These studies, in conjunction with a host of anecdotal and theoretical evidence, point to the promise of mobile phones in making markets more efficient.

BOX 3.2. Mobile Phones Enable Kerala Fishers to Identify Better Markets

As mobile phone coverage increased in Kerala, fishermen bought phones and started phoning along the coast to look for beach auctions where supplies were lower and prices higher than at their home beach. Fishermen rapidly learned to calculate whether the additional fuel costs of sailing to the high-priced auction were justified. The figure below tells a vivid visual story of how phones affected prices (reduced volatility) and wastage (significantly reduced). Price dispersion was dramatically reduced, declining from 60–70 percent to 15 percent or less. There was no net change in fishermen's average catch, but more of the catch was sold because wastage, which previously averaged 5–8 percent of the daily catch, was effectively eliminated. The rapid adoption of mobile phones improved fishermen's profits by 8 percent and was coupled with a 4 percent decline in consumer prices.

By 2001, over 60 percent of fishing boats and most wholesale and retail traders were using mobile phones to coordinate sales. The phones were widely used for fish marketing. Fishermen with phones generally carry lists with numbers of potential buyers. They typically call several buyers in different markets before deciding where to sell their catch. Boats using mobile phones on average increased profits by Rs 184 per day, compared to Rs 97 for nonusers, who tended to follow the mobile phone users. Boats with mobile phones gained more (nearly twice as much), in part because they were on average larger boats and thus caught more fish and because they were more likely to be able to profitably exploit the small remaining arbitrage opportunities. Phones appear to be a worthwhile investment: The net increase of Rs 184 per day in profits for phone users would more than cover the costs of the phone in less than two months (assuming that there are 24 days of fishing per month, and given that the handset costs approximately Rs 5,000 and monthly costs are Rs 500). Fishermen are still using phones for marketing purposes to date.

(continued)

BOX 3.2. continued**Cell Phone Impact on Fish Marketing (SW India)**

Source: Jensen 2007.

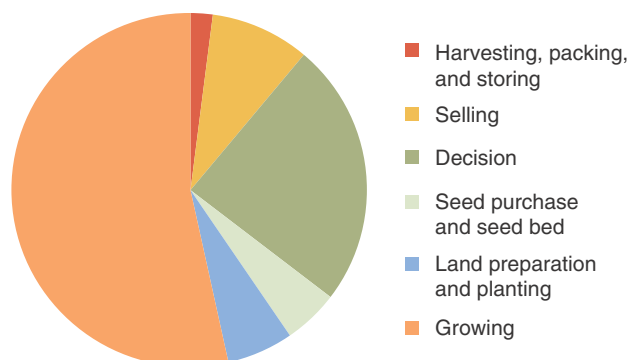
Lowering the Costs of Information

The most obvious and crosscutting way that mobile phones can improve agriculture is by improving access to information and making it less costly to obtain. In many rural areas, the arrival of mobile coverage is a radical change in the nature of the information ecosystem. Although simply having more information is not sufficient to make advantageous decisions (other resources may be needed to implement them), it is a necessary step toward access to knowledge.

Transaction costs are present throughout agricultural value chains, from initial decisions about whether and what to plant, to all of the operations during the growing cycle, harvesting, postharvest and processing operations, and selling (to intermediaries, consumers, processors, exporters).

These costs can account for a large share of the cost of a farm enterprise.

In a study that compared transaction costs throughout an extended period, 15.2 percent of the total cost of farming was transactional, and of that, 70 percent was informational (as opposed to, say, the cost of transporting crops to market). Undertaken in Sri Lanka, where an inconsistent subsidy on fertilizer introduces considerable uncertainty, the study found that 53 percent of the informational transaction costs were incurred during the growing season, when farmers were attempting to ascertain fertilizer costs. As shown in figure 3.2, another 24 percent were incurred during the initial decision to plant or not, while only 9 percent of the costs related to information were incurred during the selling stage, where studies typically

FIGURE 3.2. Information Search Cost by Stage of Farming

Source: Adapted from De Silva and Ratnadiwakara 2008.

focus (De Silva and Ratnadiwakara 2008). It is easy to understand how mobile phones could reduce farmers' informational transaction costs at critical points in the production cycle.

Reducing Transportation Costs

Mobile phones may help users to substitute phone calls for travel. Where safety standards are minimal, roads are in disrepair, and distances are great, substituting phone calls for travel reduces farmers' time and cost burdens. Time savings are important for agricultural households, because many crops have extremely time-sensitive and labor-intensive

production cycles. Farmers who use mobile phones can also save on transportation costs (Overa 2006)—an effect that is stronger the more rural the area (Muto and Yamano 2009).

Transportation cannot be avoided entirely: Crops need to get to customers. Although mobile phones can inform farmers where they should travel to market their crops, evidence suggests that the wealthy maintain an advantage in their ability to make use of this information (Fafchamps and Hill 2004). In combination with improved rural roads, ICT will encourage larger truck-traders to visit harder-to-reach areas, connecting rural and urban regions.

As noted in Module 9, the onion wholesalers known as "Market Queens" increasingly use mobile phones to coordinate supply among themselves and to improve profits by facilitating reductions in their transportation and opportunity costs (Overa 2006). These costs are particularly high in commodity chains that are geographically extensive and organizationally complex, such as the onion trade in Ghana.

A Platform for Service Delivery and Innovation

The numerous capabilities of mobile phones (box 3.3) provide ample opportunities to deliver both traditional and innovative services. Traditional agricultural extension agents are increasingly being outfitted with mobile phones through programs to increase their effectiveness by networking them to knowledge banks. Extension can reach more clients through

BOX 3.3. One Device, Many Channels

Mobile phones are multifunctional devices. From smartphones to models available secondhand in rural markets, these phones do much more than simply place voice calls. In designing a mobile intervention or project, it is important to keep in mind the various channels through which populations can be reached.

In much of the world, voice is still king, owing to widespread illiteracy; but other considerations—such as cost, ease of use, and trust—influence users' choices. In Africa, the high cost of calls has made 160-character text messages (SMS) very popular.

As networks and devices acquire more capabilities, richer uses of phones are unfolding, and information channels are converging. Camera phones send images, data transfer brings the mobile Internet to the bottom of the pyramid, downloaded software applications provide advanced functionality, and GPS sensors provide mapping functionality. Emerging market consumers are more likely to have their first contact with the Internet through a mobile device, and many are mobile-only users.^a Cisco estimates that by 2015 there will be 788 million mobile-only Internet users, and though rural areas will lag behind, the highest rates of growth will be in the Middle East, Africa, Latin America, and Eastern and Central Europe.^b In Kenya, Safaricom recently unveiled a service that converts emails to SMS messages and an interactive voice response (IVR) service, in which a computer responds to voice inquiries. Combining mobile phones with other technologies, such as radio and telecenters, can enhance their capabilities.

This potential is important to understand. It shows how adaptable the technology is, and how it can be used in areas where smartphones are likely to remain inaccessible to many in the near future.

(continued)

BOX 3.3. continued

Each form of mobile communication has its strengths and weaknesses. For example, SMS requires some form of literacy and is limited to 160 characters (although some mobile information interfaces are striving to become more visually intuitive). Data transfer is inexpensive but not available on most phones. The table summarizes types of mobile technologies and their availability.

Types and Availability of Mobile Technologies

TECHNOLOGY	DESCRIPTION	AVAILABILITY
Voice	The most basic channel; avoids most literacy or linguistic barriers	Basic phones
Short messaging service (SMS)	Ubiquitous text-based messaging limited to 160 characters	Basic phones
Unstructured Supplementary Service Data (USSD)	A protocol used by Global Service for Mobile Communications (GSM) phones to communicate with the mobile network	Basic phones
Interactive Voice Response (IVR)	Computer programs that respond to the voice input of callers	Basic phones
General Packet Radio Service (GPRS)	Low-bandwidth data service	Midrange phones
Software app (e.g., Java or iOS)	Preinstalled or downloaded software of varied sophistication	Midrange, but increased sophistication with smartphones
Mobile Wireless Application Protocol (WAP)	A limited manner of browsing the Internet	Midrange phones
Multimedia Messaging Service (MMS)	SMS-based technology to transmit multimedia (including images and video)	Midrange phones
Camera	For capturing still or moving images	Midrange phones
Bluetooth	Protocol for transmitting data over short distances	Midrange phones
Mobile Web	Full-fledged Web access	Smartphones
Global Positioning System (GPS)	Technology allowing for location-based information	Smartphones

Source: <http://www.crisscrossed.net/2009/11/01/the-many-potential-channels-for-mobile-services/>; (a) <http://www.slideshare.net/ondevice/the-mobile-only-Internet-generation>; (b) Cisco (2010).

mobile-based learning platforms—textual or richer platforms, such as video—that provide tips to farmers to improve agricultural skills and knowledge. (See the detailed discussion of advisory services and ICT in Module 6.)

Significantly, mobile phones are also a platform for user innovation. Mobile money services, now so prominent in countries such as Kenya and the Philippines, originally began as informal mechanisms between family and friends. Software engineers in developing countries are creating locally appropriate applications to be deployed inexpensively. This form of innovation is possible due to the functionality of mobile phones, but capacity needs to be grown and technological barriers, such as incompatible networks, need to be addressed (see the discussion in Module 2).

Finally, the popularity of mobile phones means that previously excluded populations can have considerably more

political voice, raising the level of interaction between policy makers and their constituents. Mobile phones can be used to direct bottom-up insights toward the appropriate recipients, informing and improving governance (see Module 12).

LESSONS LEARNED

As mobile phones come into more widespread use and phone applications for agriculture increase, it is clear that they have the potential to confer significant benefits. To summarize, they may help to increase income, improve the efficiency of markets, reduce waste, and improve welfare. They can reduce agriculture's significant transaction costs, displace costly and time-intensive travel, and facilitate innovative interventions, especially in service delivery.

Yet as many examples in this Sourcebook indicate, mobile phones, and ICT more generally, may serve agricultural development best when accompanied by complementary investments and reforms. For example, shoddy roads—or no roads—limit farmers' ability to sell their grain in prime markets. Poor access to education can prevent many rural people from taking advantage of mobile phone services that depend on being able to read.

A lack of financial services can undermine the new options that mobile phones allow. As discussed, Kerala's fishers saw their welfare increase through the use of mobile phones (image 3.1), but they ran into another financial barrier. Without access to capital, the fishers cannot own their boats. The phones eliminated some intermediaries, but boat owners may still force the fish to be sold in a less-than-optimal port. Small-scale producers and fishers can gain better access to services if they organize (see Module 8), but in many settings, increasing the bargaining power and political clout of small-scale producers remains an issue (Reuben 2007).

IMAGE 3.1. Mobile Phones Can Help Fishermen Sell Their Catch



Source: Curt Carnemark, World Bank.

To succeed, mobile services and applications also need to provide compelling value, especially for the poor. Access to devices and networks is insufficient; the technology also must be affordable and have useful applications and content. For example, in Sri Lanka, where researchers found significant potential cost savings from the use of mobile phones, farmers rarely used their phones to obtain market data because they could not obtain accurate and timely information. Instead, farmers made frequent and costly trips to distant markets to determine prices (Ratnadiwakara, De

Silva, and Soysa 2008). But when mobile phones were used for timely interventions through SMS, up to 40 percent of wastage could be prevented, a service for which farmers were willing to pay (De Silva and Ratnadiwakara 2008).

Because mobile phones may be purchased as a status symbol, and because their uses are not necessarily economically valuable (entertainment and other social uses are popular), some mobile phone owners may decide to substitute their use for important expenditures such as school fees or food. Given this possibility, it is even more important that development practitioners promote policies and programs that improve livelihoods (Heeks 2008).

An additional caution is that without specific attention to equity issues, mobile phones may reinforce inequitable social structures. Larger traders are more likely to own mobile phones than small-scale traders (Overa 2006). Compared to men, women are less likely to have access to mobile phones³ (box 3.4 provides additional insight into the role of mobile phones in relation to gender equity). To avoid exacerbating such inequalities, agricultural programs using mobile phones should be designed with equity in mind from the start.

Finally, context matters. Technology cannot be airdropped into a situation and guarantee positive results, and mobile phones may not necessarily be directed at economically useful behavior.

INNOVATIVE PRACTICE SUMMARY

Weather Forecasting Reduces Agricultural Risk in Turkey

A project recently implemented by the Government of Turkey in collaboration with international donors is an exemplary model of local weather forecasting.⁴ Rather than focusing on aggregate, national data, this project, implemented by the Agriculture Directorate of Kastamonu Province, focused on the microclimatic conditions essential for monitoring pests and diseases accurately and increasing productivity.

The Problem and the Technology

Most producers in Kastamonu maintain orchards, which are extremely susceptible to frost and local pests. Before

3 See "mWomen," under http://gsmworld.com/our-work/mobile_planet/development_fund/index.htm.

4 This section draws on World Bank (2010) and personal communication from H. Agah, senior rural development specialist, World Bank (interview with C. Belden, Agriculture and Rural Development, World Bank, March 22, 2011).

BOX 3.4. Mobile Phones, Agriculture, and Gender

The larger development community recognizes the importance of emphasizing equitable opportunities and benefits for both genders (for example, see the Gender and Agriculture Sourcebook)—a principle endorsed for the use of ICT in agriculture as well. Access to and use of ICT are often unequal, with women suffering the consequences. In a number of cases, however, ICT has been used to benefit agriculture while empowering women.

Kenya is a country of 5 million farmers, ranging from the smallest subsistence growers to large industrial agriculturalists. It is also increasingly a hotbed of technological innovations, such as M-Farm, a mobile service that aims to improve Kenya's agricultural sector by connecting farmers with one another, because peer-to-peer collaboration can improve market information and enhance learning opportunities.

Based on farmers' traditional needs, such as the need for market price and weather information, M-Farm is a relatively new subscription service that also works with larger institutions, such as NGOs and the government, to connect them with farmers. The idea was generated at IPO48, a weekend-long "boot camp" where technologists and entrepreneurs bring businesses from idea to initial product in only 48 hours. M-Farm, created by AkiraChix (an all-female team of developers that are now pursuing the project full time), won the 2010 IPO48 competition's first-place prize of more than US\$10,000. AkiraChix is also the recipient of an infoDev/World Bank grant to facilitate monthly networking events for mobile entrepreneurs and developers in Nairobi.

Both networking and incentives such as IPO48 have proven essential to facilitate the rapid creation of sustainable businesses based on mobile devices and the empowerment of women. Though IPO48 and M-Farm are new and their impacts are still limited, they are expected to generate widespread improvements in agricultural marketing, particularly for women.

The Village Phone program of the International Finance Corporation may also benefit rural women. The program provides microloans to rural entrepreneurs who purchase a mobile phone, long-range antenna, solar charger, and airtime. The recipient earns a livelihood by operating a phone kiosk in areas underserved by mobile networks. As is typical in micro-finance, the loan recipients tend to be women. Since the program's inception, nearly 6,000 women have received loans and close to 10,000 have been trained in countries such as Madagascar, Malawi, and Nigeria.

Source: Author.

the project commenced, producers had little time to react to weather that might harm their orchards, because national weather forecasts for the next day were broadcast in the evening (both FM radio and broadband Internet were unavailable). Given these constraints, mobile phones with SMS were the most applicable ICT for the project.

National aggregate weather forecasts are not particularly useful for pest management and frost prevention in rural locations. Local, specific conditions vary widely from farm to farm, depending on such variables as humidity, precipitation, crop type, and soil fertility. In addition, rural weather is often a few degrees cooler than weather in urban areas, where most forecast data are generated.

The provincial directorate established five mini-meteorological stations in rural areas throughout the province. The stations collect data on variables such as temperature, precipitation, wind, leaf wetness, and soil moisture, most of which are not collected at the national level. In addition to these

stations, the province maintains 14 reference farms where temperatures are measured and pest cycles are monitored. Monitoring the life cycle of pests, along with collecting climate data, allows researchers to predict pest outbreaks more accurately, because pest maturation depends largely on environmental conditions.

With localized weather indicators disseminated daily through SMS, producers can apply pesticides when needed and in appropriate amounts. In the first two years of the project, producers' costs fell dramatically. Pesticide applications dropped by 50 percent in one year, saving farmers around US\$2 per tree. Considering the size of the orchards, overall production costs could be reduced by as much as US\$1 million each year.

A similar design was used to avert frost damage. Climate change and shifting temperatures have increased spring frosts in Kastamonu Province. If the meteorological stations measure lower-than-normal temperatures, subscribers with personal digital assistants (PDAs) and mobile phones receive

alerts at 4:00 P.M., giving them sufficient time to prepare for the cold snap.

Anecdotal Evidence of Impact

Though the project has not gone through rigorous assessment, anecdotal evidence clearly points to its success. The means chosen to disseminate information were essential to the project's success, because mobile applications matched the technological capacity of the area. Other dissemination and awareness strategies raised the project's visibility, including the mass media, village leaders, and other forms of human interaction and leadership. It is likely that the weather forecasts had the ripple effect common to other ICT projects, because those who received the service shared the information with family and neighbors who did not. Farmers who participated in the project were successful in planting and protecting their crops. Of 500 farmers reached through this information channel, not one experienced crop losses from frost, although farmers who did not receive the service did.

Scaling Up and Sustaining the Benefits

The project could be scaled up, but cost is a concern. For the first two years, project costs were fairly low. The five stations, telecoms, software, and system upkeep cost around US\$40,000. Costs will climb over time, however, as donor financing ends and climate conditions change (which could make it important, for example, to change the system to include other variables).

Several strategies could reduce the cost to government once external funding ends. For example, the government could partner with the private sector. Firms interested in domestic or export markets for the area's crops may have an incentive to fund some of the technologies or develop the content. Revenue could also be collected through small or tiered subscriber fees (daily forecasts in the Kastamonu Province are currently free).

Scalability is also difficult because of the nature of this particular project. Site-specific climate information is more expensive to obtain than aggregate temperature predictions. Moreover, other areas will produce crops vulnerable to a different spectrum of biological and climate stress, making each target group fairly small. One way to reduce these costs and broaden the scope of a similar program might be to focus first on crops or livestock that represent the most widely pursued or highest-value enterprises.

Transferring this kind of early warning system to Central Asian countries, as planned by the World Bank, may pose particular

challenges. Turkey's national meteorological system is more advanced than the systems of most of its neighbors. High-resolution images and national capacity for weather forecasting are necessary to achieve local efforts. Because global satellites provide basic climate information free of charge, they may fill the technological gap in some countries; but their resolution is low. Alternative strategies like climate modeling have succeeded in Latin America and Africa, but they have not been empirically tested for their effectiveness in forecasting weather.

Anecdotal evidence also shows that technological capacity is not the only factor influencing success. Institutional capacity is equally important. The local government's high level of commitment to the project and consistent implementation were crucial to building client trust and ensuring that the technologies were used appropriately.

INNOVATIVE PRACTICE SUMMARY

Mobile Phones Are the Heart of Esoko's Virtual Marketplace

Esoko (<http://www.esoko.com/>) (which began as TradeNet in 2005) is a market information service that provides price information and a virtual marketplace for buyers and sellers of agricultural commodities to connect through mobile phones and the Internet.⁵ Mark Davies—a successful British technology entrepreneur who also manages Ghana's largest ICT center, BusyLab—set up Esoko.⁶ Since then, it has become one of Africa's most successful agricultural services using ICT. Esoko's technology is used in nine African countries and is expanding quickly. Mobile phones are at the center of its system.

Services

Esoko provides four key services:

- **Live market feeds.** Real-time SMS alerts on market prices and offers are delivered automatically to subscribers. Users can submit offers directly to the system using SMS.

5 Aside from the sources cited in the text, this summary also draws on Gakuru, Winters, and Stepman (2009).

6 Esoko, which began as a private initiative with encouragement from FAO and the UN, became a partner with USAID's MISTOWA program in West Africa and CIAT's FoodNet program in Uganda, and it was supported with a grant of US\$11 million. More recently, IFC (a member of the World Bank Group) and the Soros Economic Development Fund (a nonprofit investment fund that works to alleviate poverty and community deterioration) each invested US\$1.25 million of equity in Esoko. The investment will give smallholder African farmers and businesses timely crop information that can be shared via text messaging, enabling farmers to increase their incomes.

- **Direct SMS marketing and extension.** This service targets specific user groups or sends extension messages, which reduce travel and communication costs.
- **Scout polling.** It is possible to set up automatic SMS polling for field activities to track inventories and crop activities (among other things) and monitor and report on crop cycles and yields.
- **Online profiling and marketing.** All users can have a customizable Web space to advertise their goods and services. This space can be updated using Esoko's mobile2web content management service.

Participants throughout agricultural value chains can exchange real-time market information. Farmers receive current demands, prices of crops, and the location of seed and fertilizer outlets directly on their mobile phones. Businesses can track how their products are used and market themselves to new customers. Associations and governments can share critical information with thousands using a simple feature for bulk text messaging.

Anyone in the world can visit esoko.com and register for a free account. There, in addition to 800,000 prices from hundreds of markets, users will find a library of resources and thousands of members offering to buy and sell agricultural products. Prices and transactions are also available via the universal SMS channel; and for slightly more sophisticated phones, a downloadable application offers additional functionality. Users can even receive automated SMS alerts for certain commodities in a given market (box 3.5). Because anyone with a mobile phone may post offers to the website through SMS, smallholder farmers are able to reach a far wider audience than they typically would. Esoko users also are in a better position to negotiate with buyers owing to their enhanced knowledge of prices in other markets.

Esoko offers training and strategy sessions on how to use the platform and can provide customer services for

BOX 3.5. An Esoko Transaction

Here's how it works: A farmer in northern Ghana is selling 20 tonnes of millet. The farmer texts in SELL MILO 20MT to TradeNet's international number, and that information is processed by the software and immediately published on the website. The same details are also redistributed to every other user that has signed up to receive alerts on millet sales in Ghana.

Source: Quoted from Bartlett 2008.

farmer groups. The firm also publishes the first commodities indexes in Africa. These powerful tools ensure that farmers are fairly compensated for their crops, as formal commodity exchanges are very rare on the continent. The company is initially publishing two indexes that provide prices for 12 agricultural commodities in 7 markets in Ghana.

Impact

The impact of this information on traders, exporters, transporters, procurers, and others in the agricultural value chain is still to be determined. The service is believed to have the potential to reduce inefficiencies in the value chain. For example, an exporter took 60 days and needed 5 people in the value chain to procure a natural plant product, but with Esoko's technology, the procurement process required 31 days and 3 people, improving both the major traders' and producers' share of the export price. Free field trials for farmers elicited self-reported evidence of a 20–40 percent improvement in revenue. Sixty-eight percent of farmers said that they would pay for the service; every farmer who received information would forward it to an additional 10 farmers.

Building and Sustaining a Business Model

The idea driving the model is that most businesses in the agricultural value chain collect and deliver their own data; Esoko will provide tools and a platform and co-opt businesses to generate content for the platform. Esoko pays on an incentive basis to acquire information, using targets and bonuses. Its revenue-generation model is based on levels of subscriptions (bronze, silver, gold, platinum), each with a different pricing structure and its own mix of content and tools.

For a US\$1 per month subscription (beginning in 2011), farmers automatically receive information on commodities, markets, and other topics of interest. In developing a model for selling information to farmers, Esoko encountered a few challenges. Farmers are widely dispersed in the field and hard to reach. It is also difficult to quantify the exact value that the service generates for farmers.

Esoko provides additional functionality for other users, including organizations that would like to customize the technology for their needs. For example, paying subscribers can access Esoko's supply chain tools, which allow harvest activities to be tracked. Mark Davies (quoted by Magada 2009) believes this holistic approach, as opposed to simply providing price

information, is key: “While running TradeNet, we realised that there was a need for a platform to integrate the whole supply chain, not to just provide prices. . . . We’re missing the point if we don’t integrate the whole industry.”

But this scale requires significant investment; whereas Davis started the business with US\$600,000 of personal money and US\$200,000 from donors, he has suggested that nationwide rollouts require US\$1 million in funding. The money goes toward new hardware and for staff to

operate the hardware and work in the commodity markets collecting prices and news. To support this activity, in addition to the tiered subscriptions mentioned above, Esoko pursues public-private partnerships (Donner 2009). Partnerships are key, with governments, donors, and the Esoko Networks, a group of affiliated companies, using and building upon the platform. Esoko demonstrates that finding the right business model is not easy, but donors and government have a role in supporting new interventions.

Topic Note 3.2: TWO TYPOLOGIES AND GENERAL PRINCIPLES FOR USING MOBILE PHONES IN AGRICULTURAL PROJECTS

TRENDS AND ISSUES

As governments, donors, NGOs, and private firms attempt to use this popular technology for development goals, researchers are developing frameworks to make sense of these initiatives and help design new ones. This topic note reviews two such typologies. The first focuses on the services that operate through mobile phones to improve aspects of agricultural livelihoods. The second focuses on the various forms that mobile applications might take to develop the agricultural sector. Both of these approaches may be useful when considering programs to use mobile phones. This note also reviews principles for designing a program to use mobile phones in agriculture, based on what has been learned to date.

Typology 1: A Focus on Mobile Livelihood Services

Jonathan Donner, a researcher with the Technology for Emerging Markets Group at Microsoft Research India, has developed a framework that examines the various livelihood services available to mobile phone users in the developing world (Donner 2009) (table 3.1). His survey finds six types of “mobile livelihood” services—mediated agricultural extension, market information systems, virtual marketplaces, comprehensive services, financial services, and direct livelihood support—and five possible effects—improving internal activities, adding market information, adding market participants, bypassing middlemen, and starting businesses. Note that

TABLE 3.1. The Impact of Mobile-Based Livelihood Services

SERVICE	IMPROVE INTERNAL ACTIVITIES	ADD MARKET INFORMATION	ADD MARKET PARTICIPANTS	BYPASS INTERMEDIARIES	START BUSINESSES
Mediated agricultural extension (e.g., Collecting and Exchange of Local Agricultural Content—CELAC, http://celac.or.ug/)	X	X			
Market information systems (e.g., Kenyan Agricultural Commodities Exchange Program—KACE, http://www.kacekenya.co.ke/)		X			
Virtual marketplaces (e.g., Google Trader, http://www.google.co.ug/africa/trader/home)		X	X	Sometimes	
Comprehensive services (e.g., Manobi or Esoko— http://www.manobi.net/worldwide/ ; http://www.esoko.com/)	X	X	X	Sometimes	
Financial services (e.g., M-PESA, http://www.safaricom.co.ke/index.php?id=250)	X		X		
Direct livelihood support (e.g., txteagle, http://txteagle.com/)				X	X

Source: Adapted from Donner 2009.

Note: For more information on M-PESA, see “M-PESA’s Pioneering Money Transfer Service,” in Module 2; for txteagle, see “Txteagle Taps a Vast Underused Workforce,” in Module 2.

although many livelihood services are bound to have more than one effect—it is perfectly plausible that a service that provides market information will also draw new participants into the market and help farmers bypass intermediaries—table 3.1 emphasizes the main areas of impact.

Typology 2: A Focus on Mobile Applications for Agriculture

Alternatively, Kerry McNamara has suggested four categories for understanding the forms that mobile applications may take to help the agricultural sector (Hellstrom 2010) (table 3.2). Mobile agricultural applications, in this framework, may (1) educate and raise awareness, (2) distribute price information, (3) collect data, and (4) track pests and diseases.

TABLE 3.2. Various Roles for Mobile Phones in Agriculture

GOAL	METHOD
Education and awareness	Information provided via mobile phones to farmers and extension agents about good practices, improved crop varieties, and pest or disease management.
Commodity prices and market information	Prices in regional markets to inform decision making throughout the entire agricultural process.
Data collection	Applications that collect data from large geographic regions.
Pest and disease outbreak warning and tracking	Send and receive data on outbreaks.

Source: Hellstrom 2010.

PRINCIPLES FOR DESIGNING A PROGRAM USING MOBILE PHONES IN AGRICULTURE

The use of mobile phones in agriculture, though relatively new, has already witnessed failure as well as success. What separates the two outcomes may often be unpredictable and locally nuanced factors, but a survey of what has been learned indicates that a number of principles can improve the chances of sustainable impact.

Understand Users and the Technology

Time and again, interventions have failed to gain traction because users' needs and practices were incompletely understood. In technological interventions, this risk is even more of a concern. Practitioners need to think carefully about why mobile phones are the technology of choice and consider alternatives, from the cutting edge to the mundane.

Farmers already have information sources and learning opportunities, so it is best to avoid reinventing the wheel if a mobile intervention will not significantly improve upon the experience.

Mobile phones are far from unitary, as box 3.3 shows, and an understanding of the platform's strengths and limitations is essential. For example, while it is ubiquitous, SMS is limited to 160 characters. Although the mobile Internet is still limited in scale and is often confusing to users, it can be sophisticated and is spreading; in fact, some research has even shown more impact from the Internet than mobile phones, so their convergence is an exciting opportunity (Goyal 2010). There is always a risk that new technologies serve to blind the development community to more tried-and-true methods, so considering how mobile phones fit with needs and existing practices is a key initial step.

Engage in Participatory, Iterative Project Design

Understanding local needs is a difficult task that can be made easier by directly involving communities in the design and implementation of interventions. In addition to surveys of global and regional activities (such as this Sourcebook), on-the-ground analysis is needed. Partnerships with local organizations, extensive fieldwork, and interactive design sessions offer ways to understand the subtle differences between agricultural subsectors and regions. Trying to “do everything” has doomed projects, while initiatives that start small and focused (such as M-PESA, which began with peer-to-peer money transfers) can evolve into diverse offerings (purchases, credit, and savings). One example of a small, focused program comes from Chile, where a small cooperative receives critical information for production and marketing.

Development practitioners can also learn from software developers who practice the mantra “release early and often,” meaning that “good enough” prototypes should be piloted and improved in a rapid feedback loop. The risk with this practice is that it may confuse communities that may not understand the process; but if the goal of the project is to reach considerable scale, using a small pilot and focus groups to improve earlier versions is a worthy practice.

Bringing communities into the early stages of the project can also foster local ownership, a key component of sustainability. This principle is closely aligned with the need to “go beyond the technology” and focus on people. For example, a lack of cultural awareness almost caused Text to Change, a Dutch NGO working in Uganda, to derail an effort to provide

HIV/AIDS information via SMS. Only on the morning of the program's launch did the NGO finally realize that the SMS code assigned to it was 666—locally known as “the devil's number”—and have to scramble to receive a new number to avoid upsetting Christian partners and users.⁷

Mobile phones, like other technologies, are not silver bullets, but instead are tools that will be shaped by social conditions. Practitioners attempting to integrate mobile phones with agricultural communities need to design their programs for equitable access.

Identify Partners with the Appropriate Knowledge, Collaborative Capacity, and Alignment of Goals

As the innovative practice summaries in this module indicate, it is unlikely that any one organization—whether an NGO, ministry, donor, or private firm—will have all of the expertise required to succeed in designing and implementing successful mobile phone interventions in agriculture. Partners should be chosen for their specialized knowledge, willingness to collaborate, and alignment of goals. Special care should be taken at the very beginning of project planning to ensure that the key stakeholders will work together positively.

Projects must seek to leverage trusted intermediaries. One example discussed in this module is Kilimo Salama, which relies on the trusted M-PESA money transfer service and agricultural input suppliers to offer weather insurance to farmers (box 3.6). Another is IFFCO Kisan Sanchar Limited. The partners behind this service (which provides market information and agricultural advisory services) are IFFCO, a well-known farmers' cooperative organization that maintains a presence in 98 percent of India's villages, and Bharti Airtel, a large mobile network operator (MNO) (for details, see IPS “Long Experience in Farm Communities Benefits IFFCO Kisan Sanchar Limited,” in Topic Note 2.4).

By their very nature, most agricultural services using mobile phones partner with at least one MNO. For the network operator, the services are a way to boost rural subscribers (an important source of growth) and decrease customer turnover. This objective does not necessarily mean that the network operator has any interest in farmers' livelihoods (although it may), and partners should be cognizant of potentially conflicting motivations. That said, operator buy-in can be a powerful benefit, especially through distribution and marketing. Zain Zap, the mobile international banking service, operates in

BOX 3.6. Kilimo Salama Demonstrates the Convergence of Mobile Phones and Sophisticated Mobile Services

Kilimo Salama (“safe farming” in Kiswahili) is an innovative program operated by Safaricom (Kenya's largest MNO), Syngenta Foundation (the foundation established by the Swiss agribusiness), and UAP Insurance. The initiative delivers crop insurance to smallholder farmers in rural Kenya through the use of mobile phones. Farmers insure their crops with Kilimo Salama when they purchase seed and fertilizer from registered vendors. The vendors are equipped with a camera phone loaded with special software. At the time of sale, the salesperson takes a picture of a special barcode on the products, and an SMS is sent to the farmer's phone confirming the insurance policy. For their work, agents receive a commission. Pricing has changed; the premium was originally subsidized, but in mid-2011, farmers were paying a 10 percent insurance premium.

The Kilimo Salama system relies on weather stations in each agricultural region to measure rainfall and other climate information. When conditions fall below historical benchmarks for farming (indicating that crops will be lost and inputs wasted), the service automatically pays insured customers in that region, using the M-PESA mobile money service.

Kilimo Salama demonstrates the potential for mobile phones and services (such as mobile money) to deliver sophisticated financial products to smallholders, and it underlines the importance of distribution channels and product reliability. Affordability and trust remain obstacles, especially if farmers dispute payouts from the system.

Source: Author, based on IFC Advisory Services 2011.

rural areas where commercial banks have few or no physical branches and benefits from Zain's vast international One Network (see IPS “Zain Zap Promotes Borderless Mobile Commerce,” in Topic Note 2.3). Partnering with private firms, including MNOs and input suppliers, is often required for mobile phones—for-agriculture interventions to endure.

Ensure That the Technology Is Widely Accessible

Mobile phones represent a great opportunity for agricultural interventions because they are one of the most accessible

⁷ See <<http://failfaire.org/2010/10/15/brilliant-fails-in-m4d/>>.

information platforms available, although barriers do remain. They can take the form of illiteracy or prohibitive cost, or they can be technical or cultural (image 3.2). Given the tenuous nature of smallholders' livelihoods and the lack of social safety nets, many smallholders are particularly risk averse. They are unlikely to participate in a new initiative without significant education, advertising, and local support. Even those who wish to use a mobile intervention may be frustrated if the program is not widely available. Nokia's Life Tools application is intentionally designed to be widely available on its low-cost handsets and fill a gap in low-income communities with a large latent demand for information.

IMAGE 3.2. Other Challenges, Like Inadequate Transportation, Affect Mobile Phone Success



Source: Mano Strauch, World Bank.

Projects that are exclusive to one MNO or a specific type of phone may face implicit barriers to adoption. Open technological standards and free and open source software can be used to reach a wider audience and avoid lock-in. They can do much to enable unanticipated user innovation. For example, individuals around the world save money through “beeping,” or intentionally missed calls that communicate predetermined messages without using expensive airtime. Elsewhere, users send money through unofficial routes using airtime transfers. Given flexibility and understanding, communities will provide innovative solutions for their needs.

Sustainability Based on a Viable Business Plan

Sustainable agricultural projects are key to long-term growth and livelihood improvements, but often projects fail to

continue for an extended term. It is essential to develop a viable business plan from the very conception of a project to use mobile phones in agriculture. Such a plan requires a clear understanding of who will pay—the government, end users, cooperatives, or a combination, for example—and how much they are willing to pay for a service. Farmers are willing to pay for timely and contextual information, but different strategies may be needed to encourage poorer farmers to use a service (such as payments per query rather than a long-term subscription). The Reuters Market Light service offers a range of price and service formats to accommodate a wide range of clients.

Innovation in technology is often less important than innovation in the business model; prepaid mobile airtime was arguably more important than low-cost devices in enabling mobile phones to spread. When Google introduced three mobile applications in Uganda for free, they gained significant traction; but when fees were introduced, usage dropped, indicating failure to accurately gauge the appeal of the service and willingness to pay (Kubzansky, Cooper, and Barbary 2011).

Market-based solutions can be more sustainable, but donors and governments often remain important as anchor buyers or subsidizers (see IPS “Mobile Phones Are the Heart of Esoko’s Virtual Marketplace,” in Topic Note 3.1). When interventions are not undertaken for profit, they can benefit from approaches commonly used in the private sector, such as advertising to stimulate demand, rigorous benchmarking, market segmentation, and documenting failures as well as successes for internal and external learning.

Monitoring and Evaluation

Although mobile phones have had positive impacts on agriculture, a better understanding of these outcomes would help in designing new interventions. A recent review of ICT-based interventions in agriculture suggests a number of questions to address (Aker 2010b):

- What is the impact of ICT on farmers’ knowledge, agricultural practices, and welfare?
- Are the observed changes due to the ICT or something else?
- What is the causal mechanism behind the effect?
- How does the impact differ between both farmers and the type of information provided?

- What are the potential spillovers or unintended consequences for participants and nonparticipants?
- Is the ICT-based approach cost-effective relative to other, more traditional, interventions?
- Do the results transfer to different regions and contexts?

LESSONS LEARNED

Although mobile phones continue to evolve quite rapidly, the evidence suggests that they can promote improved livelihoods through networking and informing previously unconnected portions of the population. The evidence comes from users' own rapid grasp of the technology's potential (Kerala's fishers using phones to seek optimal markets for their catch) and from planned efforts originating from commercial information providers and development practitioners (as in the market information and insurance programs described in the innovative practice summaries that follow).

Improving agricultural productivity is one of the most pressing issues for developing regions. Although mobile phones are no silver bullet, their widespread availability and flexibility position the technology as a necessary component of sustainable improvements in agriculture. Coupled with corresponding innovation in existing social and institutional arrangements, mobile phones have the potential to make significant contributions. As mobile phones converge with other mobile devices such as netbooks and tablets, the opportunities will proliferate.

For donors, governments, NGOs, and private entities working to promote better agricultural policies, current efforts offer much to learn. Designing programs and initiatives in a careful, flexible manner will enable rural communities to adopt and use new technologies and methods to improve their lives.

INNOVATIVE PRACTICE SUMMARY

Mobile Service Gives Local and Global Edge to Chilean Farmers

In Chile, the Mobile Information Project (MIP) delivers targeted agricultural information from the Web directly to farmers, using software to create news channels on

mobile phones.⁸ The software, developed by DataDyne (a nonprofit organization based in the United States), organizes searchable content from the Internet into news feeds (RSS) and then transmits that content to farmers via SMS messages. The system was designed to work on simple mobile phones that sell for US\$15–20 in Chile and operate effectively even over slow networks with intermittent connectivity.

MIP solved the challenge of sending information from the Internet via SMS messages; the next challenge was to ensure that the content was valuable to the user. Because text messages transmit a maximum of 160 characters, there is no guarantee that messages contain useful information. Even when a system chooses relevant information, the first 160 characters may not accurately convey its meaning.

Starting Small: A Pilot with a Small Cooperative

To test the system, a pilot project, DatAgro, was set up in early 2009 between DataDyne and an agricultural cooperative in the Cachapoal Valley, two hours south of the capital, Santiago. The cooperative, Coopeumo, has just under 350 small-scale farmer members, most of whom grow maize and some other crops. Members' coop dues covered the cost of the new SMS system. There was no extra subscription fee and no charge for the text messages (the current cost of US\$0.06 is borne by the coop). Training sessions were held at the beginning of the project to teach farmers how to send and receive text messages. Most coop members are men, and thus about 90 percent of those receiving training were men.

Coopeumo farmers received weather, news, sports, and other information via SMS. The information came from several sources. Two of the project's partners, UNESCO and Chile's Foundation for Agricultural Innovation (FIA),⁹ created messages based on work already done but not yet shared with the community. Two national newspapers sent news to the system. Users could customize the feeds they subscribed to and could rate the messages they found the most helpful.

8 This summary is based on information from Cagley (2010) and personal communication with John Zoltner, DataDyne.org.

9 UNESCO = United Nations Educational, Scientific, and Cultural Organization; FIA = Fundación para la Innovación Agraria.

Impact: Local and Global Advantages

In less than a year, the DatAgro service proved popular. One Coopeumo member, Hugo Tobar, reported that his entire crop for 2009 was saved by an SMS message that urged him to delay planting because of impending bad weather. Torrential rain during the next week would have washed his seedlings away.

Ricardo Danessi, executive manager of Coopeumo, said, “Our farmers can now find information about supply prices, product prices, the weather, and what’s going on in international markets. That’s important, because today, everything that goes on outside Chile also affects us. When there’s an excess of production in one place, the prices go down here. Or when there is a sudden disaster or catastrophe somewhere else, the prices improve here. When demand goes up in China or India, the prices here get better. Everything is related in this connected world, and small-scale farmers aren’t left out of that reality” (quoted by Cagley 2010).

Sustaining the Gains and Scaling Up

Farmers have stressed the importance of the information they receive and the convenience of the MIP platform. Since the end of the pilot project, Coopeumo has assumed responsibility for creating, sending, and paying for the SMS messages. The only ongoing cost to DataDyne is the incremental cost of maintaining and continuing to improve MIP. Developing the MIP platform, testing it in the field, and local implementation cost a little over US\$200,000.

Looking to the future, DataDyne plans to expand the use of MIP based on use of the successful mobile data collection tool, EpiSurveyor (<http://www.episurveyor.org>). EpiSurveyor, available via the Internet, can be used free of charge by everyone who wants to collect data, unless they have very heavy needs or require new functions. After a little more than a year, more than 2,500 organizations in more than 140 countries are using EpiSurveyor, 99 percent of them for free. The same model will be used for MIP. If new functions are needed, DataDyne can tailor the system accordingly and charge a fee for doing so, but it will automatically make the new functions available for free to other users. In the case of heavy data requirements, DataDyne will charge a US\$5,000 annual license fee. There will also be a charge related to the cost of SMS messages, because the telecoms companies have to be paid to transmit the messages.

The experience in Chile suggests that disseminating information via simple mobile phones is a good way to reach farmers in areas where Internet facilities are unlikely to be provided in the near future. Refinements to the system should make it easier to provide relevant content to each individual, and a current challenge is to tailor the content automatically; when information is mediated by a human editor, bottlenecks can be introduced.

INNOVATIVE PRACTICE SUMMARY For Reuters Market Light, the Wider Network of People Matters

While on a fellowship at Stanford University, a Reuters employee hit upon the idea of offering highly customizable market information to farmers through the increasingly ubiquitous platform of mobile phones. From this initial idea, the international news giant launched Reuters Market Light (RML) in 2007 to provide market prices, weather, and crop advisory services to farmers in India. This launch was preceded by 18 months of market research, tests, and pilot programs to refine the idea and tailor it to the local context (LIRNEasia 2008).

To subscribe, a farmer calls a toll-free number to activate the service in the local language and specify the crops and markets in which he or she has an interest. Throughout the subscription, farmers receive four to five SMS alerts with relevant information throughout the day. According to RML’s managing director, Amit Mehra, the pilot farmers greatly preferred automated messages instead of having to ask for them. Initial studies show that farmers who receive the service are receiving 5–10 percent more income. (See IPS “Impact of Immediate Market Information in Asia and Africa,” in Topic Note 9.3, for additional details on farmers’ gains through RML.)

Impact

Today, the RML application is one of India’s largest market information services, serving hundreds of thousands of paying customers in tens of thousands of villages. Via SMS, it delivers highly personalized, professional information to India’s farming community, covering more than 250 crops, 1,000 markets, and 3,000 weather locations across 13 Indian states in 8 local languages (Mehra 2010) (image 13.3). The impact is likely even larger than Reuters can count, due to the widespread sharing of

IMAGE 3.3. The Reuters Market Light Interface

Source: Medianama.

information that takes place within informal farmer networks. Additionally, RML today has hundreds of employees, many of whom are trained as dedicated price collectors in markets throughout India.

Continuing Competition for Clients

Reuters Market Light has sought to reach as many customers as possible through a number of strategies. RML has attempted to avoid exclusive partnerships with MNOs, though in some cases it has found that telecommunications firms provide a strong value proposition (notably through sales reach and by providing a subscriber catalog that could lessen customer turnover). To make it easy for unregistered users to try the service before committing to a subscription, RML has set up sales offices through the postal network, local shops, input suppliers, and banks. Customers can obtain RML in basic SMS through prepaid scratch cards that give access to the service for a given amount of time—initially only 1 month; but now 3, 6, and 12 months. After much experimentation, pricing has settled at Rs 60, 175, 350, and 650, respectively. (For details of the technology and business model, see IPS “First-Mover Advantage Benefits Reuters Market Light,” in Topic Note 2.4 in Module 2.)

Although a leading example, RML is hardly a monopoly. It competes with both traditional information services (radio, market intermediaries, newspapers) and other services that use mobile phones. IFFCO Kisan Sanchar Limited (IKSL) offers similar market information for rural farmers but uses voice messages so that illiterate farmers are able to use the

service. Best of all, the service is free and benefits from its partnership with India’s largest MNO (Bharti Airtel), which views the service as a way to attract new customers in rural areas.

According to Mehra, reaching economies of scale is essential for profitability. Media reports suggest that RML had invested US\$2 million by late 2009 and expected to break even within a few more years. In 2009, RML reportedly crossed the US\$1 million sales mark. Farmers seem willing to pay for the service—indeed, they are paying for longer periods of service than they were before. Up to 2008, most farmers purchased quarterly installments of the service. But by 2009, the half-year and one-year plans were becoming more popular (Preethi 2009). It also partnered with Nokia as an information supplier for Nokia’s Life Tools application. There are plans to bring the service to Afghanistan and Africa (Reuters Market Light 2009).

Providing Customized Information Requires a Wide Network of People

RML and its competitors suffer from the high expense of collecting market information and maintaining a sophisticated technological infrastructure. RML sources information from various content providers and sorts, organizes, and personalizes it for dissemination. A significant portion of this information comes through partnerships with agricultural institutes. These institutes are typically funded by the government but lack the means to disseminate the information. Students and researchers in these institutes contribute content relevant to RML, which includes it in their package and delivers it to farmers (Preethi 2009).

To process the information, RML employs over 300 office staff in eight states. The teams are organized according to content area and include a news division that scours media sources for agricultural news (pest and disease reports, government programs, weather reports, and local news). The information is finely sorted by geography. Farmers are informed if a particular market in a village is closed or if a pest or disease could affect their specific crops (Preethi 2009).

The importance of customized information is highly evident in RML's operations. As much as technical acumen is important in mobile phone interventions, RML shows that a wide network of people—in this case, price collectors, agricultural institutes, and other information providers—is another essential ingredient.

INNOVATIVE PRACTICE SUMMARY

Nokia Life Tools Uses Simple Technologies to Deliver New Functionality

Nokia is famous for making the low-cost handsets that sit in more pockets than the products of any other manufacturer.¹⁰ More recently, the Finnish mobile phone maker has begun developing mobile applications for its phones, and low-income communities are one of its primary audiences. The most notable of these efforts is Nokia Life Tools, unveiled in mid-2009 for the Indian market and subsequently expanded to other countries (China, Indonesia, and Nigeria) (O'Brien 2010).

Life Tools is aimed at rural, predominantly agricultural communities in the developing world. It is available on a number of Nokia handsets that retail for much less than US\$50, and despite the application's rich graphic elements (image 3.4), it uses SMS to communicate, making it affordable and widely accessible. Additionally, because SMS can be delayed, users need not have perpetual network coverage. The application is a prime example of how simple technologies can be tweaked to bring about new functionality.

In India, Nokia has collaborated with multiple partners across the Indian government and private enterprises—including Tata DOCOMO, MSAMB, Syngenta, Pearson, RML, and

EnableM—to create a rich ecosystem to deliver the services. Content is divided into:

- **Basic agriculture**, at Rs 30 per month, provides tips on technique and news.
- **Premium agriculture**, at Rs 60 per month, additionally offers market prices and weather updates.
- **Education**, also Rs 30 per month, provides simple English courses and exam preparation services. For an additional Rs 30, the General Knowledge option provides daily world news.
- **Entertainment**, at Rs 30 per month, provides regional news, astrological predictions, cricket news, and ring-tone downloads.

The agriculture service, available across 18 states, offers two plans. The basic plan, at Rs 30 per month, provides daily weather updates and agricultural news, advice, and tips. The premium plan, at Rs 60 per month, provides the closest market prices for three crops chosen by the subscriber, as well as weather information, news, advice, and tips. Nokia Life Tools supports 11 Indian languages: Hindi, Malayalam, Kannada, Tamil, Telugu, Punjabi, Marathi, Bengali, Gujarati, Oriya, and English.

Because most subscribers are prepaid users who do not have a contract, the charges are subtracted weekly. To facilitate this payment, Nokia has partnered with the MNO IDEA Cellular.

IMAGE 3.4. The Agriculture Package in Nokia LifeTools



Source: Nokia.

¹⁰ The material for this case study was drawn primarily from Koh (2009).

Nokia believes that hyperlocalization is key to the success of this service. The Indian application was launched with nine local languages, and future expansions will reformulate Life Tools for the unique conditions of new countries and regions.

The key lesson is that Nokia's mobile application recognizes the multiplicity of human interests: Packaging agricultural information with entertainment can drive adoption (a lesson learned by MxIt as well). Nokia also has shown that partnerships are a viable alternative to going it alone.

REFERENCES

- Aker, J.C. 2010a. "Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger." *American Economic Journal: Applied Economics* 2 (3): 46–59.
- . 2010b. "Dial 'A' for Agriculture: A Review of Information and Communication Technologies for Agricultural Extension in Developing Countries." *Agricultural Economics*.
- Bartlett, S. 2008. "Making the Marketplace Mobile." ICT Update 44. <http://ictupdate.cta.int/en/Feature-Articles/Making-the-marketplace-mobile>, accessed May 2011.
- Cagley, M. 2010. "From the Web to the Phone." ICT Update. <http://ictupdate.cta.int/en/Feature-Articles/From-the-web-to-the-phone>, accessed May 2011.
- Cisco. 2010. "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010–2015." Cisco, San Jose. http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.pdf, accessed July 2011.
- De Silva, H., and D. Ratnadiwakara. 2008. "Using ICT to Reduce Transaction Costs in Agriculture Through Better Communication: A Case-Study from Sri Lanka." LIRNEasia. <http://www.lirneasia.net/wp-content/uploads/2008/11/transactioncosts.pdf>, accessed May 2011.
- Donner, J. 2009. "Mobile-Based Livelihood Services in Africa: Pilots and Early Deployments." In *Communication Technologies in Latin America and Africa: A Multidisciplinary Perspective*, edited by M. Fernández-Ardévol and A. Ros, 37–58. Barcelona: IN3.
- Economist, The*. 2010. "The Next Billion Geeks: How the Mobile Internet Will Transform the BRIC Countries." September 2. <http://www.economist.com/node/16944020>, accessed July 2011.
- Esoko. 2010. "African Farmers Get Boost from IFC, Soros Economic Development Fund, and Esoko." Press release, November 22. http://www.esoko.com/about/news/pressreleases/2010_10_22_Esoko_IFC_SEDF_Investment.pdf, accessed May 2011.
- Fafchamps, M., and R. Vargas Hill. 2004. "Selling at the Farm-Gate or Travelling to Market." CSAE Working Paper Series 2004-30, Centre for the Study of African Economies, University of Oxford, Oxford.
- Ferris, S., P. Engoru, and E. Kaganzi. 2008. "Making Market Information Services Work Better for the Poor in Uganda." CAPRI Working Paper 77, CGIAR Systemwide Program on Collective Action and Property Rights (CAPRI), Washington, DC.
- Goyal, A. 2010. "Information, Direct Access to Farmers, and Rural Market Performance in Central India." *American Economic Journal: Applied Economics* 2 (3): 22–45.
- Gakuru, M., K. Winters, and F. Stepman. 2009. "Inventory of Innovative Farmer Advisory Services Using ICTs." Paper presented at the W3C Workshop on Africa Perspective on the Role of Mobile Technologies in Fostering Social Development, April 1–2, Maputo. http://www.w3.org/2008/10/MW4D_WS/papers/fara.pdf, accessed May 2011.
- Hellstrom, J. 2010. *The Innovative Use of Mobile Applications in East Africa*. Stockholm: Swedish International Development Cooperation Agency.
- Heeks, R. 2008. "Mobiles for Impoverishment?" Blog post, ICTs for Development, December 27. <http://ict4dblog.wordpress.com/2008/12/27/mobiles-for-impoverishment>, accessed May 2011.
- IFC Advisory Services. 2011. "Kilimo Salama: Index-Based Agriculture Insurance: A Product Design Case Study." Washington, DC. <[http://www.ifc.org/ifcext/globalfm.nsf/AttachmentsByTitle/Kilimo+Salama%E2%80%93Index-based+Agriculture+Insurance/\\$FILE/Kilimo+Salama%E2%80%93Index-based+Agriculture+Insurance-Final.pdf](http://www.ifc.org/ifcext/globalfm.nsf/AttachmentsByTitle/Kilimo+Salama%E2%80%93Index-based+Agriculture+Insurance/$FILE/Kilimo+Salama%E2%80%93Index-based+Agriculture+Insurance-Final.pdf)>.
- Ilahiane, H. 2007. "Impacts of Information and Communication Technologies in Agriculture: Farmers and Mobile Phones in Morocco." Paper presented at the Annual Meetings of the American Anthropological Association, Washington, DC.
- IT News Online. 2010. "Nokia, Tata DOCOMO to Offer Ovi Life Tools in Rural, Semi-Urban India." *IT News Online*, July 20. <http://www.itnewsonline.com/news/Nokia,-Tata-DOCOMO-to-Offer-Ovi-Life-Tools-in-Rural,-Semi-Urban-India/19934/7/1>, accessed May.
- Jensen, R. 2007. "The Digital Divide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector." *Quarterly Journal of Economics* 122 (3): 879–924.
- Koh, D. 2009. "Case Study: Nokia Life Tools." *CNET Asia*, October 20. <http://asia.cnet.com/reviews/mobilephones/0,39050603,62058745,00.htm>, accessed May 2011.
- Kubzansky, M., A. Cooper, and V. Barbary. 2011. *Promise and Progress: Market-Based Solutions to Poverty in Africa*. Cambridge: Monitor Group.
- Labonne, J., and R. S. Chase. 2009. "The Power of Information: The Impact of Mobile Phones on Farmers' Welfare in the Philippines." Policy Research Working Paper 996, World Bank, Washington, DC.
- Ling, R., and Donner. 2009. *Mobile Communication*. Cambridge: Polity.

- LIRNEasia. 2008. "Agricultural VAS through Mobile 2.0." Policy Brief. http://www.lirneasia.net/wp-content/uploads/2008/05/Agriculture_VAS_briefV2.pdf, accessed May 2011.
- Magada, D. 2009. "Esoko: The New Market Info System for African Farmers." *BNET*, May 2009. http://findarticles.com/p/articles/mi_qa5327/is_353/ai_n31882131/, accessed May 2011.
- Mehra, A. 2010. "Small Technologies Fuel Big Results in the Developing World." *Huffington Post*, September 13. http://www.huffingtonpost.com/amit-mehra/small-technologies-fuel-b_b_715274.html, accessed October 2010.
- Muto, M., and T. Yamano. 2009. "The Impact of Mobile Phone Coverage Expansion on Market Participation: Panel Data Evidence from Uganda." *World Development* 37 (12): 1887–96.
- O'Brien, K. J. 2010. "Nokia Taking a Rural Road to Growth." *New York Times*, November 1. <http://www.nytimes.com/2010/11/02/technology/02nokia.html>, accessed May 2011.
- Overa, R. 2006. "Networks, Distance, and Trust: Telecommunications Development and Changing Trading Practices in Ghana." *World Development* 34 (7): 1301–15.
- Preethi, J. 2009. "Reuters Market Light Goes Pan-India with Nokia." *MediaNama*, <http://www.medianama.com/2009/04/223-reuters-market-light-goes-to-himachal-pan-india-with-nokia-txt-vs-gprs-vs-voice/>, accessed October 2010.
- Ratnadiwakara, D., H. de Silva, and S. Soysa. 2008. "Transaction Costs in Agriculture: From the Planting Decision to Selling at the Wholesale Market—A Case-Study on the Feeder Area of the Dambulla Dedicated Economic Centre in Sri Lanka." LIRNEasia.
- Reuben, Abraham. 2007. "Mobile Phones and Economic Development: Evidence from the Fishing Industry in India." *Information Technologies and International Development* 4 (1): pp 5–17.
- Reuters Market Light. 2009. "IDEA Partners with Reuters Market Light to Launch a Unique Service for Rural Markets." Press Release. <http://www.1888pressrelease.com/idea-partners-with-reuters-market-light-to-launch-a-unique-s-pr-148099.html>, accessed October 7, 2010.
- World Bank. 2010. "New Uses for Global Forecasts: FY 10 ECA Innovation Grant." Istanbul.

Module 4 **EXTENDING THE BENEFITS— GENDER-EQUITABLE, ICT-ENABLED AGRICULTURAL DEVELOPMENT**

SOPHIE TREINEN (FAO) and ALICE VAN DER ELSTRAETEN (FAO)

IN THIS MODULE

Overview. While the digital revolution is reaching rural areas in many developing countries, the rural-urban digital divide remains, and rural women face a triple divide: digital, rural, and gender. This module looks at the benefits of ICT when placed in the hands of men and women working in agriculture and rural areas. It examines the challenges that must be overcome and provides recommendations for rural communities to take full and equal advantage of ICT.

Topic Note 4.1: Mobile Finance and Gender in Rural Areas. Bypassing social restrictions on mobility and traditional legal barriers to account ownership, new mobile finance services significantly boost women's economic empowerment and entrepreneurship, allowing them to save and transfer money, process financial transactions, and receive credit. Development practitioners are well aware of the potential of mobile finance, especially for rural and agricultural development, and are seeking to create an enabling environment in which appropriate mobile financial services are widely available at a reasonable cost for providers and customers.

- **Designing Mobile Finance Products for Rural Women in Zimbabwe**

Topic Note 4.2: Mobile Learning, Gender, and Agriculture. Mobile learning expands the learning opportunities available to rural communities, enabling them to access educational resources, create communities of learners to share information, and create content, both inside and outside classrooms. Mobile learning can help rural women improve skills and knowledge in agriculture, business, and nutrition that are vital to their livelihoods and the well-being of their families. Addressing social barriers to mobile learning at the community level—with the involvement of both men and women—is likely to have the greatest impact on women's capacity to take advantage of mobile learning.

- **Dimitra Clubs: Rural Communities Learn and Mobilize for Change with Participatory Communication Technology**
- **Participatory Community Video Highlights Local Agriculture-Nutrition Links and Best Practices for Health**
- **Talking Books Deliver Valuable Advice, No Reading Required**

OVERVIEW

The importance of achieving gender equality and the empowerment of all women and girls (Millennium Development Goal 5) was reconfirmed by the international community in the 2030 Agenda by dedicating one of the 17 Sustainable Development Goals to the issue. Goal 5 now includes a specific target related to ICT. Target 5.b aims at enhancing the use of enabling technology, in particular ICT, to promote the empowerment of women (UN 2015).

The previous version (2009) was written by Cristina Manfre (Cultural Practice, LLC) with contributions from Pietro Aldobrandini (FAO), Christiane Monsieur (FAO), Clare Pedrick (FAO), and Gerard Sylvester (FAO).

Gender in Agriculture

Women play a central role in agricultural development throughout the world. On average, they make up 43 percent of the agricultural labor force in developing countries, ranging from 20 percent in Latin America to almost 50 percent in East and Southeast Asia and Sub-Saharan Africa. FAO (2012) asserts that “the empowerment of women could raise farm productivity by 20–30 percent, increase national agricultural outputs by 2.5 to 4.0 percent and ultimately, lift 100 to 150 million of people out of hunger.”¹ Although women are major producers of food crops in most of the world, they lag well behind men in terms of access to land, productive resources,

1 “International Women’s Day: FAO Gender Policy Aims High” (FAO 2012).

income from land, education, financial services, information, and the ability to share and learn from this knowledge (FAO 2011, 2017). Technology, including ICT, can empower women to close these gaps—which is why the gender-equitable use of ICT is now recognized as an integral part of sustainable development.

Gender and ICT

In 2015, FAO reviewed the use of ICT in agriculture over the previous decade.² The review concluded that despite substantial progress in making ICT available and accessible for rural communities, challenges remain with regard to seven critical success factors (FAO 2015b, 2017) (box 4.1).

The presence of *gender and diversity* as one of the critical factors and remaining challenges to using ICT successfully in

agriculture highlights the fact that access and opportunities are not distributed equally among users, creating asymmetries that must be addressed with specific policies targeting the sources of the inequalities. For example, access for women, youths, older farmers, and individuals in the most remote areas is hindered by the cost of using ICT and by the persistent inequalities that these groups face. Gender inequalities remain a serious issue in the digital economy, along with the gap between urban and rural populations. The digital divide is not exclusively related to technological infrastructure and connectivity. It is a multifaceted problem of ineffective knowledge exchange and management of information content, insufficient human resources and institutional capacity, and the lack of sensitivity to gender and the diverse needs of different groups. For example, the digital skills of illiterate and older farmers are less developed, so they are less likely to adopt ICT (FAO 2015b, 2017). The many facets of the digital divide are illustrated in box 4.2, figure 4.1, and image 4.1.

BOX 4.1. Seven Critical Factors for the Success of ICT in Agriculture

1. Provide adapted and reliable content from trusted sources.
2. Develop capacities for three dimensions: the individual's capacity, organizational capacity, and the enabling environment.
3. Mainstream gender and diversity.
4. Increase access and participation.
5. Engage in partnerships, especially public-private.
6. Identify the right mix of technologies.
7. Ensure economic, social, and environmental sustainability.

Source: FAO 2015b.

² The review (FAO 2015b) reported on the implementation of Action Line C7 (ICT Applications: e-agriculture), adopted by the World Summit on the Information Society (WSIS). The Tunis Agenda for the Information Society states that the WSIS implementation mechanism at the international level should be organized taking into account the themes and action lines in the Geneva Plan of Action, and moderated or facilitated by UN agencies when appropriate. The WSIS action lines are: C1. The role of public governance authorities and all stakeholders in the promotion of ICT for development; C2. Information and communication infrastructure; C3. Access to information and knowledge; C4. Capacity building; C5. Building confidence and security in the use of ICT; C6. Enabling environment; C7. ICT Applications: E-government, E-business, E-learning, E-health, E-employment, E-environment, E-agriculture, E-science; C8. Cultural diversity and identity, linguistic diversity and local content; C9. Media; C10. Ethical dimensions of the Information Society; and C11. International and regional cooperation.

Many factors that constrain men farmers from adopting more sustainable and productive practices constrain women even more. Specific gender barriers further limit women farmers' capacity to innovate and become more productive. Young people's access to and familiarity with technologies, as well as their role in the social dynamics of rural communities, are not sufficiently leveraged. For these reasons, gender, youth, and diversity should be addressed systematically in development projects—not only in the initial design and planning phase but also throughout the life of the project. Access to technology and equipment among females and young people, as well as

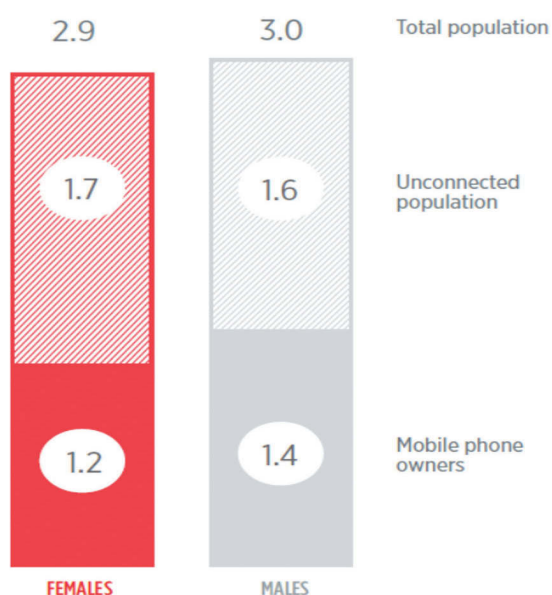
BOX 4.2. The Gender Divide in Numbers

- 1.2 out of 2.9 billion females own a mobile phone in low- and middle-income countries (41%).
- 1.4 out of 3.0 billion males own a mobile phone in low- and middle-income countries (46%).
- Nearly 2/3 of unconnected (not owning a mobile phone) females live in the South Asia and East Asia and Pacific regions.
- 300 million unconnected females live in Sub-Saharan Africa.
- Women are 14 percent less likely than men to own a mobile phone.
- Women in South Asia, where the lowest levels of access are reported, are 38 percent less likely than men to own a mobile phone.

Source: GSMA 2015a.

the potential consequences for social dynamics within communities, should be addressed before a project is initiated to identify ICT gaps and ensure that solutions are adopted sustainably within communities. It is also crucial to collect gender-disaggregated data in projects and in national ICT-related statistics (FAO 2015b, 2017).

FIGURE 4.1. Mobile Phone Ownership in Low- and Middle-Income Countries



Sources: GSMA Intelligence; World Bank data; and Altai Consulting analysis.

Note: The numbers show population in billions. There are 80 million fewer females than males in low- and middle-income countries; the unconnected population includes individuals who do not own, but may borrow, phones.

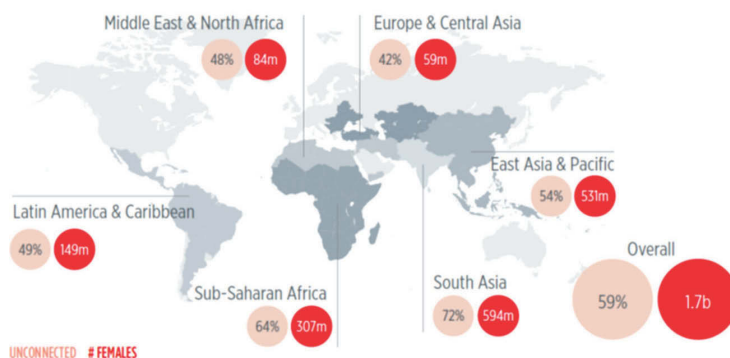
Remaining Barriers and Challenges for Women and ICT

The barriers that affect women's and girls' access to, control, and use of ICT will reduce the efficacy of any ICT-based initiative in agricultural and rural development unless they are addressed appropriately. The gender differences are as important to consider as the gender barriers; men and women differ in their access to ICT, control of ICT, how they use ICT, and even in which types of ICT they use (FAO 2017).

Cultural and Social Limitations

Cultural attitudes can discriminate against women's access to ICT and ICT-based education. For example, it may be perceived as inappropriate for women to visit telecenters or cybercafés, or women might be reluctant to visit them because they do not feel comfortable doing so. Women may be uncomfortable using a telecenter or cybercafé that is located next to a bar (or in a bar), owned by a man, or frequented only by men. If an intervention requires women to use ICT or attend a course, the location of a telecenter or training center should be considered carefully to ensure that they can do so. A location close to a market or hospital, where women often go, can be a good choice. At all times, the telecenter or training center needs to be in a neutral and safe place for women and youths. At the same time, ICT can overcome some cultural or social barriers to using technology. For instance, even females who must remain in the local community or within the household compound can engage in e-learning on computers or mobile devices, and communicate with others in remote locations (FAO 2017).

IMAGE 4.1. Population of Unconnected Women in Low- and Middle-Income Countries



Sources: GSMA Intelligence and World Bank data. Altai Consulting analysis.

Note: The map shows women who are unconnected by region; "unconnected" women are those who do not own a mobile phone, but may borrow one.

Time and Mobility Constraints

ICT cannot solve all the gender-related disadvantages that women and men face in value chain development or in other agricultural activities, but they can alleviate challenges that are intensified by the constraints on women's time and mobility (including security challenges; see box 4.3). Women may not have time to travel to or frequent cybercafés, but mobile phones provide an alternative and very direct means of gathering and exchanging information without traveling or interrupting activities.

Finance and Control

For women, access to mobile phones and services offers the benefits of feeling connected, safer, and more autonomous;

the ability to access critical information and services; and the potential to take advantage of greater employment and educational opportunities (GSMA 2015b,35). Yet women are still less likely to be able to buy ICT hardware (even mobile phones, despite their wide availability) or to pay for access or training. A household may have a mobile phone, but it is important to identify who owns it and controls its use (FAO 2017). Women in Zambia, when asked about this issue, have said that men do not allow their wives to use their mobile phones (World Bank 2015d).

Cost is the most important overall barrier to owning and using a mobile phone, particularly for women, who often have less financial independence. Lower hardware and

BOX 4.3. Remote Control for Irrigation Alleviates Time and Mobility Constraints

Remote irrigation control enables farmers to switch a water pump on and off and check the availability of water without having to examine pumping equipment and fields. In addition to saving time, water, and energy, the technology helps producers to outmaneuver erratic electricity and water supplies. Because farmers no longer need to be present to irrigate their fields, they can pursue other livelihood activities, and avoiding field visits is an added advantage when safety is a concern.

The judicious use of water and electricity are major issues in India, where well over 25 million water pumps deliver water to agricultural fields. Electricity in rural areas often is available only during off-peak hours, at night. Visiting fields after dark is not only inconvenient but also risky, especially for women, who now head farm households in greater numbers as more men leave for cities in search of work. Rather than living with the inconvenience and potential risk of visiting fields multiple times after dark to operate irrigation pumps, some farmers leave their pumps switched on permanently, to operate whenever electricity becomes available. This practice leads to massive waste of energy and water, reduces producers' incomes, and increases soil erosion.

The Technology

Nano Ganesh, a remote control for water pumps, was developed by the Ossian Group, an Indian company. Simple and low-cost, Nano Ganesh uses electronic hardware with mobile signal connectivity at both ends. Activated remotely by a mobile phone, the system serves as an interface between the high-voltage starters of water pumps and low-voltage mobile phones, enabling farmers to switch their water pump on and off from a distance, and to check the water supply in the tank connected to the pump. Irrigation can be timed for the precise duration needed, which prevents excessive irrigation and erosion and preserves soil nutrients and quality.

By sending codes on a mobile network, users can also obtain information on the availability of electricity and water. Some Nano Ganesh models can also send a short message to a registered mobile phone in the event of tampering or attempted theft of the irrigation pump. By the end of 2015, more than 20,000 farmers in India were using Nano Ganesh, and the number is growing. This innovation brings with it additional income-generating opportunities, such as installation, repair, courier services, training, and demonstrations. There are job opportunities for women in the company's rural call centers, electronics assembly, and marketing and training activities.

(continued)

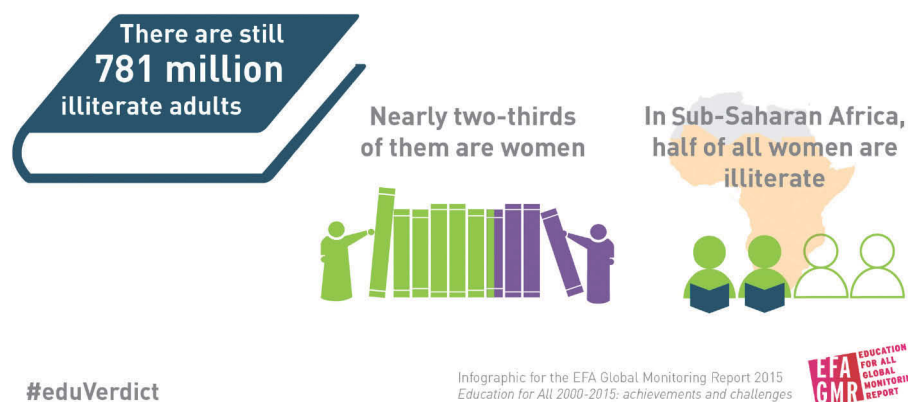
BOX 4.3. continued

Generally, if a farmer invests US\$100–150 in a Nano Ganesh unit for a 5 HP pump, he or she saves US\$300 in fuel (and 10 g of CO₂ per day), US\$200 in water, US\$75 in electricity, and US\$25 in soil in one year. In other words, an investment of US\$100 can yield savings of US\$600 every year.

The Challenges

One of the problems the technology is designed to overcome—irregular electricity in villages and farms—can make it difficult to demonstrate, install, test, and commission the technology. Some technicians are reluctant to take up the challenges of working in rural areas. The company needed time and patience to convince farmers to use the technology. On the financial/marketing side, there was a huge disparity between the high costs of research and development, promotion, marketing, training, and after-sales support and a purchase price that was acceptable to farmers. A great deal of time was invested in pioneering the technology, but once it was on the market, rival products emerged. Even so, considerable scope exists for Nano Ganesh to continue expanding in India and other countries with similar challenges, and remote control technology is being adapted to other kinds of agricultural machinery and operations.

Source: Sylvester 2015.

FIGURE 4.2. Women Predominate among Illiterate Adults

Source: UNESCO 2015a.

connection costs can disproportionately benefit women and help to increase both access and use (GSMA 2015b). Research on mobile phone use suggests that rural women will divert income from other uses to pay for phones (GSMA Development Fund and Cherie Blair Foundation for Women 2010). This finding indicates that women value the benefits of mobile phones. It suggests that closing the gender gap in the ownership and use of mobile phones in low- and middle-income countries could substantially benefit women and society through the delivery of extension and other services

(public and private), such as G2P payments, mHealth services, and mobile money (see Topic Note 4.1).

Literacy and Education

Differences in education and literacy between and among men and women (figure 4.2) limits the effectiveness of certain types of ICT. The proliferation of audio- and video-based technologies is increasingly circumventing the literacy requirement. At the same time, mobile learning offers a major opportunity for women and girls to overcome the many obstacles to education

imposed by time and mobility constraints, costs of tuition and travel, and sociocultural norms (see Topic Note 4.2). Increasing women's and girls' access to mobile phones, smartphones, tablets, and the Internet is an important step toward more accessible and better education (FAO 2017).

Initiatives to Close the Gender Gap in ICT Use and Access

Major initiatives addressing unequal access to and control of ICT between men and women include programs set in place by the United Nations specialized agency for information and communication technologies (ITU), the Broadband Commission, FAO, USAID, CTA, the World Bank Group, and many others.

World Development Report 2016: Digital Dividends (World Bank 2016) observes that ICT has brought massive changes and has a huge potential, but digital dividends are not spreading fast enough, for two main reasons. First, nearly 60 percent of the world's people are offline and cannot fully participate in the digital economy, while the digital divides persist across gender, geographical, age, and income lines. Second, some of the perceived benefits of the Internet are neutralized by new risks. Vested business interests, regulatory uncertainty, and limited competition across digital platforms could lead to harmful concentration in many sectors. Rapidly expanding automation, even of midlevel office jobs, could hollow out labor markets and worsen rising inequality. The poor record of many e-government initiatives points to the high failure rate of ICT projects and the risk that states and corporations might use digital technologies to control citizens, not to empower them (World Bank 2016).

In the mobile industry, the Groupe Spéciale Mobile Association (GSMA)³ launched the GSMA Connected Women Programme in 2012. The Connected Women Programme focuses on the socioeconomic benefits of greater inclusion of women at all points in the mobile industry continuum, from consumer to employee to leader. Aside from closing the gender gap in mobile access and skills, it aims to attract and retain female expertise in the mobile industry and encourage female leadership in technology on a global basis. In "Bridging the Gender Gap: Mobile Access and Usage in Low- and Middle-Income Countries," the program highlights barriers that are especially pronounced for women,

including some of the those described here: the high costs of mobile handsets and credit, poor network quality and coverage, security concerns and harassment over mobile phones, lack of trust in agents and operators, and low technical literacy and confidence (GSMA 2015b).

KEY POLICY ISSUES

Despite the clear advantages of using ICT to increase and extend agricultural innovation and improve coordination among different stakeholders, two specific challenges reduce the potential for ICT applications to contribute to gender-equitable agriculture development. First, smallholder farmers are often considered an undifferentiated group of beneficiaries, with the same needs and the same opportunities. Second, ICT is considered gender neutral—in other words, the assumption is that men and women have the same ability to access, use, and control these technologies. Combined, these challenges present a different landscape of the potential opportunities and constraints to using ICT to enhance agricultural gains—a landscape in which gender plays a central role in determining how men and women participate in agricultural activities, access ICT, and derive benefits from agricultural growth. Therefore, practitioners must carefully consider how to optimize the benefits of ICT in specific contexts where men and women may have different opportunities and capabilities. The following strategies and recommendations focus on overcoming the challenges associated with using ICT in agriculture, with a specific emphasis on the gender implications (for a summary guide, see box 4.4).

Conduct a Gender Analysis to Identify Opportunities for Using ICT to Enhance Current Practices

The analysis should describe where and how men and women participate in the specific value chain or agricultural activity. It should capture what information and services men and women farmers need and how they are currently meeting those needs. It should also assess what types of ICT are already in use and the type of access men and women have to them (direct or mediated). Sex-disaggregated data on education and income, as well as attitudes toward technology use, should be collected to help identify the most appropriate ICT applications. In some instances, content providers themselves may have critical information on gender gaps in access to technology and information. Box 4.5 presents insights from Esoko, a communication tool for businesses, projects, NGOs, and governments to connect with farmers.

3 Also known as the Global System for Mobile Communications Association.

BOX 4.4. A Step-by-Step Guide to Introducing ICT-Based Solutions with a Gender Focus on Agricultural Projects**1. Document the characteristics of men and women farmers / members of producer organizations through a gender analysis:**

- Farmer group's level of organization.
- Farmer group's level of activity (regular meetings and other involvement).
- Type of economic activities.
- Literacy level.
- Mobile phone ownership.
- Different areas of the value chain in which the group is engaged.
- Provision of extension services.

2. Conduct a needs assessment to identify information needs and constraints, such as:

- Extension information.
- Group management information (organizational and financial management system, productivity and financial management data).
- Business model training.
- Interactive communication channel for farmers and service providers.

3. Select or develop the ICT platform/tool:

- Conduct a review of ICT tools/platforms available.
- Involve target groups in the selection/design of the ICT tool.

4. Identify which provider can supply appropriate content to meet the needs of women farmers:

- Ministry of Agriculture.
- National Agricultural Research Institute.
- Private sector.

5. Explore the ICT infrastructure in the selected project sites:

- Mobile phone coverage.
- Internet connectivity.
- Access to electricity.
- Cost of calls.
- Number of users/subscribers to mobile data.
- Maintenance.

6. Check the national policies and regulations on:

- Gender.
- Agricultural development.
- Access to information.
- Information and communication technologies.
- Business environment.

7. Develop a business model for developing, promoting, and running the ICT platform, which may include:

- Hardware.
- Software.
- Group training and sensitization.

(continued)

BOX 4.4. continued

- Sensitization of extension workers to respond to women's needs.
- Development of training materials.
- Software and user support.
- Evaluation.
- Financing: Public support and self-financing.

8. Develop a plan that ensures the continuity and sustainability of the tool/platform:

- Ensure that the tool/platform is supported by an organization (private enterprise) that is committed to managing the tool over the long term.
- Ensure that the organization can provide reliable and current information.
- Ensure that the organization can provide training/capacity building.

Source: World Bank 2015d.

BOX 4.5. Esoko's Mobile Market Information Service Reaches Farmers in 16 African Countries, but Finds a Gender Gap

Since 2005, Esoko has grown to be the leader in delivering market information to farmers across Africa, operating in 16 countries, employing more than 200 people, driving social and economic impact in rural communities, and increasing farmer incomes by 10 percent. For agricultural institutions such as farmer associations, Esoko facilitates direct marketing campaigns through text messaging. Its Internet-based services provide pricing and buying/selling information to all users and offer a platform for organizations to maintain a presence on the Web. Members register with Esoko to receive text alerts with commodity market prices and offers to sell or buy produce.

Esoko is well placed to examine gender differences in its client base, and initial observations show that women still have limited access to the information Esoko disseminates. Many female farmers do not own mobile phones and rely on their husbands' or children's phones. Since education was not a priority when some of these female farmers were younger, they are less literate than their male counterparts. Extension providers still tend to approach men rather than women farmers, thinking that men will pass information along to the rest of the household. These limitations have an impact on farm productivity as well as economic growth, and they illustrate why better access to ICT among women could have a positive impact on rural communities.

Source: <https://esoko.com/>.

Develop Appropriate Content to Meet the Needs of Women and Men Farmers

Women and men take part in different production, processing, and marketing activities, even when they are working in the same value chain. As a result, women and men farmers do not always share the same information needs. To enable ICT applications to improve the productivity of women and men farmers, it is necessary to ensure that appropriate content is developed for them in a language that they easily understand, and in an appropriate format.

Consider Using a Range of Types of ICT

While the inclination may be to find ways of integrating the most cutting-edge technology into value chains, practitioners should recognize the infrastructure constraints, as well as gender-based constraints, that can limit the effectiveness of the newest technologies. Programs need to look at the array of technology available and determine which types of ICT are most appropriate for overcoming specific constraints. In Africa, Esoko has found that women repeatedly state that using a mobile phone to exchange information on farms and agricultural products can lead to marital problems, due to suspicions of infidelity by their husbands.

Radio arguably remains one of the most effective means of reaching farmers in the field, because the infrastructure already exists. Reports indicate that combined ICT programming—using radio and mobile phones—might provide new opportunities for women. Although there may be disputes over control of the household radio, programming can be designed to interest both men and women farmers.

Use ICT to Complement Existing Information Channels

Men and women farmers are already exchanging information. Often through word of mouth, farmers share farming practices, experiences with different inputs, preparation of different crops for consumption, and so on. Women especially rely on these familiar channels, because their time and mobility constraints often limit their exposure to new information providers.

ICT can support and enhance traditional information channels by providing access to expertise and more up-to-date information. For instance, the Women of Uganda Network relies on the strength of locally developed information channels to increase the audience for its services. Women's groups are given a mobile phone and a radio cassette player to use as they listen to local agricultural radio shows, call extension officers, or share information between groups. Information is disseminated in the local language, and the groups are encouraged to spread the word to other women farmers. Part of the program's success is due to the fact that it works within channels that are familiar to women (GSMA Development Fund and Cherie Blair Foundation for Women 2010). In the same way, FAO's Dimitra Clubs use solar radios and mobile phones to connect listeners to rural radio, opening the way to questions and feedback on air, and facilitating discussions among listeners after the radio program has ended (see "Dimitra Clubs: Rural Communities Learn and Mobilize for Change with Participatory Communication Technology").

Develop Direct Relationships with Men and Women Farmers

The most recent ICT innovations will fail to bring women into agricultural programs if leaders and practitioners do not engage women directly. Buyers, extension agents, input suppliers, and other service providers must reward individuals for their participation in the value chain. By reducing overall transaction costs for firms, ICT can allow firms to invest more in developing relationships directly with their suppliers. Firms can contract men and women separately and, more important, ensure that payment is distributed to reward the man or woman responsible for the labor.

Identify Employment Opportunities for Women with Providers of ICT Services for Agriculture

Do not overlook the potential for women to find employment with providers of ICT services for agriculture. Much of the literature reviewed for this module outlined the benefits of ICT applications for farmers, buyers, or the value chain as a whole.

Although only a little research has been done on the potential for creating new ICT-related employment opportunities for men or women in agriculture, it suggests that women have at least two areas of opportunity. First, women can be employed as call center consultants and operators, for example, with M-Kilimo,⁴ delivering agricultural information to farmers. This option may be particularly attractive for women agricultural extension officers who find it challenging to travel to remote districts to meet farmers. Second, rural women should be recruited and trained at the village level to act as information intermediaries for other farmers (see the experience with Digital Green in South Asia, "Participatory Community Video Highlights Local Agriculture-Nutrition Links and Best Practices for Health").

Design Two-Way ICT Programs to Collect and Disseminate Information

The exchange of information through ICT must consider not only "push" mechanisms for sending information but also "pull" mechanisms for collecting it. In gathering data on farmers, it is critical to ensure that the information collected is sex disaggregated, including data on land holdings, productivity, and labor force participation. As noted, evidence from Esoko has shown that women's ICT needs differ completely from men's. Establishing mechanisms for men and women to become co-creators of knowledge products will enhance the understanding of innovation occurring at the local level, as well as opportunities for capturing men's and women's climate adaptation and mitigation strategies.

MercyCorps uses EngageSPARK, a new tool that enables anyone, anywhere, to build and launch text and voice call alerts, surveys, educational curriculums, and on-demand information campaigns to more than 200 countries within minutes. Using EngageSPARK, the TobangKO campaign in the Philippines offers cash transfers for natural disaster survivors and encourages end users to save their money and use it in ways that will ensure a sustainable income. TobangKO disseminated 844,000 SMS texts and voice minutes over 12 weeks using EngageSPARK and created two separate soap opera series that end users can access through a mobile phone. Women farmers can also use mobile phones to listen

4 In Kenya, the M-Kilimo helpline gave agricultural advice to nearly 25,000 farmers during its 18-month pilot phase. The project, funded by the Rockefeller Foundation and GSMA and managed by KenCall in Nairobi, uses a mobile helpline to provide specific, timely, and accurate information to smallholder farmers, as well as tips to help increase their incomes and farm productivity.

to agricultural extension information. To assess whether people were actually listening to the messages and whether they were gaining information or knowledge, EngageSPARK helped MercyCorps implement a short text- or voice-based quiz at the end of each soap opera episode.

Capacity development initiatives in ICT programs can operate in three dimensions: building individual capacity, organizational capacity, and the enabling environment. At the individual level, it is important to adapt capacity development initiatives to the needs of men and women. Depending on the context, it can be useful to offer learning opportunities for women and men separately, and at some point bring the two groups together to exchange experiences. In this way, men and women have both separate and shared moments of learning, which can improve participation while providing opportunities for women and men to speak freely (some individuals find it more difficult to articulate their concerns in mixed groups) (FAO 2017). It is also a good idea to include literacy courses in any initiative, since the limitations that illiterate people face go beyond the use of ICT. Meanwhile, simple, effective applications (radio, mobile phones, and tablets) have been applied in the field to jump-start access to information even without literacy, providing information that is critical to users' socioeconomic welfare (FAO 2017).

When limitations on mobility reduce access to capacity-building initiatives (as is often the case for women), individuals are likely to benefit from the new possibilities offered by e-learning, making it a potent tool for gender mainstreaming. E-learning can also be integrated into existing organizational and educational structures as a hybrid system that can be called "ICT-supported learning" (Tiwarei 2008).

At the organizational level, much can be done to improve gender equality. The capacities of all organizations involved in an ICT initiative for agriculture or rural development initiative should be developed to take greater account of gender in their work and activities (FAO 2016). Regarding the importance of gender-sensitive organizations, the International Institute for Communication and Development (IICD) concluded that:

Well-functioning and gender sensitive farmer organizations will understand the importance of equal participation and opportunities for men and women farmers. At the organizational level it is important to ensure gender responsive systems and structures. In order to design and implement gender responsive ICT projects, organizations need capable staff, monitoring and evaluation systems that capture well what happens on the ground

differentiating between women and men, cooperation and team work between staff with different tasks, and learning mechanisms to deal with gender gaps when and where they arise.

IICD (2015)

In an enabling environment, ICT policies and e-agriculture strategies must take gender into account. When policies and strategies are developed, it is important to ensure that all stakeholders are represented at all levels. If an initiative is implemented at the local level, it will require mechanisms for sharing information at a higher level to disseminate the local lessons on taking greater account of gender. Accurate, sex-disaggregated data and indicators are necessary to understand trends in participation, inform policy makers of potential gaps and inequalities, and develop strategies to address them (FAO 2017).

Develop Gender-Equitable National or Regional ICT Policy

The gender dimensions of rural infrastructure and the enabling environment for ICT are important considerations. ICT can have an impact on women's lives only if infrastructure reaches them and appropriate policies and programs are in place to address poverty and gender issues in accessing and using ICT.

NEW DIRECTIONS, PRIORITIES, AND REQUIREMENTS FOR INVESTMENTS

If approached properly, ICT can improve women's ability to act effectively and productively in agriculture. New applications and cheaper devices have created opportunities for women to engage in agriculture in ways previously unavailable to them. The following subsections highlight some of them.

Facilitating Women's Access to Agricultural Information, Market Prices, and Services

One of the most important contributions of ICT to agricultural development is the ability to disseminate critical information to farmers through various channels, whether a radio program, video, text, or phone call. Real-time and cost-effective information on the weather, market prices, pests, diseases, and services allows farmers—especially women farmers, who may not otherwise have access to this type of information—to make more informed decisions about land preparation, planting, harvesting, and marketing.

By increasing women's access to information and services, ICT can close gender gaps in yields and productivity. Box 4.6 describes how innovative voice messaging technology can be a critical equalizer by providing information to women farmers with no or limited literacy.

The Irrigation Development and Support Project (IDSP) in Zambia and the Kenya Agricultural Productivity and Agribusiness Project (KAPAP) analyzed the platforms and tools available to provide opportunities for women to participate in commodity value chains. In both countries it was clear that female farmers needed technical information to improve agricultural production and processing, as well as support to manage their organizations, production, sales, finance, and communication.

BOX 4.6. Women Advancing Agriculture Promotes Equal Access to Information through Voice Messaging

Women Advancing Agriculture, an initiative of Farmerline, advocates increased gender equality and access to information for women in Ghana. Just 29 percent of women in rural northern Ghana are literate. This initiative sends educational voice messages in local languages directly to the mobile phones of female agricultural workers, telling them about best farming practices, weather forecasts, and regional market prices, as well as providing information on financial literacy, maternal health, and family planning. The goal is not merely to help women farmers boost productivity but also to address their unequal access to information. Voice messaging technology enables Farmerline to develop communication channels that empower women to improve crop yields and income, market their produce more confidently, gain control of their finances, and make informed decisions about their health.

This initiative is only one aspect of Farmerline's work, which focuses on empowering small-scale producers more generally. Since its launch in 2013, Farmerline has reached more than 5,000 small-scale farmers in rural Ghana and more than 200,000 through partner organizations in Cameroon, Nigeria, and Sierra Leone. Its educational mobile phone messages have led to increases in farmers' yields (some as high as 55 percent) and income (up to 44 percent).

Source: <http://farmerline.co/farmerline-launches-gender-equality-initiative-in-ghana/>.

The Sustainable Tree Crops Program in Ghana trained predominantly illiterate and semiliterate women cocoa farmers through farmer field schools and video viewing clubs. A 10–15 minute video was shown on a topic relating to integrated crop and pest management, accompanied by a discussion. Out of 56 video clubs, 32 were women-only, while the others were mixed sex groups.

Improving Coordination Between Women Farmers and Other Actors in the Value Chain

As the previous examples illustrate, ICT can reduce the coordination challenges between different actors in a value chain, providing better information to producers on product specifications and volumes, helping to coordinate transportation, and arranging to deliver goods at times when they can secure the best prices. ICT can also improve the functioning of producer groups, recording financial accounts as well as registration and management processes. Women will benefit from these efficiency gains only if they can access the associations and are trained to use ICT (see Module 8 on farmers' organizations).

Coprokazan (a shea butter cooperative organized by women producers in Zantiébougou) and the Malian Association for the Promotion of Youth (AMPJ)⁵ were jointly seeking solutions for the problems they encountered in marketing shea butter nationally, regionally, and internationally. Promotional activities needed to be strengthened to generate higher sales and improve producers' livelihoods. A project supported by IICD set out to install electricity and computers, train members to use software and office tools (to make training presentations, handle overseas orders by email, and perform accounting operations), create a website, and advertise on radio and television. Animated presentations were developed and organized in surrounding villages for women to share their knowledge of how to improve the quality of their shea butter. Product quality and sales rose considerably, and Coprokazan and AMPJ have used the additional income to continue their work (IICD 2009; FAO 2016).

Enhancing Transparency in Governance, Business Registration, and Land Administration

A number of modules in this Sourcebook describe the advantages of integrating ICT into governance and administrative

5 Association malienne pour la promotion des jeunes.

procedures in the agriculture sector. Improving the timeliness, accuracy, and transparency of these processes is among the key advantages of ICT. These same benefits can apply to gender-equitable objectives. For example, more accurate and transparent recordkeeping can identify the gender gaps in land administration and provide information to advocacy groups supporting women's land rights. For women traders and entrepreneurs, increasing the efficiency of registering a business and conducting customs transactions can ease time burdens and may also reduce opportunities for corruption. In the framework of the Voluntary Guidelines for the Responsible Governance of Tenure, FAO has developed open source software called OpenTenure that supports a crowdsourcing approach to the recording of tenure rights by individuals and communities.

Contributing to the Collection of Sex-Disaggregated Agricultural Data

The lack of sex-disaggregated agricultural data is frequently cited as a constraint on understanding women's contributions to agriculture and the benefits they derive from it. Many countries do not disaggregate agricultural census data by gender, and donor-funded agricultural development programs have been slow to recognize the importance of assessing gender-differentiated results. ICT applications alone will not motivate change in the behavior of these institutions, but they can ease the burden of gathering and recording sex-disaggregated data on farmers, suppliers, buyers, and other stakeholders.

Improving Women's Control over Income and Access to Financial Services

Women's lack of access to income is a significant constraint on their participation and productivity in agriculture. Without access to and control over income, women are unable to accumulate lump sums to pay for inputs and services or invest in upgrading activities. Moreover, when women contribute to agricultural activities without seeing the income invested in the household, they lack the incentives to improve their position in agricultural value chains. The rapidly growing mobile finance sector holds considerable promise for increasing women's savings and control over their own financial destiny, as discussed in Topic Note 4.1. Development practitioners are well aware of the potential of mobile finance, especially for rural and agricultural development, and are seeking to unlock that potential by creating an enabling environment. To achieve financial inclusion through mobile finance, appropriate mobile

financial services must be widely available at a reasonable cost for both provider and customer.

CONCLUSIONS

Participatory approaches that include both men and women in ICT initiatives for agriculture are key to bridging the gender digital divide. A 10-year review of e-agriculture (FAO 2015b) shows that successful initiatives often complement existing infrastructure, are low-risk in terms of time and financial investment, are financially self-sustaining, and are based on locally adapted content and context. They also frequently enable multidirectional discussions among peers and social groups, which would otherwise be unable to connect. As a result, these initiatives lead to knowledge sharing while also providing information to specific users.

Much scope remains for improving the capacity of people and institutions to employ ICT in gender-equitable agricultural development, however. Equal access, resilience, and empowerment need to be strengthened, as do partnerships and the active participation of beneficiaries. Agriculture is becoming more knowledge-intensive. Producers require more information to make increasingly complex decisions on land use, crop selection, choice of markets, and other issues that affect the livelihoods of their families and communities. Linking knowledge to innovation is crucial in addressing the information and knowledge gaps in the agricultural sector.

Many valuable initiatives promote the use of ICT for agriculture, but their sustainability is a concern. Too often, after the pilot phase, these initiatives cease to operate because of financial, human, and other constraints. Scaling up should be integrated in the formulation and implementation of such initiatives.

The rural digital divide is created in part by ICT infrastructure that restricts the types and quality of applications and services that can operate in rural areas. The costs of devices and connections, poor quality and limited connectivity, and the limited array of services in rural areas are major hindrances to using the Internet and mobile technology effectively, especially by women who do not have the same opportunities to attain income, education, and employment as men do. The triple divide—digital, rural, and gender—needs to be addressed through national policies and ICT strategies, ensuring that digital technologies produce meaningful gains for all.

Topic Note 4.1: MOBILE FINANCE AND GENDER IN RURAL AREAS

Even with the gender gap in mobile phone ownership, the fast-growing mobile finance sector (box 4.7) holds considerable promise for increasing women's access to financial services in rural areas. Mobile finance can overcome social restrictions on mobility or legal barriers to account ownership, providing a significant boost to women's economic empowerment and entrepreneurship. It can offer women a new way to save and transfer money, process small financial transactions, and receive credit from microfinance institutions.

OPPORTUNITIES FOR FINANCIAL INCLUSION

As of 2015, 271 services offered mobile finance in 93 countries, and the number of registered accounts had risen to 411 million by the end of 2015. Mobile providers are processing an average of 33 million transactions per day (GSMA 2015c).

The data also show that significant opportunities remain for increasing financial inclusion, especially for women and poor people. Worldwide, men are 7 percent more likely than women to own a mobile finance account. This gender gap is widest in developing countries, and is even more pronounced for adults living below the US\$2 per day poverty line; women in that group are 28 percent less likely than men to own an account (World Bank 2015a). When women do use mobile money, they still lag behind men in the number of payments they make with their account (World Bank 2015a). A study of the mobile financial service M-Pesa in Kenya revealed that women are more likely to be passive receivers than senders and that women are less likely to try a new service (GSMA 2015b).

The opportunities for mobile finance to improve financial inclusion are clear, but so are the many challenges. Mobile

finance seeks to improve access to financial services for people who cannot use formal banking services, yet very large numbers of people in developing countries are financially illiterate—69 percent of men and 75 percent of women (World Bank 2015b). Making the change from cash to digital transactions requires an investment in technology and a significant behavioral shift. If users are to trust mobile financial services, they need to understand how the services work, learn how to make basic transactions, and learn what to do when something goes wrong. Above all, they need to have confidence that the system is safe and reliable (World Bank 2015b).

Aside from these general challenges, women face particular challenges of their own in adopting mobile finance (World Bank 2015b, GSMA 2015b):

- Women generally have lower incomes and do not see the need to open an account.
- Women face more legal barriers than men when trying to open a (mobile) account.
- Women have lower financial literacy rates than men.
- Mobile financial services deliver mostly generic finance products that are not gender sensitive and/or adapted to the agricultural/rural context.
- Women face more technological challenges and are still less likely to own a mobile phone than men.
- Women with access to mobile finance use it less than men.

The fact that mobile financial services tend to be generic rather than adapted to different contexts or groups of clients has important implications. If mobile financial services are to contribute effectively to financial inclusion and to closing the gender gap, products and services must be adapted to variations in income, age, gender, and occupation. A rural woman farmer will have different needs from an urban man employed in the formal sector.

BOX 4.7. Mobile Finance Defined

Mobile finance “provides channels for credit, savings, insurance, transfers and payments. It encompasses not only mobile money and mobile banking, but also other alternative delivery channels such as e-vouchers, debit cards, smart cards, branchless banking, ATMs and point-of-sale devices.”

Source: Babcock and Stratham 2014,2.

POTENTIAL BENEFITS

When women gain access to mobile financial services, they benefit from a safer and more confidential way of handling their money, which ultimately should give them

better control over their finances and increase their economic empowerment (World Bank 2015b). Potential positive impacts on finance and business opportunities for women include:

- Increased access to an account for women.
- Increased control over finance by women.
- Increased saving. Women are less likely to use money saved in a mobile account than if they keep the money at home. Mobile finance can also increase savings through automatic deposits or text reminders.
- Lower costs for the provider and client.
- Increased remittances—mobile money makes it easier for rural women to solicit funds from their husbands and other contacts in the city and overseas.
- Better access to credit to improve women-owned businesses. Mobile accounts create a history of financial transactions, which helps to establish creditworthiness.
- Increased participation of women in the labor force—including more opportunities for women to work remotely from home.

Potential positive impacts on social relationships and quality of life include:

- Empowerment for women.
- Positive shifts in men's and women's relationships within communities.
- Overcoming mobility restrictions.
- Savings in time and transportation costs.

For specific evidence of positive impacts, see boxes 4.8 and 4.9.

Yet the introduction of mobile finance can also have negative impacts. If products and services are not adapted to local needs, including the needs of specific groups, they may even widen the financial inclusion and other gaps. Another consideration is that sending payments directly to suppliers of goods, instead of traveling to the supplier, can reduce the opportunity to control the quality of the goods ordered, which is important for agricultural produce (Ndiaye 2015).

POLICY ISSUES

Mobile finance was introduced in about 2000 and has grown continuously ever since. Initially, mobile finance platforms targeted highly populated areas, but they have

BOX 4.8. Evidence of Positive impacts of Mobile Financial Services on Women's Finance and Business Opportunities

- In USAID's ADVANCE II program in Ghana, women with mobile money accounts have reported that they can better manage household expenditures, since no one else knows how much they have received or saved (USAID 2016).
- When reminders to save were texted to mobile banking clients in Bolivia, Peru, and the Philippines, savings increased by up to 16 percent (World Bank 2015b).
- A randomized evaluation in Niger found that using mobile payments for unconditional cash transfers saved recipients 75 percent on payments. They used those savings to purchase a greater variety of food and to grow a greater variety of crops (USAID 2016).
- Mobile money services offering International Money Transfer saw the volume of cross-border remittances increase by 52 percent. Cross-border transactions were the fastest-growing mobile finance product in 2015 (GSMA 2015b).
- Farmers in Niger realized time savings for each mobile finance payment, equivalent to an amount that would feed their family for a week (World Bank 2015b).

Sources: USAID 2016; World Bank 2015b; GSMA 2015b.

since expanded to the rural market. Much additional scope exists for diversifying the products offered, including credit and insurance to complement current mobile payment packages. The insurance industry is expected to earn up to US\$1.7 trillion from women alone by 2030, presenting a major opportunity for sustainable and inclusive growth (IFC 2015).

As the previous discussion indicates, the introduction of mobile finance is accompanied by changes in **social relationships** at the household level (between men and women), within communities, and within agricultural value chains. Developing mobile financial services for women will not tackle all of the issues of gender mainstreaming, however. Achieving this objective will require structural and cultural changes among all stakeholders involved in providing the services, as well as mainstreaming gender in policies (IFAD 2009).

BOX 4.9. Positive Impacts from M-Pesa in East Africa

M-Pesa—M for “mobile,” and “pesa” for money in Swahili—is a mobile-phone-based money transfer, financing, and microfinancing service launched in 2007 in Kenya and Tanzania. In 2015, about 70 percent of the adult population of Kenya used M-Pesa. Research within fishing communities in Migory County, located on the Kenyan side of Lake Victoria, shows that M-Pesa has brought significant positive changes for women, including the chance to save money in a safe place and to build up resources for costly activities and purchases, such as helping families in times of need and sending children to school. Women confirmed that they were less likely to spend money when they saved through M-Pesa, compared to keeping their savings in cash at home, since their husbands no longer had access to the money. Transportation costs and time have also declined significantly, allowing women to invest more money and time in their businesses, as a result of which they now process and sell more fish. M-Pesa has also changed relationships between men and women. Since women can save money using M-Pesa, they no longer need to ask for credit when they buy fish from the men. Direct payments have also increased trust within the communities.

Source: Ndiaye 2015.

Governments play an important role in putting policies in place to enable equal access to mobile financial services. For example, governments can reform discriminatory policies that make it harder for women to access mobile financial services, such as requiring a husband’s signature to open an account or borrow money. Governments also need to provide a favorable regulatory environment that allows mobile financial services to be offered and aligns banking and telecom sector regulations (World Bank 2015b). A good example of a government initiative comes from Malawi, where the FHI360 Mobile Money Accelerator Program is coordinating with the government to introduce electronic salary payments for teachers, rather than cash payments (Hasselback 2014). The new systems will eliminate the need for teachers to spend time and money traveling to the nearest bank to collect their salaries (often only to learn that the money has not yet arrived).

The **private sector** can expand the mobile finance market by increasing the number of digital payments significantly,

paying its employees digitally, and digitizing purchasing and payment data. The **financial sector** also has an important role to play in extending the mobile finance market, by recognizing the importance of extending and adapting its products to female and rural markets and training agents who can educate customers (World Bank 2015b). The introduction of larger numbers of mobile phones has an impact on the **environment**, for which mechanisms need to be put in place.

LESSONS LEARNED

Mobile phone ownership, or at least access to a mobile phone, is a prerequisite for participating in mobile finance. Women who own phones make more savings deposits than women who borrow phones (Grameen Foundation 2012).

The savings, investment, and spending patterns of women differ from those of men and also vary depending on the roles played on the farm or within the agricultural value chain. Mobile network operators and mobile finance providers have not yet made substantive efforts to conduct this kind of market research and adapt products, services, and marketing strategies accordingly, especially in rural areas (CTA 2015). Strategic alliances between an agricultural organization, such as an NGO, a development organization or a private sector firm, and a mobile finance provider can improve the adaptation of the financial services to the specificities of the agricultural sector (Babcock 2014). “Designing Mobile Finance Products for Rural Women in Zimbabwe” explains how an analysis of women’s needs for financial services in Zimbabwe led to the development of an outreach strategy that took those needs into account.

Studies show that women have limited mobile phone literacy, even when they own a phone, and that they are often financially illiterate, so they need training and support (Grameen Foundation 2012). In Indonesia, Mercy Corps’ Agri-Fin Mobile program combines the delivery of rural advisory services and financial services to increase agricultural productivity and farmers’ ability to manage their increased income. The program pays particular attention to women beneficiaries and their specific needs. Apart from learning through the mobile service, women requested face-to-face learning to acquire the necessary skills. They learned to open an account and access savings, loan, and payment services through their mobile phones (Mercy Corps 2015).

Trust remains an important barrier to the introduction of mobile finance. People do not always immediately trust the idea of their money becoming virtual and being stored on a mobile phone. In Papua New Guinea, for example, Nationwide Microbank has launched MiCash, a savings product. It was important to choose the right ambassadors to increase awareness of the mobile finance product and convince potential users that it was trustworthy. Active mobile money customers were used to educate their peers about the use and benefits of mobile money. The peer-to-peer learning was crucial in increasing the use of MiCash among women (GSMA 2014). Women constitute 38 percent of the customer base and use it primarily for savings.

RECOMMENDATIONS FOR PRACTITIONERS

Overall, there is still a need to address current gender discrimination and to ensure gender sensitivity at all levels and within all institutions involved in mobile finance. Development practitioners can play an important role in developing capacity for gender mainstreaming in the design, development, and delivery of financial services.

Gender issues also need to be addressed at the policy and legal levels, to ensure that women and men have the same rights in accessing and using mobile financial services. Increased use of mobile finance by women will go hand-in-hand with modifications of laws that affect the rights of women to access, use, control, and own natural and physical assets (Fletschner and Kenney 2011).

Digital and financial literacy training is needed if women (and men) are to be able to profit fully from mobile finance innovations.

Mobile finance products must be adapted to fit the needs of specific groups. More research is needed to assess the real advantages and potential disadvantages of the mobile finance revolution for rural women (Ndiaye 2015), as well as gender-disaggregated data from mobile service providers.

Women will benefit from the strengthening of existing women's groups, where they can find a safe space to experiment with new mobile finance products. They are more likely to trust peers who have already tried mobile finance (Fletschner and Kenney 2011).

INNOVATIVE PRACTICE SUMMARY

Designing Mobile Finance Products for Rural Women in Zimbabwe

FAO's Zimbabwe Livelihoods and Food Security Programme developed a gender strategy that included an analysis of women's access to finance and financial needs (FAO 2015c). The findings of the analysis reflected revealed many of the concerns that have been discussed throughout this module:

- Women lack access and control of assets to obtain loans.
- Women have lower financial literacy rates than men.
- Women farmers experience more difficulties in accessing formal financial services.
- Men and women both use mobile financial services.
- The general consensus is that mobile technology is important to further the delivery of rural financial services.
- Mobile financial services have tended to restrict themselves to generic rather than specialized financial products (with no gender sensitive products).

The findings and the resulting recommendations on gender and finance led FAO to partner with the Netherlands Development Organization (SNV) and Steward Bank, a subsidiary of Econet Zimbabwe, to develop and implement a Rural Finance Outreach Strategy for the Livelihoods and Food Security Programme (SNV 2015). The outreach strategy focuses on making relevant, appropriate, and affordable financial services available to rural households in a cost-efficient and sustainable manner.

In the rural areas targeted by the initiative, women mainly save and obtain small loans through rural savings groups that have no access to formal financial services. Aligning with this traditional model, Steward Bank developed the Eco Cash Savings Club (a savings account for groups) and Eco Cash Savings Club Loans (loans offered to groups for onward lending to members). Club members guarantee the loans to mitigate credit risk. These products have the potential to benefit the large numbers of women who are the majority in rural savings groups. Steward Bank has also committed to look into products that can promote the specific value chains and crops that women dominate, such as groundnuts, cowpeas, and small livestock.

Topic Note 4.2: MOBILE LEARNING, GENDER, AND AGRICULTURE

The digital revolution is reaching rural areas in many developing countries, creating new openings for using ICT tools to drive agricultural and rural development. This topic note highlights how the range of learning opportunities for rural communities is widening through the spread of rapidly evolving mobile devices to improve knowledge and information, especially about agricultural issues. Women stand to benefit significantly from mobile learning opportunities, which can help them to improve their livelihoods and the well-being of their families. Experience shows that addressing social barriers to mobile learning opportunities at the community rather than the individual level—with the involvement of both men and women—is likely to have the greatest impact on women’s capacity to take advantage of mobile learning.

Mobile learning (or m-learning) can be used to offer formal and informal learning for children and adults in a vast range of areas. Definitions vary, but the following convey a sense of the scope and variety of applications:

- Mobile learning is “learning across multiple contexts, through social and content interactions, using personal electronic devices” (Crompton 2013).
- Mobile learning is commonly used to describe “the use of mobile technology, either alone or in combination with other [types of ICT], to enable learning anytime and anywhere. People can use mobile devices to access educational resources, connect with others, or create content, both inside and outside classrooms” (UNESCO 2013:6).

Mobile learning can be adapted to schools, workplaces, urban and rural areas, and formal and informal contexts (e.g., see the innovative practices described at the end of this topic note). Mobile devices are regularly used to create communities of learners to exchange useful information. Realizing all of the potential benefits of m-learning in a rural context will require some adaptation to overcome the barriers to using the technology, especially for women.

Among the post-2015 Sustainable Development Goals (SDGs), two are directly related to mobile learning:

- SDG Goal 4, to “ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.”

- SDG Goal 5, to “enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women.”

Mobile learning devices are generally digital, easily portable, owned and controlled by an individual rather than an institution, can access the Internet, have multimedia capabilities, and can facilitate a large number of tasks, particularly those related to communication. Devices that can be used for m-learning include handheld computers, MP3 players, notebooks, mobile phones, and tablets. M-learning focuses on the mobility of the learner, interacting with portable technologies. This form of learning is convenient because it is accessible from virtually anywhere. Sharing feedback and tips is almost instantaneous among everyone using the same content—which is a major advantage in remote, rural areas.

There are numerous opportunities in agriculture for m-learning to provide information, including information on climate-smart agricultural practices, improved marketing strategies, more effective pest and disease control, and agricultural advice. The specific challenges that prevent rural dwellers (women in particular) from taking advantage of m-learning opportunities resemble the challenges pertaining to the use of ICT in general: high cost and weak connectivity in rural areas; low literacy levels and lack of digital skills; a lack of content adapted to users’ needs, in their own language; and sociocultural norms (such as those restricting women’s use of mobile devices).

Literacy is a catalyst for participation in social, cultural, political, and economic activities, as well as for lifelong learning (UNESCO 2015b). Yet as noted in the overview, two-thirds of adults who lack basic literacy skills are women, a proportion unchanged since 2000. Half of the adult women in South and West Asia and Sub-Saharan Africa cannot read or write (UNESCO 2015b).

POTENTIAL BENEFITS

The benefits of mobile learning go beyond the freedom to learn at any place and time. M-learning can bridge formal and informal learning and link online and offline environments.

It can minimize educational disruption in conflict and disaster areas and assist learners with disabilities (UNESCO 2015b). In a rural setting, mobile learning provides valuable information for improving agricultural production and gives producers a way to contact other producers and sources of expertise, which is especially important in remote areas.

If challenges posed by the digital gender gap can be overcome, there is particular scope for linking women to m-learning, to improve agricultural outcomes and livelihoods. A study covering 12 Latin American and 13 African countries from 2005 to 2008 found that fewer women accessed and used ICT because they had less access to employment, education, and income; but when researchers controlled for these variables, women turned out to be more active users of digital tools than men (Martin 2011).

More and more projects in the agricultural sector are using mobile devices. Mobile learning is just one means of integrating mobile devices into agricultural development initiatives, and more work is needed to examine the efficacy of mobile learning in such initiatives, using sex-disaggregated data.

POLICY ISSUES

Sustainability can be largely influenced by the cost of mobile services. Some mobile learning projects have tested the strategy of providing mobile phones and services to users/learners, either at no cost or at affordable prices through temporary agreements with private providers. In UNESCO projects implemented in Cambodia and Senegal, subsidies or bulk prices for SIM cards were negotiated with private providers. When the cost of the SMS aggregation/disaggregation system was transferred to the implementing NGO in Senegal, it became unsustainable, and the service was terminated. A notable alternative to this approach was tested in Tamil Nadu, India, where a goat-rearing project for women included the cost of mobile phones in the business plans that participants prepared and presented to a public sector bank to obtain credit (box 4.10). Sharing mobile phones is another strategy for reducing costs and increasing cooperative learning. It is also important to explore community-based solutions for charging and repair services, such as solar-based mobile phone charging centers.

Negative social attitudes regarding the educational potential of mobile technology are a significant barrier to more widespread mobile learning. In many cases, mobile devices are viewed as portals to entertainment, not education, and as

a result the technology is dismissed as distracting or disruptive. Although the small screens and awkward input methods of mobile devices were once seen as disadvantages to their use in education, these views are changing rapidly due to technological advances. Policy makers should take steps to educate the public about the benefits of mobile learning (UNESCO 2015b) and strive to promote **gender equality** for mobile learning.

Institutional considerations include ensuring equal access to mobile technology and participation in mobile learning for all students and teachers. Students should be allowed to “own” their mobile device whenever possible. Government departments and educational institutions should be encouraged to negotiate with vendors and leverage the purchase of mobile devices.

Since fewer women than men own mobile phones, women are a new market segment, one that is likely to be offered less sophisticated, lower-priced devices than those used by men. Devices offered in rural areas should be durable (resistant to shocks, dust, and humidity), energy efficient, and easy to maintain and repair. These conditions will limit e-waste and subsequent damage to the **environment**.

Private sector mobile service providers have a role to play in reducing the costs of making calls or sending SMS texts, and as the Tamil Nadu case study shows, there is scope to discover creative strategies for reducing costs. The gender gap in mobile phone ownership and use is unlikely to close

BOX 4.10. Mobile Learning Expands Women’s Livestock Rearing and Business Skills

In the Theni District of Tamil Nadu, India, an initiative is encouraging rural women to use mobile phones as learning and business tools. Each of the 300 women participating in the scheme developed a business proposal to obtain credit to buy nine female goats, one buck, and one mobile phone. The microfinance institution Vidiyal entered into an agreement with one of the biggest mobile service providers in southern India to send audio messages and voicemails to the women. The 500 audio messages, adapted to the local culture and dialects, covered such topics as buying goats, feed management, animal health, and marketing. Vidiyal also encouraged the women to discuss issues concerning their enterprises with one another and offered training in effective conversation using mobile phones.

Sources: UNESCO 2015b; Balasubramaniana et al. 2010.

without targeted intervention from the mobile industry, policy makers, and other stakeholders (GSMA 2015a).

For countries where the digital economy is still emerging and access to the Internet is limited, various **reforms** are needed. They include reforms to remove barriers, such as (1) a lack of basic ICT and supporting infrastructure, (2) excessive regulation of product markets, and (3) high tariffs for digital goods (which exceed 25 percent in some countries). Education systems need to focus on basic literacy and numeracy skills, connect teachers to digital content, and promote adult literacy (World Bank 2016).

LESSONS LEARNED

Beyond doubt, a primary lesson is that it is critical for rural communities to gain better access to affordable communication technology infrastructure, services, and devices. In addition:

- Due to low literacy levels, inadequate digital skills, and sociocultural norms, the most interesting alternatives and complements to phones for mobile learning may be video, radio, and talking books (see “Talking Books Deliver Valuable Advice, No Reading Required”).
- Instructions and content should be offered in local languages (box 4.11) and use visual literacy strategies (box 4.12).
- During the life of a project, users/learners can gain access to mobile phones and services at a reduced cost through temporary agreements with private providers. But to ensure sustainability after a project ends, the cost of using a mobile device should be included in the business model.
- Participatory design, planning, and implementation with the community, including men, can help to overcome social barriers to women’s use of mobile devices for effective learning.
- It is important to monitor and evaluate the impact of mobile phone technology on women’s and girls’ literacy and empowerment.
- Mobile learning demands new pedagogies, including new approaches to delivering and facilitating instruction.
- Pilot projects that have shown good results should be scaled up. It bears repeating that promising pilots should have sustainability built into their design, so that the benefits can be sustained when funding ends.

BOX 4.11. Mobile Learning in Local Languages

In Nigeria, the government’s Growth Enhancement Support Scheme for agriculture is harnessing m-learning to increase agricultural productivity in rural farming communities. The scheme is overcoming the twin challenges of developing literacy and of providing knowledge and information to speakers of many diverse languages by designing content for mobile platforms in English, Hausa, Yoruba, Igbo, and Nigerian Pidgin, among others. The content, delivered to mobile phones via synthesized speech and text messaging, provides extension information, such as notices of preseason activities and site selection for growing rice. The availability of content in a medium and language that can have an impact on literacy and knowledge levels should enhance farmers’ productivity in a significant manner.

Source: Ofulue, Adegbola, and Egbokhare 2013.

BOX 4.12. Videos Easily Adapt to Local Audiences to Build Women’s Knowledge of Maternal and Child Nutrition

GloCal—Global issues in Local context—aims to improve the nutrition and health of mothers, children, and families around the world through educational videos that focus on maternal and child nutrition. A set of 45 videos will be available for each region of the world, using familiar local foods and local women actors, to ensure that the target audience can relate to the information, even if they are not literate. Through voiceover, the language can easily be altered to suit any local language or dialect. The content, based on World Health Organization guidelines, is consistent with government policies.

The videos can be shown in health care centers and other public places as well as on local TV channels, and they will soon be available for download from the Internet. Rural health care workers can also use a tablet to show the videos to mothers. A GloCal application will allow health care workers to quickly determine the specific information needs of each mother and automatically locate the videos addressing those needs for viewing. The GloCalMom application includes growth charts and vaccination record cards.

(continued)

BOX 4.12. continued

The videos were piloted in 42 villages in 3 districts of Bihar, India, to investigate how locally produced videos could increase community knowledge and the adoption of improved nutrition practices. The findings were very positive. Community members said that they learned about best practices in maternal and child health and nutrition. The familiar local dialect used in the videos helped them to remember key messages.

Currently, the GloCal videos are available in English and Kiswahili, and translations are under way into French, Portuguese, Amhara, and Tanzanian Swahili. In Kenya, the effectiveness of the video set is being tested with 1,200 mothers in urban and rural areas in a joint research project by the University of Helsinki and Kenyatta University.

Source: www.globalnutrition.com.

- Developing strategies to teach relevant ICT skills to women and girls (box 4.14), as well as to men and boys.
- Encouraging self and/or collective learning with skills and content relevant to learners' prior knowledge, diverse needs, and expectations.
- Designing mobile learning content and interaction that is gender-sensitive and equitable.
- Opening mobile learning to a wide range of educational settings and pedagogical processes.
- Rethinking curriculums and teaching methods. Digital technologies can assist teachers and students, by allowing group work among classrooms connected online, apps that stimulate creativity and problem solving, and games designed for education (gamification) (World Bank 2016).
- Pursuing blended learning—mobile learning grafted onto existing nonformal education and community initiatives.
- Promoting self-learning and peer-to-peer learning.

For resources to pursue some of these recommendations, see box 4.15.

RECOMMENDATIONS FOR PRACTITIONERS

UNESCO, which is committed to enabling “all people around the world to make use of the huge potential of ICT for learning and self-empowerment,” recommends a number of policy measures to promote m-learning (UNESCO 2015b; World Bank 2016):

- Using low-cost devices and relying on affordable SMS-delivered content and interaction, as well as hardware and systems with which users feel comfortable.
- Designing projects that take advantage of the benefits of sharing mobile phones—to lower costs and encourage more cooperative and peer-to-peer learning.
- Building mobile-phone enhanced literacy components within existing literacy and empowerment endeavors.
- Linking mobile-phone-enhanced literacy to collective efforts to improve women's livelihoods, participation, and employment opportunities.
- Improving gender gaps in the use of ICT in education by encouraging women and girls as well as men and boys to leverage mobile technology for learning.
- Identifying culturally relevant ways of normalizing mobile phone ownership and use, for women and girls in particular (see the examples in box 4.13).

BOX 4.13. Adapting Mobile Phone Use to Sociocultural Norms

A project in Cambodia found a solution to sociocultural practices that limit women's ownership of mobile devices. Phones were colored pink to signal that they belonged to women, as a way of circumventing men's predominant ownership of the device. The Pink Phone project in Cambodia trains women leaders to use mobile handsets to share ideas, information, and resources in a virtual space. Women draw on the expertise of females in their virtual network to assist people in their physical communities.

Another creative way of overcoming obstacles to female phone ownership in male-dominated households was used in a goat-rearing project in the Theni District of Tamil Nadu, India. Women carried their mobile phones in a small pouch (*surukku pai*) that is associated with women's identity and objects in Indian culture.

Source: UNESCO 2015b.

BOX 4.14. Women and the Web Alliance—Training That Empowers Women and Girls Online

The Women and the Web Alliance is a public-private partnership designed to improve women's digital literacy in Kenya and Nigeria. Through local training and online activities, the goal of the alliance is to enable women, their families, communities, and countries to realize the socioeconomic benefits that can arise when more women and girls know how to benefit from the Internet.

Increased Internet access enables women and girls to connect, engage with, and find new educational and career opportunities, greatly expanding their capacity to create economic change for themselves. By producing, curating, and sharing high-quality digital content, including training content customized for women and girls, the Women and the Web Alliance helps to sustain their interest in using the Internet and reaping the benefits in the long term.

The alliance aims to reach 600,000 young women online in Kenya and Nigeria in the next two years and enable them to use the Internet for social and economic empowerment. The alliance's partners are the United States Agency for International Development (USAID), Intel, NetHope, World Pulse, World Vision, UN Women, Women in Technology in Nigeria, and Internews.

Source: <http://www.womenandtheweballiance.org/>.

BOX 4.15. An Open Course on Digital and Mobile Learning

The global Community of Digital Learning offers free material on digital and mobile learning. Topics explored on a step-by-step basis include digital learning, quality in digital learning, new digital learning scenarios, augmented learning, blended learning, gamified solutions, mobile learning, massive open online courses (MOOC), scenario-based learning, self-paced learning, and the peer-reviewing process.

Source: For details, see: <https://quality4digitalllearning.org/>.

INNOVATIVE PRACTICE SUMMARY **Dimitra Clubs: Rural Communities Learn and Mobilize for Change with Participatory Communication Technology**

The FAO Dimitra Clubs are groups of women, men, and young people—mixed or not—that decide to organize to

promote change in their communities. They meet regularly to discuss the challenges they face in their daily lives, make decisions, and take action to resolve their problems. Set up in several Sub-Saharan African countries (Burundi, Democratic Republic of Congo, Ghana, Niger, and Senegal), the Dimitra Clubs follow a simple formula: the determination of community members to mobilize, a wind-up solar-powered radio, close collaboration with community radio stations, and support from FAO (mainly in capacity development). The clubs use mobile phones to improve information sharing and networking within and among clubs, as well as with the radio stations and other stakeholders. In sum, the participatory communication technology enables the clubs to promote change more effectively.

More than 60 percent of the population of Sub-Saharan Africa lives in rural areas, where the main challenges are not only restricted access to productive resources and markets, but also to information, knowledge, skills, and networking. Participatory communication approaches play a central role in addressing these challenges by enhancing people's potential and facilitating their involvement in decision making, dialogue, knowledge sharing, and partnership with development stakeholders.

The Dimitra Clubs seek to contribute to individual and collective socioeconomic empowerment of rural communities, especially women and young people. Through this approach, women and men cease to be mere recipients of development actions and become protagonists. The process is guided by the principles of gender equality, social cohesion, solidarity, and participation. Discussions may revolve around any topic of importance to club members, such as agriculture, natural resources, food security, and everyday issues linked to the relationship between men and woman and the division of household tasks.

Since 2007, over 300,000 people, more than half of them women, have been empowered through 1,500 Dimitra Clubs. As documented in specific context-linked assessments, the clubs have significantly improved organizational capacity, social mobilization, access to information, gender relations, and women and men's active participation in decision-making processes. In the Democratic Republic of Congo, an IFAD supervision report concluded that "the project in the Tshopo Province has developed the self-development capacities of the members of the clubs, the gender dimension and structuring of youth in groups. The clubs are increasingly engaged in farming activities and many of their members have joined the local Union of Farmer Organizations (69%)."

In Niger, the use of radio, mobile phones, and other means of communication has contributed strongly to building women's leadership and self-esteem, and reinforced their capacity to speak in public and take part in local decision-making processes. Furthermore, the approach has brought about behavioral changes in various areas, including nutrition and agriculture, and has helped to bolster community resilience to climate change. For example, in the village of Banizoumbou, women organized into Dimitra Clubs have obtained a 99-year lease from local landowners to use 3 hectares of land. This result came after months of on-air discussions, with club members calling community radio stations to discuss how to solve women's lack of access to land. Meanwhile, in the Democratic Republic of Congo the clubs have played a key role in changing people's view of food taboos for women. In the village of Yalosuna, a series of awareness-raising activities conducted by the Dimitra Clubs, coupled with club discussions that were broadcast live, have resulted in a community decision that women should improve their protein intake and eat food such as catfish, which was previously reserved for men.

A number of lessons have emerged from this experience that are relevant for similar activities:

- Participatory communication is key, using ICT to promote empowerment.
- Facilitating dialogue and exchange is crucial for ensuring ownership by communities.
- Generally, Dimitra Clubs become autonomous after two years of support from FAO.
- Sustainable partnerships between clubs and community radio stations are based on confidence and respect.
- The approach encourages rural populations to be creative in solving development challenges using local resources.
- The flexibility of the model is one of its strengths, but it also presents challenges for scaling up.

INNOVATIVE PRACTICE SUMMARY **Participatory Community Video Highlights Local Agriculture-Nutrition Links and Best Practices for Health⁶**

South Asia has the highest rate of hunger in the world. According to one estimate, 336 million people (nearly 23 percent of the population) are routinely hungry, and new threats such as

climate change are likely to make the crisis even worse. At the same time, increasing problems of people being overweight and obesity, especially in India, are creating another kind of public health concern related to nutrition. The South Asia Food and Nutrition Security Initiative (SAFANSI), supported by the World Bank Group and the UK Department for International Development (DFID), teamed with the international NGO Digital Green to use a participatory video to promote sound nutritional practices in rural communities, based on the close links between agriculture and nutrition in those areas. The aim was to investigate how locally produced videos could increase knowledge of nutrition in the community, encourage the adoption of better nutritional practices, and evaluate the feasibility of integrating nutritional information into the agricultural program. The pilot targeted 42 villages in 3 districts of Bihar.

SAFANSI had a secondary objective as well. It sought to enhance and promote knowledge management platforms—massive open online courses (MOOC)—both on and offline, so that a wider audience, including agricultural universities and other organizations, could use the instructional videos.

THE DIGITAL GREEN APPROACH

Digital Green uses video as a cost-effective, scalable means of bringing community members, researchers, and development practitioners together to produce and share locally relevant information on innovative practices and change behavior. Video is an intuitively accessible technology that sidesteps challenges related to literacy, and it is especially effective when local farmers themselves convey advice and information to community members. Unlike traditional, generic informational videos, these films are produced within the communities, with the help of community resource persons who are taught to film, edit, and screen the final product. Low-cost, hand-held Pico projectors, which are battery-operated, are used to showcase the videos at regular local events, such as self-help group meetings.

The topics for the videos were relevant to local agricultural systems and nutritional needs, to ensure that their messages would resonate with the community and have an impact. For example, the topics included cultivating kitchen gardens to increase the access to nutrient-rich vegetables, balancing the agricultural workloads of pregnant women, and improving dietary quality and diversity for women and children. General public health and nutrition advice (for instance, information on personal hygiene and breastfeeding) was also included.

6 For more information, see World Bank 2015c and visit digitalgreen.org.

BENEFITS AND IMPACT

Community involvement was central to the success of the initiative. During screenings, the community resource person would pause the video at strategic points and engage the group in productive discussions on their understanding of the featured practice. Small groups (the typical group had 15 to 20 people) created an informal and intimate environment, enabling all members to interact, ask questions, and clarify doubts.

In a controlled evaluation, Digital Green's approach was shown to be at least 10 times more effective, on a cost per adoption basis, than a conventional approach to agricultural extension, with a sevenfold increase in the rate of behavior change.

LESSONS LEARNED AND ISSUES FOR WIDER APPLICATION

Community members remembered key messages in the videos, as the local dialect was familiar to viewers and the messages were clear. Some videos were screened more than once, at the request of viewers, to enable viewers to retain their messages better. The videos increased knowledge of best practices for health and nutrition. Women found the nutritional content especially useful, since they are largely in charge of household dietary decisions (decisions on agricultural practices are traditionally dominated by male household members). The videos helped to dispel myths related to pregnancy and childbirth, such as not eating pumpkin during pregnancy. Communities said they felt better informed about maternal and child health and nutritional practices after watching the films.

INNOVATIVE PRACTICE SUMMARY

Talking Books Deliver Valuable Advice, No Reading Required⁷

Literacy Bridge is an NGO that aims to save lives and improve the livelihoods of impoverished families by providing on-demand access to locally relevant knowledge. At the heart of its programs is the Talking Book, an innovative, low-cost audio computer designed for the learning needs of illiterate people living in the poorest areas of the world. The device links users to valuable information on agriculture and other rural issues.

In many rural areas of Ghana, farmers rarely receive visits from extension officials, and when they do have the chance to meet agricultural experts, they cannot always

remember all of the information. Being illiterate, they are unable to take notes.

Other knowledge exchange approaches that do not require literacy have their limitations. Mobile phone solutions require funds for network time or expensive and fragile smartphones. These options are valuable for transmitting simple, time-critical information, but they may be less effective as teaching systems. Texts are no use to the illiterate. Local radio programs reach a wide audience through a single broadcast, but broadcasts cannot be replayed or shared with people who were not present when the program airs. A single broadcast generally is not enough for someone to learn a new technique. With Talking Books, users can listen to a recording as many times as they need, before incorporating a new practice into their lives.

Combining Talking Books with other knowledge exchange approaches can provide good results for illiterate farmers, however. For example, coupling a Talking Book with a mobile-based intervention combines timely distribution of content with the ability to play lengthier content on demand at no cost. Likewise, adding Talking Books to a radio-based intervention combines radio's broadcast capability with a network of devices that act as local audio libraries. In all cases, those targeted for the Talking Book project are people with oral cultures and few or no literacy skills, families without electricity, communities with unreliable or expensive mobile networks, mothers without a phone, and grandmothers who do not like technology.

HOW THE TALKING BOOK TECHNOLOGY WORKS

The Talking Book is a small portable recording device (12 cm × 12 cm × 6.5 cm, weighing 225 g without batteries), built to withstand dry dust storms and tropical rain, and storing 140 hours of audio content. It is affordable, simple to use, and runs on batteries. The device features indented touch buttons, to facilitate use by visually impaired people and by all users at night. With a simple audio menu offered in a range of local languages and dialects, users can select the information that interests them. The audio content can be replayed as needed, played for family and friends, and easily loaned to third parties.

The Talking Book disseminates information created and recorded by local experts for rural communities. Recordings may feature agricultural extension agents describing farming techniques—such as fertilizer preparation, seed spacing, and livestock care—or microfinance institutions offering

⁷ For more information, visit <http://www.literacybridge.org/talking-book/> and the Literacy Bridge 2014 Annual Report.

business guidance and explaining topics such as credit and rotating savings plans.

Literacy Bridge does not sell Talking Books. It includes Talking Books as part of its ongoing partnerships designed to help organizations develop and distribute effective audio content based on formative research and continuous monitoring. Literacy Bridge collaborates with its partners to apply best practices in social and behavior change to address the specific needs of a community, leading to healthier practices and more productive skills.

Once loaded with information, Talking Books are distributed to remote areas, where they serve as a rapidly expanding audio library offering information when it is needed. New audio recordings are regularly added to Talking Books (typically every 1–3 months) via USB from a smartphone, tablet, or laptop. Users can also record their own messages to ask questions, expand on ideas, and relay feedback.

BENEFITS AND IMPACT

By 2008, 1,000 people had used a Talking Book. By 2015, that figure had risen to 175,000 in Ghana alone. Each month, users listen to more than 1 million minutes of valuable material. The impact has been significant. Since the launch of the device, Talking Book users have won a variety of farming awards. In 2009, the average Talking Book farmer's harvest increased by 48 percent after one year. In 2012, the average Talking Book farmer's harvest increased by 36 percent after one year.

LESSONS LEARNED AND ISSUES FOR WIDER APPLICATION

Literacy Bridge found that families listen to an average of 37 Talking Book messages over a period of six hours each week. Users typically repeat messages four times to absorb all of the information, and the most popular messages are conveyed through songs and drama, on the subject of children. The top four messages were child marriage, new agriculture messages, children's birth registration, and child immunization.

Monitoring features built into the device enable organizations to evaluate the achievement of impact objectives and constantly improve content as a result. The Talking Book's simple design, affordability, and flexible content are highly conducive to rapid expansion and scaling up.

REFERENCES AND FURTHER READING

- Abdoulaye, M., and A. Van der Elstraeten. 2013. "Les clubs d'écoute communautaire Dimitra au Niger." Fiche de bonne pratique: Niger, Rome. <http://www.fao.org/docrep/018/aq225f/aq225f.pdf>.
- Babcock, L. H. 2014. "Mobile Payments: How Digital Finance Is Transforming Agriculture." *Devex*, August 20. <http://www.devex.com/news/mobile-payments-how-digital-finance-is-transforming-agriculture-84191>.
- Babcock, L. H., and C. Statham. 2014. "The Agricultural Mobile Finance Revolution." *ICTUpdate*, Issue 76, February. <http://ictupdate.cta.int/en/Feature-Articles/The-agricultural-mobile-finance-revolution>.
- Balasubramaniana, K., P. Thamizolib, A. Umara, and A. Kanwar. 2010. "Using Mobile Phones to Promote Lifelong Learning among Rural Women in Southern India." *Distance Education* 31 (2): 193–209. <http://sites.asiasociety.org/womenleaders/wp-content/uploads/2010/05/using-mobile-phones-to-promote-lifelong-learning-among-rural-women-in-southern-india.pdf>.
- Baumüller, H. 2016. "Agricultural Service Delivery through Mobile Phones: Local Innovation and Technological Opportunities in Kenya." Chapter 9 in *Technological and Institutional Innovations for Marginalized Smallholders in Agricultural Development*, edited by F. W. Gatzweiler and J. von Braun, 143–59. Berlin: Springer International. http://link.springer.com/chapter/10.1007/978-3-319-25718-1_9/fulltext.html.
- Crompton, H. 2013. "A Historical Overview of Mobile Learning: Toward Learner-Centered Education." In *Handbook of Mobile Learning*, edited by Z. L. Berge and L. Y. Muilenburg, 3–14. New York: Routledge.
- CTA (Technical Centre for Agricultural and Rural Cooperation). 2015. *Mobile Payments—How Digital Finance Is Transforming Agriculture*. Wageningen, Netherlands: CTA. http://publications.cta.int/media/publications/downloads/1849_PDF.pdf.
- David-West, O. 2010. "Esoko Networks: Facilitating Agriculture through Technology." GIM Case Study B061, United Nations Development Programme, New York.
- Eurostat. 2014. "Progress of the World's Women 2015–2016: Transforming Economies, Realizing Rights." Chapter 2, 84. Retrieved from UN Women, New York.
- FAO (Food and Agriculture Organization). 2011. *The State of Food and Agriculture 2010–11. Women in Agriculture: Closing the Gender Gap for Development*. Rome: FAO.
- . 2012. "International Women's Day: FAO Gender Policy Aims High." News article, March 8. <http://www.fao.org/news/story/en/item/128104/icode/>.
- . 2014. *The State of Food and Agriculture: Innovation in Family Planning*. Rome: FAO.
- . 2015a. "Dimitra Clubs: A Unique Approach." FAO, Rome.
- . 2015b. *e-Agriculture 10 Year Review Report: Implementation of the World Summit on the Information Society (WSIS) Action Line C7. ICT Applications: e-agriculture*. Rome: FAO. <http://www.fao.org/3/a-i4605e.pdf>.
- . 2015c. *Livelihoods Food Security Programme—APN Gender Strategy*. Rome: FAO.

- . 2017. "Mainstreaming Gender in the Use of Information and Communication Technologies for Agriculture and Rural Development." FAO, Rome.
- Fletschner, D., and L. Kenney. 2011. "Rural Women's Access to Financial Services: Credit, Savings, and Insurance." ESA Working Paper 11-07, Food and Agricultural Organization, Rome. <http://www.fao.org/3/a-am312e.pdf>.
- Gandhi, R., R. Veeraghavan, K. Toyama, and V. Ramprasad. 2009. "Digital Green: Participatory Video for Agricultural Extension." *Information Technologies for International Development* 5 (1): 1–15. <http://itidjournal.org/index.php/itid/article/view/322/145>.
- Grameen Foundation. 2012. "Women, Mobile Phones, and Savings: A Grameen Foundation Case Study." Grameen Foundation USA, Washington, DC. <http://www.grameenfoundation.org/resource/women-mobile-phones-and-savings-case-study>.
- . 2013. "Best Practices in Mobile Microfinance." Grameen Foundation USA, Washington, DC. <http://www.grameenfoundation.org/resource/best-practices-mobile-microfinance>.
- GSMA (Groupe Spéciale Mobile Association). 2014. "State of the Industry: Mobile Financial Services for the Unbanked." GSMA, London. http://www.gsma.com/mobilefordevelopment/wp-content/uploads/2015/03/SOTIR_2014.pdf.
- . 2015a. "Accelerating Digital Literacy: Empowering Women to Use Mobile Internet." GSMA, London. http://www.gsma.com/connectedwomen/wp-content/uploads/2015/06/DigitalLiteracy_v6_WEB_Singles.pdf.
- . 2015b. "Connected Women 2015: Bridging the Gender Gap—Mobile Access and Usage in Low- and Middle-Income Countries." GSMA, London. http://www.gsma.com/connectedwomen/wp-content/uploads/2015/02/GSM0001_02252015_GSMAReport_FINAL-WEB-spreads.pdf.
- . 2015c. *State of the Industry: Mobile Money*. London: GSMA. http://www.gsma.com/mobilefordevelopment/wp-content/uploads/2016/02/SOTIR_2015.pdf.
- . 2015d. *Women and Mobile Money: Insights from Kenya*. London: GSMA. <http://www.gsma.com/connectedwomen/women-and-mobile-money-insights-from-kenya/>.
- GSMA Development Fund and Cherie Blair Foundation for Women. 2010. *Women and Mobile: A Global Opportunity*. London: GSMA. http://www.cherieblairfoundation.org/wp-content/uploads/2012/07/women_and_mobile_a_global_opportunity.pdf.
- Gurumurthy, A., and N. Chami. 2014. "Gender Equality in the Information Society: A Review of Current Literature and Recommendations for Policy and Practice." IT for Change, Department for International Development (DFID) and Bridge, London. <http://www.eldis.org/vfile/upload/4/document/1409/Gender%20and%20ICTs%20briefing%202014.pdf>.
- Harvey, J. 2012. "Extension Agents: Why Does It Matter if They Are Male or Female?" Cited in "Gender Mainstreaming in ICT for Agriculture," Briefing Paper, US Agency for International Development, Washington, DC.
- Hasselback, C. 2014. "Technology for Economic Growth: How Mobile Money Expands Financial Inclusion in Malawi." *Degrees*, June 9. <http://degrees.fhi360.org/2014/06/technology-for-economic-growth-how-mobile-money-expands-financial-inclusion-in-malawi/>.
- IFAD (International Fund for Agricultural Development). 2006. "Gender and Rural Microfinance: Reaching and Empowering Women." IFAD, Rome. http://www.ifad.org/gender/pub/gender_finance.pdf.
- . 2009. "Gender and Rural Microfinance: Reaching and Empowering Women." IFAD, Rome. <https://www.ifad.org/documents/10180/8551f293-2573-417d-908a-d1841359df57>.
- . 2012. "Gender Factsheet: Gender Equality and Women's Empowerment." IFAD, Rome. http://www.ifad.org/pub/policy/gender/equality_e.pdf.
- IFC (International Finance Corporation). 2015. *She for Shield: Insure Women to Better Protect All*. Washington, DC: IFC. http://www.ifc.org/wps/wcm/connect/a2d8348049d01b0c82a5a3e54d141794/SheforShield_Final-Web2015.pdf?MOD=AJPERES.
- IICD (International Institute for Communication and Development). 2009. "Gender and ICT: A Good Mix." IICD, The Hague. <http://www.bibalex.org/Search4Dev/files/310731/140254.pdf>.
- . 2015. "Promoting Equal Chances for Women and Men to Use and Benefit from ICT-enabled Solutions." IICD, The Hague. <http://iicd.org/documents/promoting-equal-chances-for-women-and-men-to-use-and-benefit-from-ict-enabled-solutions/>.
- Kaisaris, J. 2015. "Education for Women through Mobile Phone Messages." <https://www.empowerwomen.org/fr/community/stories/2015/5/education-for-women-through-mobile-phone-messages>.
- Kanwar, A. 2012. "Can Mobiles Support Learning for Development? A Gendered Perspective." Opening Remarks for the Mobiles for Development (M4D) Workshop, National Institute of Bank Management, Pune, March 7. http://dspace.col.org/bitstream/handle/11599/1082/2012_Kanwar_Mobile_Gendered_Transcript.pdf?sequence=1&isAllowed=y.
- Kumar, A., A. Tewari, G. Shroff, D. Chittamuru, M. Kam, and J. Canny. 2010. "An Exploratory Study of Unsupervised Mobile Learning in Rural India." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, New York, 743–52. <http://bid.berkeley.edu/files/papers/CHI2010a.pdf>.
- Martin, H. 2011. "Digital gender divide or technologically empowered women in developing countries? A typical case of lies, damned lies, and statistics." *Women's Studies International Forum* 34 (6): 479–89.
- Mercy Corps. 2015. *Lessons Learned on Service Delivery, Marketing, and Capacity Building on Agri-Fin Mobile*. Portland, OR: Mercy Corps. E-book. http://www.shareweb.ch/site/Agriculture-and-Food-Security/focusareas/Documents/ras_agri-fin_mobile_report.pdf.
- Miranda, V. 2011. "Cooking, Caring, and Volunteering: Unpaid Work around the World." OECD Social, Employment and Migration Working Paper 116. OECD, Paris. <http://www.oecd.org/berlin/47258230.pdf>.
- Morawczynski, O., and M. Pickens. 2009. "Poor People Using Mobile Financial Services: Observations on Customer Usage and Impact from M-PESA." Consultative Group to Assist the Poor (CGAP), Washington, DC.

- Ndiaye, O. K. 2015. "Is the Success of M-Pesa 'Empowering' Kenyan Rural Women?" *Feminist Africa* 18: 156–61. http://agi.ac.za/sites/agi.ac.za/files/standpoints_is_the_success_of_m-pesa_empowering_kenyan_rural_women_.pdf.
- OECD (Organisation for Economic Co-operation and Development). 2012. *Gender Equality in Education, Employment, and Entrepreneurship: Final Report to the MCM 2012*. Paris: OECD Publishing. <http://www.oecd.org/employment/50423364.pdf>.
- Ofulue, C., T. Adegbola, and F. O. Egbokhare. 2013. "Mobile Technology for Development in Nigeria: Designing Mobile Technology Enabled Application in Local Languages." Paper presented at the UNESCO Mobile Learning Week, Paris, February 18–20. <http://docplayer.net/3629161-Mobile-telephony-for-development-in-nigeria-designing-mobile-technology-enabled-application-in-local-languages.html>.
- Opportunity International. 2011. "Opportunity International Launches 'Banking on Women' Campaign." Press Release. <http://opportunity.org/news/press-releases/opportunity-international-launches-banking-on-women-campaign>.
- Oshadare, A. A., T. P. Ige, and C. Omowumi Lawal. 2015. "E-Learning through Information and Communication Technology: A Suitable Methodology for Adult Education in Nigeria." *Knowledge Review* 33 (3). <http://www.globalacademicgroup.com/journals/knowledge%20review/Ade%20Ariyo.pdf>.
- Plyler, M., S. Haas, and G. Nagarajan. 2010. "Community Level Economic Effects of M-PESA in Kenya: Initial Findings." Executive Summary. Financial Services Assessment, IRIS Center, College Park, MD.
- Quisumbing, A. 2003. "Household Decisions, Gender, and Development: A Synthesis of Recent Research." International Food Policy Research Institute (IFPRI), Washington, DC.
- Schneider, K., and M. K. Gugerty. 2010. "Gender and Contract Farming in Sub-Saharan Africa: Literature Review." Paper prepared for the Bill and Melinda Gates Foundation. https://evans.uw.edu/sites/default/files/public/Evans%20UW_Request%2067_Gender%20%26%20Contract%20Farming_03-08-2010.pdf.
- SNV (Netherlands Development Organization). 2015. *Rural Finance Outreach Strategy in Zimbabwe*. Harare: SNV.
- Sylvester, G., ed. 2015. "Success Stories on Information and Communication Technologies for Agriculture and Rural Development." Food and Agriculture Organization (FAO), Bangkok. <http://www.fao.org/publications/card/en/c/a891e31d-af59-461b-8f33-be75158f7b73/>.
- Tegemeo Institute, Egerton University. 2011. *KAPAP Gender Disaggregated Baseline Survey Report*. Njoro: Egerton University.
- Tiwari, S. P. 2008. "Information and Communication Technology Initiatives for Knowledge Sharing in Agriculture." *Indian Journal of Agricultural Sciences* 78 (9).
- UN (United Nations). 2010. *The World's Women 2010: Trends and Statistics*. New York: Department of Economic and Social Affairs. http://unstats.un.org/unsd/demographic/products/Worlds_women/WW_full%20report_color.pdf.
- . 2015. "Transforming Our World: The 2030 Agenda for Sustainable Development." United Nations Sustainable Development Knowledge Platform. <https://sustainabledevelopment.un.org/post2015/transformingourworld>.
- UNCTAD (United Nations Conference on Trade and Development). 2013. *Empowering Women Entrepreneurs through Information and Communications Technologies: A Practical Guide*. Geneva: UNCTAD. http://unctad.org/en/PublicationsLibrary/dt1stict2013d2_en.pdf.
- UNESCO (United Nations Educational, Scientific and Cultural Organization). 2013. *Policy Guidelines for Mobile Learning*. Paris: UNESCO. <http://unesdoc.unesco.org/images/0021/002196/219641e.pdf>.
- . 2015a. *EFA Global Monitoring Report 2015: Education for All 2000–2015—Achievements and Challenges*. Paris: UNESCO. <http://unesdoc.unesco.org/images/0023/002322/232205e.pdf>.
- . 2015b. *Mobile Phones and Literacy Empowerment in Women's Hands: A Cross-Case Analysis of Nine Experiences*. Paris: UNESCO. <http://unesdoc.unesco.org/images/0023/002343/234325E.pdf>.
- USAID (United States Agency for International Development). 2012. "Gender Mainstreaming in ICT for Agriculture." Briefing Paper, USAID, Washington, DC. http://pdf.usaid.gov/pdf_docs/jpnaec808.pdf.
- . 2016. *Guide to the Use of Digital Financial Services in Agriculture*. Washington, DC: USAID. http://www.summitwebcasting.com/webcast/02-17-16/DFS_FTF_Guide_Final_Feb%202016.pdf.
- Women and the Web Alliance (website). <http://www.womenandtheweballiance.org/about/>.
- World Bank. 2011. *ICT in Agriculture Sourcebook: Connecting Smallholders to Knowledge, Networks, and Institutions*. Washington, DC: World Bank. e-Sourcebook. <http://www.ictinagriculture.org/content/ict-agriculture-sourcebook>.
- . 2015a. "The Global Findex Database 2014: Measuring Financial Inclusion around the World." World Bank, Washington, DC. <http://documents.banquemondiale.org/curated/fr/2015/04/24368699/global-findex-database-2014-measuring-financial-inclusion-around-world>.
- . 2015b. "Digital Financial Solutions to Advance Women's Economic Participation." World Bank, Washington, DC. http://www.uncdf.org/sites/default/files/Documents/womens_economic_participation_report_16_november_2015.pdf.
- . 2015c. "Providing Agriculture-Nutrition Convergence through Participatory Extension Videos." Agriculture Global Practice Note, World Bank, Washington, DC.
- . 2015d. *Supporting Women's Agro-Enterprises in Africa with ICT: A Feasibility Study in Zambia and Kenya*. Report No. 93077-AFR, Washington, DC: World Bank.
- . 2016. *World Development Report 2016: Digital Dividends*. Washington, DC: World Bank. http://www-wds.worldbank.org/external/default/WDSPContentServer/WDSP/IB/2016/01/13/090224b08405ea05/2_0/Rendered/PDF/World0developm0000digital0dividends.pdf.

SECTION 2

Enhancing Productivity on the Farm

Module 5 **INCREASING CROP, LIVESTOCK, AND FISHERY PRODUCTIVITY THROUGH ICT**

EIJA PEHU (World Bank), CORY BELDEN (World Bank), and SUVRANIL MAJUMDAR (World Bank), with input from TEEMU JANTUNEN (FM-International Oy FINNMAP)

IN THIS MODULE

Overview. How can farmers and governments use ICT to increase agricultural productivity? At the local level, farmers can use ICT to match cropping practices to climatic trends, use inputs and resources environmentally and sustainably, and cope with productivity threats. At the national level, public officials can adjust policies to reflect the data collected with ICT, predict food supplies, and target social programs or promote yield technologies. Integrating ICT into national programs, creating a policy environment conducive for ICT investment, and designing digital systems that are compatible and common can help improve access for users, but social and financial challenges remain. Powerful yet inexpensive tools (and the financial support and training to use them) are not always available for small-scale producers in most developing countries, although some are being developed and piloted. Conducting impact studies and sharing pilot project information can focus and speed the development of such types of ICT. The productivity goals and technologies used to meet them must match the IT capacity in the focus location.

Topic Note 5.1: Achieving Good Farming Practices through Improved Soil, Nutrient, and Land Management. New types of ICT help to characterize field conditions, sometimes at a very fine level of detail, and help farmers improve soil and land productivity. Correcting past damages and ensuring future yields will require farmers, governments, and development partners to mitigate the effects of climate change and environmental degradation. Significant, national progress with some of these technologies will require appropriate legal and regulatory frameworks, monitoring systems, and liability, access, and property rights laws and regulations, such as regulations on carbon limits.

- **Seeing-Is-Believing Project Improves Precision Farming**
- **Improving Nitrogen Fertilization in Mexico**
- **Monitoring Livestock to Prevent Pasture Damage**

Topic Note 5.2: Preventing Yield Losses through Proper Planning and Early Warning Systems. ICT has considerable potential to help even small-scale producers prevent losses after investments have been made by identifying and controlling pests and diseases, receiving timely weather information, and improving resource use. At the same time, ICT allows governments and development partners to better monitor farm productivity, make more accurate projections, and plan better for the future. ICT should be used to form two-way communication networks that gather and use local knowledge. Advances in ICT are best suited to helping farmers improve their management of one or two farm components at a time. Development partners and governments need to prioritize which yield technologies or agricultural strategies to introduce. Incentives for partnering with the private sector in large-scale ICT projects may enable the investment to reach smallholders. Taking stock of the technical capacity in rural areas will clarify infrastructure needs.

- **Radio Frequency Identification to Prevent and Treat Cattle Disease in Botswana**
- **Digital Orthophoto Quads Form a Database for the Dominican Republic**
- **Using Landsat to Assess Irrigation Systems in Mali**

OVERVIEW

Agriculture is a vital sector for the sustained growth of developing countries, especially agriculture-based countries such as those in Sub-Saharan Africa. Equally important, a significant portion of the world's population—86 percent of rural inhabitants—still depends on agriculture for employment and sustenance (World Bank 2007). Demand for food is increasing, too (box 5.1). The Food and Agricultural Policy Research Institute (FAPRI) estimates that an additional 6 million hectares of maize and 4 million hectares of wheat, plus a 12 percent increase in global maize and wheat yields, will be needed to meet demand for cereals alone in the next decade (Edgerton 2009). Demand for meat is expanding as incomes rise, creating competition for land and other resources. Increasingly unstable weather and temperatures require adaptive agronomic techniques to meet the demand.

The average maize yield per hectare in wealthy countries like Canada is three times higher than the average maize yield in low-income countries (FAO 2008). Growth in yields of rice, the primary staple for a significant number of developing

countries, has stagnated in developing countries. Several regions, particularly East Asia, have seen rice yields decline by 10 percent owing to climate change. The factors contributing to low productivity are vast, including the coevolution of pests and pathogens, poor infrastructure, soil loss and degradation, waterlogging and salinity, the impact of climate change, the lack of storage facilities, and weak markets. Low investments in agricultural research have reduced the scope for innovative thinking and technological development that could address these contributing factors and improve productivity.

Despite the dim outlook for meeting global food demand in a sustainable manner, successful social, economic, and technological developments have resolved productivity and population issues in the past and may hold some hope for the future. For example, over the past 40 years, annual global cereal production has grown from 420 million to 1.176 billion tons (FAO 2000). In the 20th century, yields in the United States rose from 1.6 tons per hectare to 9.5 tons per hectare (Edgerton 2009). Similarly large increases occurred around the world from the mid-1980s to early 2000s, when cereal yields rose by more than 50 percent (World Bank 2007).

BOX 5.1. The Food Security Challenge

The lack of food. Increasing agricultural productivity and access to food are the primary development goals of the 21st century. Demand for food has reached new heights, and predictions of future demand are discouraging. Although growth in global demand for cereals will slow in the coming 40 years, demand in Sub-Saharan Africa will balloon by as much as 2.6 percent per year.^a The food-insecure population in Sub-Saharan Africa is also expected to increase by up to 32 percent by 2020, whereas food insecurity is projected to decline in Latin America and Asia.^b Overall, the world will need 70–100 percent more food by 2050, when the population increases to 9 billion.^c

The lack of nutrients. The lack of food is not the only problem. Almost one billion people were undernourished in 2010, and the lack of nutritious food has serious, long-term consequences for physical and mental health. More than one in seven of the world's people do not receive enough protein and carbohydrates in their daily diets. These people constitute 16 percent of the developing country population.^d

The rising prices. Even with projected reductions in food insecurity, price spikes could keep staple food out of the reach of poor people. The 2008 price spikes led to starvation in many countries, hitting the net food importers—typically the poorest countries—the hardest. Ethiopia, Malawi, Tanzania, and Uganda experienced maize prices that were twice as high as in the previous year. In Kenya and Mozambique, prices rose by 50–85 percent, according to the United States Department of Agriculture. Sharp and unexpected price spikes can provoke riots and political instability, aggravating an already precarious food situation. FAO recently predicted that the total costs of food imports would reach a near-record level in 2010, roughly US\$1 trillion.^e

The changing climate. Climate change has made the challenges of food security and rising prices even more stark. Continued release of greenhouse gases increases the likelihood of unpredictable weather and temperatures. The severe 2010 droughts and fires in the Russian Federation, Ukraine, and Kazakhstan raised wheat prices substantially, leading to grain embargos in multiple countries. Russia's wheat exports fell by 13 million metric tons in one year.^e Pakistan's floods are another warning of the serious climate changes facing developing countries. The loss of soil nutrients that can accompany climatic extremes makes agricultural land less productive and adds to food insecurity. This prospect is ominous, considering the consistent drop in cereal yields over the last decade.^f

Source: Authors; (a) Rosegrant et al. 2006; (b) Shapouri et al. 2010; (c) World Bank 2007; (d) FAO 2009; (e) FAO 2010a; (f) Raloff 2010.

Agricultural productivity rose around the world because more land was cultivated and more land was cultivated more intensively. Most of the gains were made through intensification. Agricultural land expanded by only 11 percent between 1961 and 2007 (FAO 2009), but between 1960 and 2000, genetic improvement and agronomic practices contributed to 78 percent of the increase in production (Lal 2010).

Bringing more land into production is infeasible, not only because of the growing number of competing uses for land but because of the environmental and social costs involved. The drive for agricultural land has often resulted in deforestation, reduced biodiversity, and provoked other forms of environmental degradation (Balmford, Green, and Scharleman 2005). It has also removed livelihood opportunities for some communities and elevated greenhouse gas emissions (Millennium Ecosystem Assessment 2005).

Given these constraints, development partners and governments alike continually seek ways to raise crop yields without using additional land. Raising yield per unit of land was observed during the Green Revolution of the 1960s and 1970s, when the use of new cultivars (shorter, higher-yielding varieties of wheat and rice) and improved practices (such as the use of fertilizer and irrigation) significantly increased crop yields throughout most of Latin America and Asia. A similar Green Revolution never arrived in Sub-Saharan Africa but is sorely needed, given that almost all of the arable land is being cultivated (Govere, Nyoro, and Jayne 1999).

Nonetheless, land can be used more intensively as well as more sustainably than in previous years, under innovative farming practices like precision farming, integrated pest management, agroforestry, and aquaculture (Burney, Davis, and Lobella 2010). Sustainable land intensification, in which yields rise but negative environmental impacts are curbed, provides a potential answer to food security and poverty reduction challenges. The sobering consideration, however, is that this type of intensification cannot occur unless 1.5 billion farmers—85 percent of whom farm less than two hectares—obtain and use these and other new technologies (World Bank 2007).

If the goal is to achieve sustainable increases in the global food supply and economic growth, it is important to ask who is responsible for producing food and commodities. Equally crucial, it is important to ask if they have access to technology, the knowledge to use it, and the purchasing power to acquire it (Pretty et al. 2006). The world as a whole, all regions, and all nations depend on farm households to provide food and by 2050 the world will ask farm households to supply double the current amount of food. Today, the farmers that the globe depends on are primarily smallholders with little access to technology, limited knowledge, and few financial resources. Notably, 43 percent are women (FAO 2011). Box 5.2 expands on why gender is a critical consideration in designing and implementing ICT for agriculture productivity.

Given that the future of food depends to such a great extent on small-scale agriculture, governments and development

BOX 5.2. Gender in Agricultural Productivity

Exploring how gender disparities affect agricultural productivity is at the forefront of the development agenda. Women play significant and essential roles in agriculture in most developing countries. Their knowledge of local agrobiodiversity and conservation practices makes them prime assets in the sustainable intensification of agriculture. Women are also responsible for processing most crop and animal products and are often more involved than their male counterparts in high-value production. In addition, females play the chief role in care-taking, making them essential to household nutrition and children's (especially girls') education. It is widely accepted that women invest more regularly, and to a greater extent than men, in the well-being of future generations. These responsibilities add to a burdensome workload that involves time-consuming activities like fetching water and fuel.

Despite women's key contributions to agriculture and rural development, they face major challenges in accessing inputs like land, improved tools, and financial services. Cultural, social, and political barriers prevent women from using their assets effectively in the field. Women are much less likely than men to purchase fertilizer or machinery. Women also have lower incomes compared to men: They receive smaller salaries in formal positions, earn less from their livestock, and are typically involved in seasonal, part-time work, if any.^a As a result, their productivity is minimized and below that of male smallholders.

This situation represents a major challenge to increasing yields, because the majority of the world's smallholders are female (75 percent in Sub-Saharan Africa). Increasing agricultural productivity requires greater attention to gender differences and women in general. FAO asserts that if women had better access to resources, they could increase yields by 20–30 percent.^a Development institutions should use ICT to address these issues—and of course make certain that women can access ICT in the first place.

Source: Authors; (a) FAO 2011.

partners are focusing on how to increase productivity in sustainable ways through new technologies that smallholders can use. Irrigation management, biotechnologies, pest management and eradication, soil assessment, improved nutrient and land management, improved market access, and innovative storage facilities are all strategies for increasing smallholders' agricultural productivity and improving their access to markets, but the challenge lies in ensuring that smallholders can obtain and use them. ICT provides an incredible opportunity to reach farmers with the technical information they require to increase yields.

Linking Technology for Agricultural Productivity with ICT

This module discusses two sets of technologies and the links between them:

- **Yield technologies**, like improved seeds, crops developed through biotechnology, tractors, pesticides, fertilizer, and irrigation systems.
- **Information and communication technologies**, like geographical information systems (GIS), wireless sensor networks, data mediation software, and short messaging service (SMS).

Though they often work symbiotically at the farm level, and though both are often required to achieve the kinds of development goals discussed in this module, the differences between them need to be understood. Figure 5.1 helps to clarify them.

When farmers have access to biophysical and other yield-enhancing technologies, frequently they do not know how to use them effectively to address their productivity challenges (for example, they may have fertilizer but not know the optimal amount to apply). ICT can fill this gap in knowledge. Global positioning systems (GPSs), radios, mobile phones, digital soil maps, and other types of ICT give farmers information to use

biophysical technologies appropriately (for example, nitrogen sensors can help to determine the correct fertilizer dose).

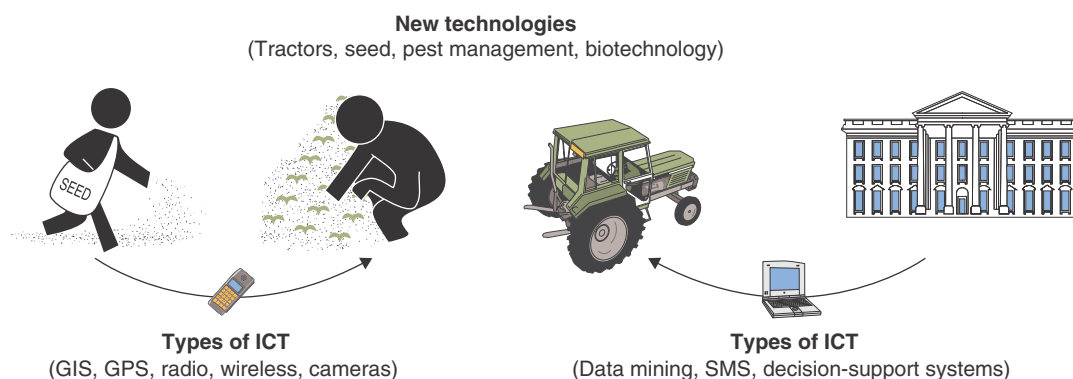
Similarly, governments or development partners may know that farmers are using new yield-enhancing technologies but may not have the capacity to understand their effects. Data-mining technologies, decision-support systems, and modeling software that can clarify the effects and outputs of yield-enhancing technologies are among the most promising means of linking productivity and ICT.

This module describes how farmers and governments can use ICT in their strategies to increase agricultural productivity. The applications are quite broad; ICT can be used to monitor pest thresholds in integrated pest management, provide relevant and timely information and agricultural services, map agrobiodiversity in multiple-cropping systems, forecast disasters, and predict yields. Crop losses diminish as farmers receive relevant and timely information on pests and climate warnings through SMS technology.

Just as important, information can (and should) go both ways: Farmers can alert local governments or other relevant actors about serious crop developments like disease symptoms. This information makes it possible to avoid disasters more effectively and improves economic management, both of which are crucial for adapting to climate change.

ICT can also lead to more optimal use of inputs. Increasing producers' knowledge of how to use and manage water; equipment; and improved seeds, fertilizer, and pesticides has strengthened of farm practices around the world. In the long run, and after collecting and analyzing multisite, multiyear data, ICT can be used to match cultivars to appropriate environments, increase the understanding of genotype-by-environment interactions, and adapt cropping strategies to the changing climate.

FIGURE 5.1. Defining the Relationship Between Types of ICT and Yield Technologies



Source: Authors.

Each of these applications increases the profitability of agriculture, reduces transaction costs, facilitates climate change adaptation, and improves livelihoods for the rural poor.

Strategies to increase yields (including strategies to avoid yield losses) include initiatives like soil nutrient assessments, weather forecasting, and crop or animal protection. The types of ICT used to enhance these strategies are discussed in the topic notes.

Topic Note 5.1, “Achieving Good Farm Practices through Improved Soil, Nutrient, and Land Management,” focuses on soil testing technologies and tools that characterize field conditions, sometimes at a very fine level of detail. These technologies help farmers apply inputs appropriately and encourage the use of sustainable, profitable farming practices.

Topic Note 5.2, “Preventing Yield Losses through Proper Planning and Early Warning Systems,” focuses on how ICT can be used to identify and control pests and diseases, improve access to timely weather information, and improve the design and management of irrigation systems.

Various examples and innovative practice summaries are included; it should be noted that most of these practice summaries come from pilot programs in Africa, where many studies and projects are currently under way. Discussions of lessons learned (covering crosscutting themes, challenges, and key enablers) conclude each note. Finally, the broad types of ICT discussed in this module fall into three categories. They are briefly defined in the subsections that follow.¹

Remote Sensing Technologies: Raw Data Collection

The first type of ICT that improves productivity includes tools that collect agricultural data:

- **Geographical information systems (GIS)** collect geographic data through computer hardware and software to capture, store, update, and display all forms of geographically referenced information by matching coordinates and time to other variables. Data sets formed by GIS constitute “layers” of information (for example, on topography, population size, or agricultural household income) that can be merged and analyzed to establish relationships and produce maps or charts that visualize geographical traits (GIS.com n.d.).

¹ This is not a comprehensive list of all of technologies discussed in the module; nor is it a comprehensive list of all the types of ICT used to increase agricultural productivity. The technologies reviewed here are the best known and most applicable to all yield technologies or agricultural strategies.

- **Global positioning system (GPS)** is a satellite-based positioning and navigation system with three basic components: satellites that orbit the Earth, control and monitoring stations on the Earth, and the GPS receivers owned by users. GPS receivers pick up signals from satellites, including precise orbital information (latitude, longitude, and ellipsoidal GPS altitude) for a given object or location, as well as the time. GPSs can function in any weather and are free for public use (GPS.gov n.d.; GARMIN n.d.).
- **Satellite imagery** is an image of Earth taken from satellites in orbit. There are four types of satellite imagery—spatial (size of surface area); spectral (wavelength interval); temporal (amount of time); and radiometric (levels of brightness)—which capture a variety of variables about a given area of varying size. The resolution (in meters) of these images depends on the satellite system used and its distance from Earth; weather can interfere mainly with satellite systems utilizing visible wavelengths of light. The cost of the technology depends on the satellite system used, on whether new or archive imagery is purchased, and on possible georeferencing to a coordinate system.
- **Aerial photography and orthophoto mosaic.** An aerial photo is an image (once a photograph, now a digital image) of the ground taken from an airplane, helicopter, or radio-controlled aircraft at a given altitude. Aerial images are presented as an orthophoto mosaic that is an alternative to a map. These images are higher in resolution (deci-meter) than satellite images, proving useful for those who want more details of the terrain such as crop conditions or land use. In addition, modern digital aerial photography is georeferenced—that is, each point has geographical coordinates, whereas satellite imagery requires georeferencing to be geographically accurate and compatible with other geographical data (for example, in GIS) (T. Jantunen, personal communication).
- **Laser scanning, or light detection and ranging (LiDAR),** is an active airborne sensor using a set of laser beams to measure distance from an aircraft to features on the ground. Airplanes and helicopters can be used for laser scanning. The data from laser scanning are three-dimensional at very high accuracy, and they also allow ground elevation under the tree canopy to be measured. The elevation accuracy of laser scanning data is much better than aerial photography, which makes laser scanning useful for accurate

topographic mapping where elevation is critical. The data can also be used to measure forest attributes such as the height and density of trees and thus the volume (above-ground biomass) of the forest (T. Jantunen, personal communication).

Information Management Technologies: Making Sense of the Data

The raw data collected, as indicated above, are fairly useless without analytical tools, both human and inanimate:

- **Spatial modeling (among other models).** Closely related to spatial analysis or statistics, models are an attempt to simulate real-world conditions and explore systems using their geographic, geometric, or topological properties. GIS (which can also perform analysis), among other types of ICT, has increased opportunities to create models that predict occurrences like yield growth and ecosystem degradation.
- **Data mining** is the extraction of stories or patterns from large amounts of data. Data mining can find four major patterns: clustering (discovering groups), classification (forming a structure), regression (finding a function), and associations (finding relationships). These analyses help to make sense of agricultural data collected by remote sensors (Palace 1996).
- **Data mediation** is the process of taking many different data sets to produce a single, coherent set of information. Data mediation software organizes different types of data (such as hourly versus daily) and synthesizes different approaches to classification (for example, the use of a different classification vocabulary), helping to mediate differences between data sources—particularly those on the Internet.

Dissemination Tools: Getting the Results to the Stakeholders

After analysis, the results must reach those who need to react to the findings, using tools like:

- **SMS.** Text options that allow interaction between fixed-line and mobile phones.
- **Radio.** transmission of information through electromagnetic waves with low frequencies.

- **WiFi.** Wireless local area network that allows various devices to connect to the Internet remotely.
- **Knowledge management system.** Electronic system that provides relevant information as it is requested.

It should be noted that extension agents and advisory programs are essential to disseminate knowledge about the types of ICT discussed in this module, but this issue is not discussed in detail here; see Module 6.

KEY CHALLENGES AND ENABLERS

Increasing smallholder productivity is one the greatest tasks in this century. Although the dimensions of the challenge are huge (growing populations, growing demand for food, rising poverty, economic stagnation, worsening environmental degradation, and climate change), the growing number and sophistication of types of ICT offer some hope of raising agricultural productivity, even in smallholders' fields. Variable rate technology, GIS, GPS, satellite imagery, and other data collection technologies have increased the information available about soil health, weather conditions, and disease outbreaks, making very site-specific farming possible. The key to using these technologies to boost productivity is to remember that complementary technologies are needed: Data analysis technologies (such as data mining or mediation software) and information dissemination technologies (such as mobile phones and radio) are essential for reaching smallholders effectively. Dissemination also includes the crucial human component: Extension agents and farmers themselves must transmit and share knowledge.

As noted, productivity can be increased by expanding the land available for agriculture or by making the land already in use more productive. Given current global circumstances, it seems that the second option is more likely to close the productivity gap and meet demand. In conjunction with technologies developed to raise yields, the use of the types of ICT discussed in this module may do just that. Mainstreaming the use of ICT devices and techniques in agriculture will also enable them to be used more effectively. Integrating ICT into national programs, creating a policy environment conducive for ICT investment, and designing digital systems that are compatible and common can help improve access for users. Conducting impact studies and sharing pilot project

information is also critical to success with ICT, as more specific lessons and impacts are learned (IICD 2006).

In closing, it is important to emphasize that the benefits of ICT can be realized on multiple levels. As ICT capacities expand, local farmers and communities as well as nations

and regions need to understand their potential uses to increase agricultural productivity. These stakeholders must learn how to tailor ICT solutions to macroeconomic needs as well as local agricultural bottlenecks, while exploring how current infrastructure can harness relevant and appropriate technologies.

Topic Note 5.1: ACHIEVING GOOD FARMING PRACTICES THROUGH IMPROVED SOIL, NUTRIENT, AND LAND MANAGEMENT

TRENDS AND ISSUES

Residue removal, tillage, overuse of pesticides and fertilizers, lack of crop diversity, overgrazing, overexploitation of natural resources, and deforestation have led to unhealthy soils and yearly reductions in crop output. Greenhouse gases worsen the situation. Changes in atmospheric temperatures (rising in most developing countries) reduce crop performance. Above 30°C, food and fiber crops develop at a faster rate, leaving less time for nutrient assimilation, biomass accumulation, and growth (Qaderi and Reid 2009). With lower yields and continued soil mismanagement, economic growth slows drastically. This outcome is seen most vividly in countries like Rwanda, Tanzania, Mozambique, and Niger, where the costs associated with the depletion of soil nutrients are estimated to account for 12–25 percent of the agricultural share of GDP (Drechsel et al. 2001).

Good farming practices maximize the chances of a good harvest. In the past, conventional farming practices treated entire farms as homogeneous units even though they are often variable in productive potential. This view is changing as technology allows producers to measure soil nutrient status, crop potential, pasture health, and water-use efficiency at specific sites within a field. Some types of ICT, like digital soil maps, provide extensive soil information that can be stored and accessed online. GPS, satellite imagery, remote sensors, and aerial images help to assess soil and land variations, and mobile applications and the Internet can disseminate the information quickly. With this array of types of ICT, precision farming can be employed to optimize crop and livestock management. Until now, however, these techniques have been concentrated in highly mechanized, large-scale agriculture in industrialized countries.

ASSESSING SOIL PROPERTIES FOR CLIMATE-RESILIENT AGRICULTURE

Accurate soil analyses and improved farming practices are needed urgently because productivity gains are highest in healthy soils and where pesticides, fertilizer, tools, and machinery are used properly. Instruments for mapping and analyzing soil properties have proliferated in the last decade, increasing farmers' knowledge about the soils on their farms and the need for climate-resilient agricultural practices. The following section discusses these technologies and their associated challenges in broad terms. Subsections discuss innovative technologies specifically related to nitrogen and carbon, two essential chemical components of successful soil conservation and climate change mitigation.

Digital soil maps are the most promising applications for visualizing soil properties and the gravity of soil nutrient depletion in a particular area.² The International Working Group on Digital Soil Mapping (WG-DSM) defines digital soil mapping as “the creation and the population of a geographically referenced soil database generated at a given resolution by using field and laboratory observation methods coupled with environmental data through quantitative relationships” (Rossiter 2004). A variety of technologies, including satellite remote sensors and cameras, can be used to survey soil and collect data to create digital soil maps.

These technologies collect soil information faster than methods that require scientists to take soil samples from

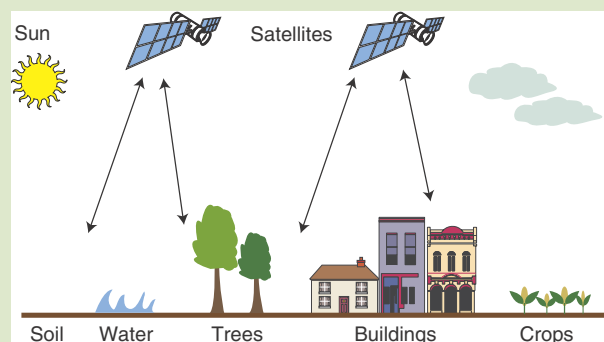
2 For a diverse set of soil maps and data, see FAO, <http://www.fao.org/climatechange/54273/en/>.

the field. In the latter methods, 80 percent of the work on soil mapping is dedicated to soil identification and boundary mapping, and only 20 percent of the time spent in the field is left to gather data on more complex and equally important topographical features, such as water-holding capacity (Manchanda, Kudrat, and Tiwari 2002). Innovative data collection technologies allow researchers to focus on a variety of soil features (box 5.3).

Practitioners can take the soil data collected from the technologies described in box 5.3 and use statistical methods, GIS, and soil inference systems to form “predictive soil maps.” These maps provide information on a soil’s capacity to provide ecosystem services (such as its capacity to infiltrate water, produce crops, or store carbon), geographical representations of soil constraints (such as aluminum toxicity, carbon deficit, or subsoil restrictions), and a baseline for detecting subsequent changes and assessing their impact (AfSIS 2009).

BOX 5.3. Using Remote Sensors and Similar Tools to Measure Soil Properties

A number of types of ICT can be used to measure soil properties for creating digital soil maps. Through near-infrared and short-wave infrared sensors, satellites measure spectral reflectance in soils on the ground. Different materials reflect and absorb solar radiation at a variety of wavelengths (see the figure). As a result, remote sensors can measure soil color, texture (sand, silt, and clay), organic matter, moisture, salinity, and absorption processes by detecting and observing the solar radiation reflected (orbit sensing). Reflectance changes depending on the soil’s contents; for example, reflectance is low in areas with low silt content.^a This technology gives researchers an accurate assessment of soil properties to use in GIS and computer modeling for digital soil maps.



Source: Authors, adapted from <http://www.crisp.nus.edu.sg/~research/tutorial/optical.htm> and Hoffer 1978.

Digital soil maps give practitioners a good picture of soil fertility, vulnerability, and potential. Statistically testing soil maps against other data on human or policy variables (like demographics, land administration, farming practices, and climatic changes) allows researchers and others to explore causes of soil damage and forms of restoration.

At a national or regional level, models created from digital soil maps can be used to improve the selection of crops and varieties (based on which crops and varieties can withstand stressful soil conditions). They can also be used in early warning systems (predicting crop failure, for example), giving policy makers more time to react to shortfalls in domestic and export markets. In addition, fine-resolution soil maps collected from a number of regions could enable climatologists, hydrologists, and crop modelers to more accurately predict the effects of climate change or new technologies on food production and environmental health.

After soil data are collected, analyzed, and reflected in digital soil maps, the results need to be shared with policy makers, scientists, and especially farmers, who would otherwise not have such detailed information on soil fertility in their respective farming communities. Recent developments in ICT increase the cost-effectiveness of soil maps: The spread of mobile phones and Internet access can transfer relevant soil information to even remote locations. Collaborating with extension staff, farmers, agrodealers, and others, development institutions can generate integrated soil fertility management schemes that improve a wide range of farming practices. Box 5.4 explains how these results can be applied.

Challenges in Soil Mapping

Although technological developments have improved access to digital soil maps, major technological and economic challenges remain to be addressed in soil science and development institutions. Broadly speaking, the impacts and outcomes of using digital soil maps in smallholders’ fields have not been captured. Soil assessment techniques certainly contribute to the knowledge of production potential, but the transformative effects of this knowledge (such as the adoption of new practices) have not been tested empirically. Another technical challenge is that some digital soil maps cannot be used in quantitative studies or in models of food production or carbon management. Such studies generally require information on the functional properties of soils—such as available water capacity, permeability, and nutrient supply—which many mapping procedures do not capture. Finally, individual soil map units are shown as

BOX 5.4. Collecting African Soil Data over Time to Understand Soil Degradation Trends

The African Soil Information System (AfSIS) Project, led by the International Center for Tropical Agriculture (CIAT), collects data that will help address food insecurity and environmental degradation in Sub-Saharan Africa. AfSIS takes advantage of recent developments in ICT—digital soil mapping, remote sensing, statistics, and soil fertility management—to analyze alternatives for protecting and rehabilitating soil. The project also tests a variety of farming techniques in an effort to discover the most effective methods to suit a wide range of conditions and situations. The soil map website and mobile networks help to ensure that the data collected can reach the complete spectrum of people involved in farming in Africa.

One objective of the AfSIS research, therefore, is to develop a baseline—an overview against which future results can be compared—using standardized tests and procedures. By applying an agreed-on process of sampling and analysis, scientists can build a comprehensive picture of soil health and degradation in an area of Sub-Saharan Africa covering 42 countries and more than 18 million square kilometers.

It is well known that farmers in Africa typically use little fertilizer compared with farmers in the rest of the world. One important initiative in AfSIS investigates methods farmers can use to improve the fertility of their soils. The trials compare the effectiveness of different fertilizers used on a range of soils, the rate of fertilizer application, and the integration of leguminous crops in rotations.

AfSIS information will also be used in a wider international effort to produce a digital map of the world's soil resources (the Global Digital Soil Properties Map Initiative). Scientists from soil information and agricultural development institutes in Mexico, Canada, and the United States work with the AfSIS team to produce the global map.

Sources: AfSIS 2009; ICT Update, "Farming From the Ground Up: Scientists Use the Latest Technology to Produce a Digital Soil Map of Africa," April 29, 2010 (<http://ictupdate.cta.int/en/Feature-Articles/Farming-from-the-ground-up>, accessed July 2011).

discrete polygons with definite boundaries. The data used in polygon maps are difficult to integrate with other forms of data, which are grid-based (like satellite images and digital elevation models) (Hartemink et al. 2010)

Social and financial challenges remain as well. Detailed yet inexpensive soil analysis tools are not widely available for

small-scale farming in most developing countries, although they are being developed and piloted. Even where technologies are free to the public (like online satellite images), the resolution is too low to capture soil characteristics on individual plots. Without accurate, affordable soil analysis technologies, resource-poor farmers are unlikely to adopt sustainable and resource-optimizing farming practices. These practices are often more expensive in the short term and are typically more labor intensive. Finally, disseminating knowledge about soil management and farming practices is challenging. Soil science is complex. Soil restoration activities vary based on a diverse set of properties and the agroecological system. Even digital soil maps that create opportunities for soil assessment at the local level will require major dissemination and training efforts by extension staff and other stakeholders.

These challenges are being overcome as technologies advance. For example, GlobalSoilMap.net (along with others) is compiling data on digital soil properties around the world into a comprehensive global map, providing access to a consistent set of soil functional properties that define soil depth, water storage, permeability, fertility, and carbon (information needed for more quantitative studies). Placing maps online helps address some of the challenges related to dissemination and smallholder relevance. GlobalSoilMap.net can be used in a variety of ways to suit a range of purposes: users can view and manipulate the data online (for example, they can compare soil patterns with satellite imagery or land-use maps) or compose and print local maps by combining several sources of online data (soil, climate, terrain, and infrastructure, among others). Development partners, soil scientists, and governments then have a firm basis for formulating policies on land use and can share this information with farmers, so that they can make management decisions such as how much fertilizer to apply.

NITROGEN MANAGEMENT

In addition to digital soil maps, which are useful over larger areas, *nitrogen-sensor technologies* are used to manage nutrients and prevent the overuse or underuse of fertilizer at the level of a single field and crop. Ineffective use of nitrogen fertilizers can limit crop biomass production and diminish carbon content in the soil. Conversely, optimal nutrient management raises yields, improves soil health (including soil carbon storage capacity), and maximizes the cost-benefit ratio. An especially important consideration for smallholders is that reduced or more accurately timed fertilizer applications can lower the cost of investing in fertilizer (see "Improving Nitrogen Fertilization in Mexico").

A key component of soil management is to maintain appropriate amounts of nitrogen in the soil to optimize crop growth and yields. Under certain weather conditions and farming practices, nitrogen applied as fertilizer, which is highly soluble, can be lost from the soil. Successful nitrogen management delivers enough nitrogen to the crop to optimize yield and profitability while minimizing losses to water and air. The timing, rate, and method of fertilizer application largely determine this optimization (Scharf and Lory 2006). Over the years, agronomists have established how much nitrogen various crops require. Using these measures, along with data collected from digital soil maps and other soil data, farmers can apply the right amount of nitrogen at the optimal time to maximize crop performance.

Farmers in developed countries use technologies that measure nitrogen levels and determine rates of fertilizer application. Evidence shows that sensors like the Yara N-Sensor (<http://www.yara.co.uk/fertilizer/index.aspx>), which measures light reflectance from vegetation and adjusts fertilizer application accordingly, can increase yields by up to 10 percent over standard farm practices while reducing fertilizer costs and minimizing environmental losses (image 5.1). N-tester, a technology

developed by the same company, is another example of sensory technology for nitrogen. This portable device, using no subsidiary equipment, measures the chlorophyll content in the leaves of cereal and potato plants to monitor the need for nitrogen. N-tester is being piloted with high-value, nitrogen-demanding crops in a range of countries throughout Northern Europe, Southern Africa, and North America.

The tools used for nitrogen-sensor technology have similar challenges to those of digital soil technology. Databases and information support systems have been established to raise awareness and disseminate information to smallholders, but widespread access is limited by the extent of network infrastructure and costs. Increasing the opportunity for communication among various stakeholders involved in farming (such as input dealers and extension agents) could improve the spread of information.

SOIL CARBON SEQUESTRATION IN AGRICULTURE

The amount of organic carbon present in soil depends on water availability, soil type, and other features. A primary factor affecting the soil's carbon content is agriculture. Soil carbon in forests, crop land, or grazing pastures increases or decreases depending on inputs that are applied, rates of deforestation, and farming practices. In recent decades, producers' poor land management practices have reduced soil carbon content. When soils are tilled, organic matter previously protected from microbial action decomposes rapidly and accelerates erosion and degradation. Improved farming practices like leaving crop residues in the field after harvest and no-till (where seed is planted without plowing) maintain soil carbon at higher levels (Lal et al. 2004),³ but these practices are not widespread. No-till is practiced on only 5 percent of the globe's cultivated land (Derpsch and Benites 2003). The overwhelming majority of vulnerable regions are those with lower organic carbon pools (figure 5.2).

High levels of soil organic carbon are crucial to agricultural productivity and environmental conservation. Studies found that increasing the pool of soil organic carbon by 1×10^9 picograms of carbon per hectare can boost yields 20–70 kilograms per hectare in wheat, 10–50 kilograms per hectare in rice crops, and 10–20 kilograms per hectare in bean crops (Lal 2010). Despite rapid depletion of soil organic carbon, projections show that carbon can be restored to about 60–70 percent of natural levels. A calculation relevant to developing countries and poor producers is that they could grow up to

IMAGE 5.1. Nitrogen-Sensor Technology



Source: Yara International ASA 2004.

³ These practices incur some costs, especially in the short term. More fertilizer may be needed before soil organic carbon increases. Similarly, crop residues that are used for fuel or feed will no longer be available (Lal et al. 2004).

Despite the growth in sensor and information technologies for carbon sequestration and restoration, significant barriers prevent smallholders from being included in efforts to monitor and increase carbon sequestration. They include the poor development of carbon markets to date, especially in agriculture, and the continuing problem of developing methods that smallholders can truly access and afford. See the discussion below.

Poor Carbon Market Development, Especially in Agriculture

Carbon markets were designed to provide incentives for carbon sequestration and good farming practices. Since 2002, developed countries and firms (primarily in Europe) have traded carbon credits (Lal 2004). Trading carbon credits can encourage firms and farmers to increase soil carbon content and switch to more environmentally conservative systems. Despite major strides in carbon market development, serious challenges remain. A variety of economic and scientific factors make it difficult to set prices for carbon credits, and assessing the biological and ecological relationship between carbon storage and climate change is even more daunting (Lal 2010; World Bank 2010a). Even more important, agriculture and livestock are not included routinely in global carbon emissions treaties, which reduce even large firms' incentives to participate in carbon sequestration. The Clean Development Mechanism of the Kyoto Protocol does not include land management, which prohibits carbon in agricultural soils from being traded in the Kyoto compliance market (World Bank 2010a). Current efforts to include agriculture in carbon trade institutions and policies will create financial incentives for governments, firms, and farmers in developing countries to use soil carbon sequestration technologies.

Accessibility and Affordability of the Technology for the Poor

Beyond poorly functioning carbon markets, other technical and social barriers prevent smallholders from adopting practices that increase soil carbon levels. As noted, the types of ICT used to monitor, report, plan, and verify the amount of carbon sequestered are not appropriate for small farms. Monitoring sequestration is easiest when the potential is large, or around 100,000 carbon tons (Bajtes 2001). This limitation is a major challenge for carbon sequestration, given that "90 percent of the potential for carbon capture can be found in the developing world, where land managers are largely poor farmers on small plots of land" (Smukler and Palm 2009, 1).

Most available ICT not only inhibits smallholders from participating in carbon markets (or their development) but also

reduces their ability to participate in simple soil restoration and conservation techniques. Recent World Bank projects have shown that robust, clear, and cost-effective accounting methods that outline how carbon is measured and quantified are essential if projects designed for smallholders are to function well, as is transparency in monitoring to assure farmers' participation (World Bank 2010a). In the future, development institutions can focus attention on reducing the costs of ICT for soil carbon (using coarse-to-medium resolution satellite imagery) (Smukler and Palm 2009), improving land rights and enforceability (which will help regulate carbon trade), and determining how financial incentives might be created (for example, through local carbon markets or payment for ecosystem services) to ensure that smallholders can participate (box 5.5) (World Bank 2010a).

BOX 5.5. Rewarding Farmers for Carbon Sequestration in Kenya

The Kenya Agricultural Carbon Project is one of the first examples of a soil carbon project that not only addresses issues like food security and climate change but also provides financial assistance to rural dwellers. Kenya is a prime candidate for carbon sequestration. Agriculture contributes to over 50 percent of gross domestic product and one-third of the country's population lives on ecologically fragile arid land.

Funded by the World Bank and designed by the Swedish Cooperative Center–Vi Agroforestry, the project, located in Western and Nyanza Provinces, addresses most issues faced on arid land. On approximately 45,000 hectares of land, farmers adopt good practices that result in carbon sequestration. These practices are expected to generate 60,000 tons of carbon dioxide each year, increase yields, and allow smallholder farmers to access the carbon market and achieve supplemental income through payment of environmental services. Extension agents disseminate technical knowledge, monitor and account for carbon sequestered, and build capacity in farmers' organizations.

Once carbon is sequestered, the credits will be sold to the World Bank's BioCarbon Fund. Project developers expect that improved practices will result in an additional US\$350,000 in 2011 for the communities involved. The project also promotes improved carbon management policies and strategies that improve agriculture productivity and sustainability at the national level.

Sources: World Bank Ghana Office 2010; World Bank 2010d.

PERFECTING THE FARM THROUGH PRECISION AGRICULTURE

Site-specific information that allows producers to make management decisions about discrete areas of the field is called precision farming or precision agriculture. Determining soil and crop conditions to improve whole-farm efficiency—while minimizing impacts on wildlife and the environment—is the crux of precision farming. It has been used successfully in many developed countries and has the potential to change agriculture dramatically in this century.

A variety of tools can be used in precision agriculture. GPS, satellites, sensors, and aerial images can help to assess variation in a given field. Farmers can match input applications and agronomic practices with information received from these types of ICT. Precision agriculture has been applied to many types of agricultural produce (hay, pasture, fruit, and cereals, for example) and to fisheries under many different climatic conditions. Many of these efforts have been limited to large-scale farming because of the significant investment required, but applications under smallholders' conditions are gaining visibility. Remote sensors, sonar-based technology, and other types of ICT can also improve aquaculture and livestock production.

Essentially, precision farming provides a framework of information for farmers to make management and production decisions. It can answer questions pertaining to land preparation (including tillage depth and type, residue management and organic matter, and reductions in soil compaction); seeds (planting date and rotation, density and planting depth, cultivar selection); fertilizers (nitrogen, phosphorous, potassium, and other nutrients, as well as pH additives, application methods, and seasonal conditions); harvest (dates, moisture content, and crop quality); and animals and fisheries (pasture management, animal tracking, and school identification).

Precision Farming through Wireless Sensor Networks

Consistent advances in microsensing, smaller devices, and wireless communication (Kabashi et al. 2009) have resulted in new, comprehensive technologies that offer even more consistent and reliable systems for smallholders and policy makers alike. Wireless sensor networks (WSNs), which combine many kinds of sensory data in one location, are some of the most innovative technologies available for farming and agricultural planning. With the right components, these networks can form knowledge management systems, research databases, and response systems that can guide local communities and governments in agricultural development.

A WSN is a group of small sensing devices, or nodes, that capture data in a given location. These nodes then send the

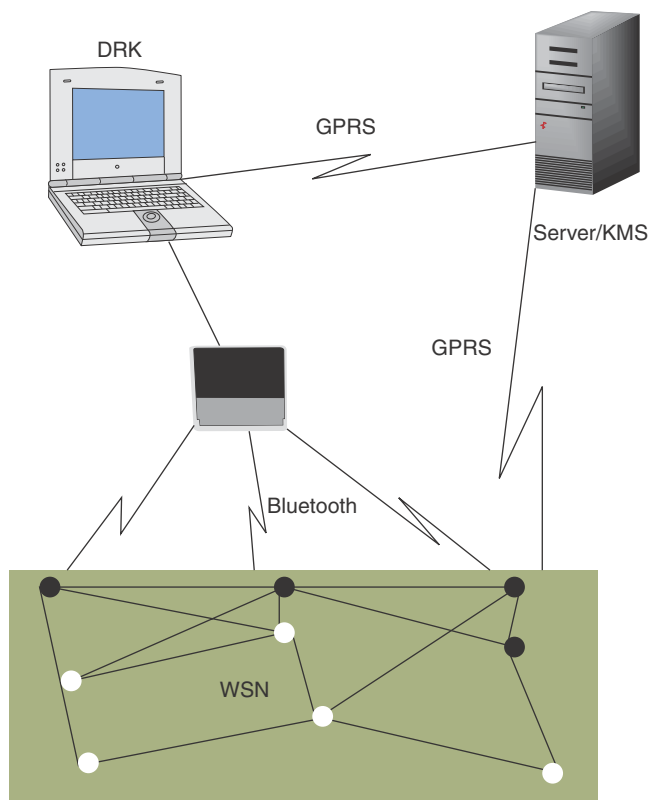
raw data to a base station in the network, which transmits the data to a central computer that performs analysis and extracts meaningful information. The base station acts as a door to the Internet (typically a local area network), providing operators with remote access to the WSN's data (Dargie and Zimmerling 2007). Because the networks can have multiple sensory devices, the data can contain information on soil, climate, chemicals, and other relevant subjects. The wide application of WSNs allows them to be used not only in managing agriculture but also in testing water quality, managing disasters, detecting volcanic activity, and conducting environmental evaluations.

These networks have several key features. First, WSNs have both active and passive sensors. Active sensors release a signal to detect a physical phenomenon like seismic activity and radar. Passive sensors, which transform a physical phenomenon into electrical energy, can detect a vast array of phenomena, including temperature, humidity, light, oxygen, and chemicals (Dargie and Zimmerling 2007). Once sensors (for example, temperature and soil moisture) are selected, node locations are needed. Node density in developing countries should be scarce to better guarantee network connectivity for each node, reduce maintenance, and improve the network's reliability (though it will limit field-mapping techniques). In addition, because low-income countries often experience poor network and telecommunications connectivity, nodes will often require a "buffer," where data can be rerouted or stored in another node if connection to the base station fails. If an active node fails to transmit data to the base, the network will "wake up" the closest neighboring buffer node (Kabashi et al. 2009), providing a "multihop transmission" (see figure 5.3 for a basic illustration of the process).

The design and implementation of WSNs requires a number of important features. The nodes should monitor the field(s) continuously and for a significant period—it is best if maintenance is not required for at least one cropping season (or 4–6 months). The nodes should cover a wide area, be small to prevent animal and human interference (like stealing), and tolerate harsh environmental conditions like monsoons and extreme heat. Self-organization is also important: The network should automatically detect removed or newly arrived nodes and adapt the messaging route (Depienne 2007).

WSNs offer extensive benefits to farmers producing plants and animals. Agriculturalists can detect problems at an early stage and use more precise applications of fertilizer, water, and pesticide. Pastoralists can use WSN to monitor grazing land productivity. Placing wireless nodes in pastures allows farmers to move animals according to environmental indicators like soil moisture (see image 5.2 and IPS "Monitoring Livestock to

FIGURE 5.3. Wireless Sensor Network (WSN), Distributed Collection Architecture



Source: Kabashi et al. 2009.

Note: DRK = Distributed Resource Kits GPRS = General packet radio service; KMS = Knowledge Management System.

Prevent Pasture Damage,” in Topic Note 5.1). WSNs can also be used to manage irrigation and even to measure water quality.

Governments and development partners also benefit financially from WSNs. The technology is fairly cheap; some units cost as little as US\$100 (Dargie and Zimmerling 2007). Developing countries often experience power deficiencies, but nodes that operate on batteries and alternative energy sources do not need electricity. Data are collected more easily. Whereas traditional methods of collecting agricultural data for national planning rely on occasional data logging by human operators, WSNs can collect continuous data with minimal human interaction. Even though some types of ICT, like mobile phones and transceivers, can collect information faster in the field, they often have trouble cooperating with other software or Internet servers (Fukatsu et al. 2004). WSNs integrate the Internet into the software, making the data more user friendly and accessible.

Data organization is vital to the output of WSN as well as other remote technologies. If countries want to use WSN data to construct yield models or predict climate shifts, making

IMAGE 5.2. WSN Can Help Monitor the Quality of Pastures

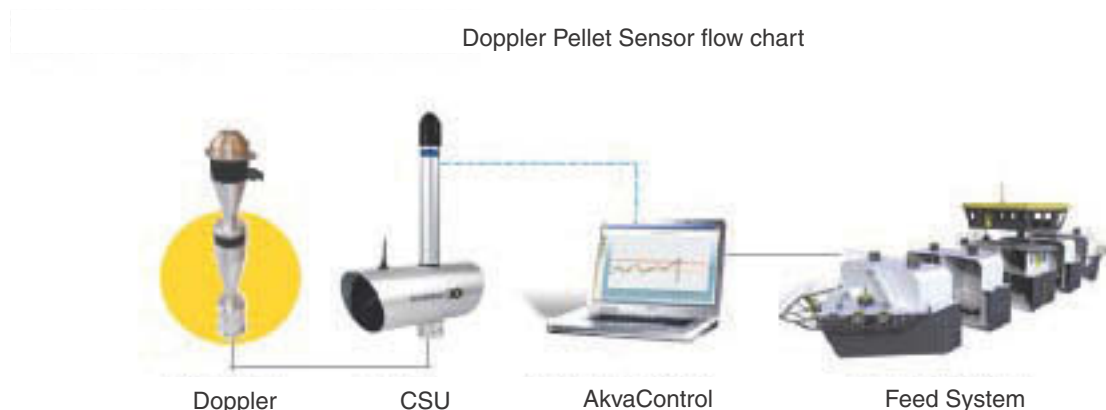


Source: Curt Carnemark, World Bank.

sense of the data is pertinent to the design. The data produced can be used to improve crop management strategies and even develop knowledge management systems where best practices, crop disease identification, and planting techniques can be disseminated to smallholders. It is important to note, however, that although battery-operated nodes can function in areas with low power connections, changing batteries in remote areas may prove difficult. Sleep settings and well-designed energy-conserving hardware can help prevent frequent battery changes (Dargie and Zimmerling 2007).

Wireless sensors can also be used in aquaculture. Though concentrated in developed countries, the use of underwater wireless sensors has great potential for developing countries. Real-time information is crucial for effective and profitable aquaculture. Akvasmart (see <http://www.akvagrroup.com>), a Norwegian firm specializing in commercial fish farming, uses a wide variety of ICT tools, including sensors. Sensor systems can monitor oxygen, tidal currents, temperature levels, fish behaviors, and water conditions. Interestingly, Doppler pellet sensors with a built-in camera can detect uneaten food in fish cages (figure 5.4). With this information, signals from the sensors can stop the feeding, allowing for more specific care and feed purchase. The sensors can also adapt to the accurate feeding rate of the fish over time.

Wireless sensors in water, just like those on land, can be coupled with other cameras for more precise readings. Akvasmart offers a video image system called the Vicass Biomass Estimator that measures the height and length of the fish in the pond. These figures can be used to estimate the weight of the fish. Other camera systems can be placed at the surface or underwater. Monochrome cameras monitor the feeding process by “looking up” from the bottom. Color cameras can monitor feeding and inspect the pond or cages and surrounding environment.

FIGURE 5.4. Akvasmart Doppler Pellet Sensor Network

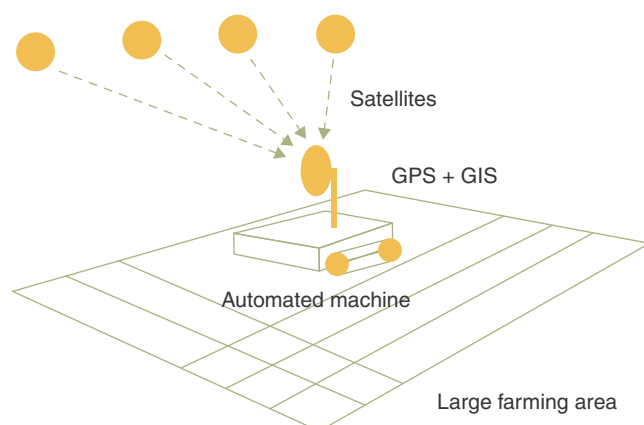
Source: Akvasmart (<http://www.akvasmart.com/index.cfm?id=205626>).

Note: CSU = Cage Sensor Unit.

Remote access cameras can tilt, zoom, and pan according to the interest of the fish farmer. Each of these camera and wireless sensor systems can be accessed from a personal computer and in some cases the Internet, where the data are collected.

Precision Farming through Satellite Technologies

Precision farming through satellite technology utilizes three technologies: GPS (which can position a tractor within a few feet in the field), GIS (which can capture, manage, and analyze spatial data relating to crop productivity and field inputs), and variable rate technology (which provides site-specific, “on-the-fly” estimates of field inputs for site-specific application). The three types of ICT combined provide information that allows producers to apply inputs, such as fertilizer and insecticide, precisely where they are needed (figure 5.5).

FIGURE 5.5. Precision Farming through Satellite Technologies

Source: Adapted from GIS Development Net.

Agricultural information is typically captured spatially, making it more convenient to handle on a regional scale. GIS technology is promising because it allows for a more specific focus. Variable rate technology has helped to identify weed infestations and water stress in areas where crop pest levels are high, which improves the targeting of chemical applications and reduces waste associated with conventional blanket spraying (Munyua 2007). In addition to the potential productivity gains and cost savings, precision farming through satellite technology enables governments to study how agricultural practices affect the ecosystem and to develop better regulations.

Once data are collected through GIS, scientists can interpret the images and analyze the soil and crop conditions to achieve better results. Although satellite imagery cannot detect soil quality directly as sensors can, it can record soil properties like light reflections and color. As crops start growing, precise pictures of the crops are captured more efficiently. The condition of the fully grown plants can then provide a clearer picture of the quality of the crops and what they require for a successful harvest.

Based on soil and crop conditions, farmers can estimate the precise amounts of seeds, pesticides, and fertilizer they need; organize the distribution of inputs; plan which crops to plant in which areas; and make new investments. Knowing the size and shape of fields can also help rural communities plan for future developments and investments like mechanization. Small, fragmented, or awkwardly shaped fields are difficult to work with a tractor or even animals. Above a certain minimum field size, it becomes cost-effective to use a tractor. Precision farming provided through satellite imagery can determine this threshold before a community invests in new equipment. If an area is suitable for mechanization, the benefits can be extensive. A GPS system that controlled tractor steering in Sudan cut planting time on the farm by 60 percent (Munyua 2007).

Precision farming must also rely on an information dissemination process. Many rural areas in developing countries are isolated from sources of new agricultural information; not surprisingly, farmers in these areas use few modern technologies. ICT is beginning to play an important role in providing advisory services in real time to farmers, which helps them plan and manage production, postharvest activities, and marketing more efficiently (see Module 9). Online information, consultation, and land suitability maps with Web-based systems can play an important role in improving and updating knowledge for producer organizations.

Management and information-sharing tools are also necessary for effective precision farming based on satellite technologies. RiceCheck and the online knowledge bank at the International Rice Research Institute (IRRI) (<http://irri.org/knowledge/training/knowledge-bank>) are two of the most advanced knowledge management tools in rice production today. Collecting, analyzing, and sharing information on individual plots has been difficult, but through RiceCheck, farmers can now monitor crops, have an online group meetings (often with agronomists), and compare their yields to regional benchmarks for high yields (for a description of these benefits in Malaysia, see box 5.6). Through IRRI's site, connected farmers can also make a checklist for their daily activities and review plans for the entire growing season.

LESSONS LEARNED

This topic note primarily reviews soil and land productivity, particularly for the planning and preplanting stages of the production cycle. Correcting past damages and ensuring future yields, however, will require farmers, governments,

BOX 5.6. Web-Based GIS for Paddy Precision Farming, Malaysia

In Malaysia, an interactive, Web-based GIS provides information for precision farming and mapping in the Sawah Sempadan rice-growing area in Tanjung Karang, Selangor (Che'Ya et al. 2009). The system allows farmers to access information about rice cultivation in their area. Because it uses open source software, the system is cost-effective for users. Farmers can print variable-rate fertilizer application maps and historical data about yield per paddy lot in previous seasons. This helps farmers analyze and reflect on the best strategy for the coming growing season. Farmers can share information, especially on fertilizer recommendations. A Web presence also allows policy makers to access rice information.

and development partners to mitigate the effects of climate change and environmental degradation on soils. With the expanding reach of ICT, achieving this goal is more likely in both developed and developing countries, but challenges remain in using ICT to improve soil and land health. They are discussed in the following paragraphs, along with some means of preventing or overcoming them.

To begin with, these technologies are relatively new, even in developed countries, and their potential is just being realized in developing countries. National awareness of the importance and benefits of soil fertility takes time to develop. As with carbon sequestration, using ICT to improve and maintain the fertility and productivity of land will require new legislation and policies outlining their use and providing incentives to achieve their benefits. Appropriate legal and regulatory frameworks, monitoring and verification systems, and liability, access, and property rights laws and regulations, such as regulations on carbon limits in some countries, are necessary to make significant, national progress. Though not all technologies require such stringent legal frameworks, government involvement—specifically at the national policy level—often raises the visibility and adoption rates for new types of ICT.

Testing methods for soils vary and are still in development. For this reason, results are not always reliable and may be difficult to harmonize. Continued research—particularly in poor countries, where research is typically limited—will help to address these challenges. Developing countries also lack the financial footing and human capital to use expensive technologies that require reliable operation and maintenance, even more so in harsh conditions. Strategic and long-term investments are needed to sustain improvements in soil and land productivity, especially if they are used in rural areas, where farmers who may be required to maintain ICT devices have little time to do so.

Farmers may not have a contemporary perspective on the environment because they have received little new information. They may not have access to the country's environmental regulations (for example, prohibiting the burning of charcoal) or export requirements (such as limits on pesticide residues). Extension education and campaigns using types of ICT like radio will help farmers to make decisions related to environmental policies and strategies.

Despite the benefits of soil technologies, smallholders have limited access to credit to use them. Even if they have access to soil maps or nitrogen estimates, their adoption or adjustment rates might be low. The inputs required to change practices are often out of reach in poor rural areas. New credit

insurance schemes or financial rewards (like carbon markets) may reduce these monetary concerns.

Soil ICT devices are not only new but complex. Farmers will require training and education to learn how to use them. Electronic education (e-learning) is an option, but infrastructure must be considered. In some cases, technologies function well with low bandwidth (WSNs are one example), but in others they do not (the RiceCheck Web interface is an example). The productivity goals and the technologies used to meet them must match the IT capacity in the focus location.

Finally, the lack of institutional capacity poses other challenges for increasing soil and land productivity. Governments that want to incorporate the use of carbon markets or digital soil maps into agricultural policy will have to make major adjustments and investments in human resource capacity. Development partners like the World Bank can support some of these efforts.

INNOVATIVE PRACTICE SUMMARY

Seeing-Is-Believing Project Improves Precision Farming

Small-scale farmers in West Africa are experiencing unpredictable changes in their agricultural land. Soils are infertile in many areas, reducing agricultural productivity and spurring fear and uncertainty about future livelihoods among farmers. In the past few years, many West African farmers have abandoned their land, which had been in their families for generations.

It is imperative that smallholders obtain the knowledge about changing soil and crop patterns that can help them manage their farms. The Seeing-Is-Believing West Africa (SIBWA) Project has been assisting farmers with accurate satellite information and imagery of their farm fields to help them improve their agricultural practices.

In June 2009, SIBWA started working with six farming communities in this region—three in Mali, and one each in Ghana, Burkina Faso, and Niger. SIBWA is funded by the Bill & Melinda Gates Foundation through AGCommons, with supplementary funding from the United States Agency for Internal Development and Germany's Federal Ministry for Economic Cooperation and Development (CODE-WA project).

Led by scientists at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the SIBWA team provided farmers with very-high-resolution satellite images (such as those on displayed on Google Earth) of their land. To get a more precise picture of soil fertility, scientists can analyze the images when the crops are at their peak growth stage.

When the ICRISAT team acquires a very-high-resolution image (VHRI), they use computer software to enhance it, adding extra layers of information, and analyze data that would be useful to farmers, such as variations in soil fertility, land size, and shape. Although a single VHRI image costs US\$1,000–US\$1,500, this method of analysis is often still cheaper than visiting every individual farmer's field to collect samples. Partnering with local NGOs and extension officers, the SIBWA team visits the project sites to verify their findings with the farmers. ICRISAT further analyzes the images using feedback from field research to build a database that they can use to develop an accurate map of each farm.

SIBWA partners translate the soil and image information into local languages and take the detailed maps back to individual farmers, who can use them to plan and manage their crops for the coming season (image 5.3). The maps show areas of low or high fertility inside each field. With an overview of soil and crop conditions, farmers can organize the distribution of fertilizer throughout their fields and estimate which crops will produce the highest yields. The SIBWA team works with the farmers to determine the area of each field, making it easier for farmers to calculate the amounts of seeds, pesticides, and fertilizer required for each field.

Another advantage of VHRI is that it shows the direction of furrows on the field and areas where farmers can plow along the contour lines of the land. Using this imagery, farmers monitor whether they were following the contour lines accurately and efficiently to reduce soil erosion. SIBWA also involved local NGOs specialized in technology and extension services in each community to help farmers make use of the data.

IMAGE 5.3. Farmers Learn to Use Images of Their Farms to Improve Productivity and Resource Management



Source: Work funded by AgCommons, a program executed by the CGIAR.

Data from projects like SIBWA can be used to develop growth and yield models by various means. Some rely on computer simulation and include weather-related variables; others are statistical estimation models based on multiple regression equations. While no single model has proven satisfactory in all conditions, both low- and high-resolution types of imagery have benefits extending beyond the decisions of individual farmers. Low-resolution yield prediction can benefit food importers and exporters as well as international and government agencies concerned with global markets and prices. In this regard, data collected from imagery in localized projects will be useful in years to come. Although it remains too early to analyze the effects of SIBWA, the team expects that the farmers will use the data when planning for the new growing season (Traoré 2010; ICRISAT 2010).

INNOVATIVE PRACTICE SUMMARY

Improving Nitrogen Fertilization in Mexico

The International Maize and Wheat Improvement Center (CIMMYT) recently piloted a nitrogen sensor on 174 wheat plots in Mexico's Yaqui Valley, in collaboration with the State of Sonora, Oklahoma State University, and Stanford University (image 5.4). A handheld device with an infrared sensor captures light to measure biomass and red wavelengths to measure chlorophyll content. These two measures determine how much nitrogen a plant requires and thus the appropriate amount of fertilizer to apply (CIMMYT 2005).

In Sonora, farmer-advisers purchase the sensors for US\$5,000 and charge 7 pesos per hectare to diagnose farmers' crops

IMAGE 5.4. Infrared Sensor Technology Increases the Cost-Efficiency of Nitrogen Fertilizer Applications in the Yaqui Valley



Source: Iván Ortiz-Monasterio, CIMMYT.

(I. Ortiz-Monasterio, personal communication). Though the cost of the diagnosis is expensive for smallholders, they needed significantly less fertilizer to maintain yields. Farmers who did not use the sensor applied 219 kilograms of nitrogen per hectare for yields of 6.92 tons per hectare; those who used the sensor applied as little as 158 kilograms of nitrogen per hectare for yields of 6.91 tons per hectare. For a 100-hectare farm, these savings add up to approximately US\$7,500 per harvest (CIMMYT 2007).

The technology not only reduces costs but also lessens environmental damage: Nitrogen that washes into the ocean or local streams can harm ecosystems. CIMMYT is now working on a prototype pocket sensor that costs US\$100–US\$200, which would facilitate more affordable nitrogen testing services for farmers in developing countries (I. Ortiz-Monasterio, personal communication).

INNOVATIVE PRACTICE SUMMARY

Monitoring Livestock to Prevent Pasture Damage

Animal production in Australia traditionally required animals to be restrained to a particular location. The cost of installing fences and maintaining them constitutes around 30 percent of the cost of rearing one animal. Controlling animal location implies that farmers need to know about pasture conditions, because overgrazing leads to land erosion and nutrient depletion. With this in mind, researchers implemented a static and mobile node and camera network to remotely monitor the condition of grass throughout a field.⁴ Using solar panels, which generate much higher energy outputs compared to what is needed, the team observed soil moisture, greenness level, grass height, and grass coverage.

Consisting of an Atmega 128 microcontroller at 8 MHz, a Nordic NRF903 radio transceiver with a bit rate of 76.8 kilobits per second, a temperature sensor, and a soil moisture sensor, the commercially available static node (ECH20 capacitance-based) takes readings every minute with a ± 2 percent error rate. Pictures of the pasture, troughs, and gates help to guide herdsmen in cattle movement. Additional mobile nodes connect directly to the cattle (around their necks). These nodes measure the livestock's speed and turning rate, which improves tracking capacity.

With these two technologies, scientists can build generic models of herd movement so that herdsmen can better manage resources in smaller pastures. Though the technology is focused on developed countries, these types of ICT hold great potential for developing countries.

4 This section draws on Wark et al. (2007).

Topic Note 5.2: PREVENTING YIELD LOSSES THROUGH PROPER PLANNING AND EARLY WARNING SYSTEMS

TRENDS AND ISSUES

ICT can help to prevent and reduce losses in crops through well-planned investments and disaster warnings or time-sensitive alerts. Water management and disease or pest prevention are crucial to increased productivity. Advances in ICT—such as GPS, GIS, mediation software, mobile phones, and satellite imagery—have improved smallholders' ability to adjust farm strategies and reduce risk. At the same time, these advances allow governments and development partners to better monitor farm productivity, make more accurate projections, and plan better for the future.

Water is a primary topic in this thematic note. Although water is scarce and is becoming more so due to climate change, many water resources in developing countries are simply not exploited. In fact, the vulnerability facing agriculturalists in most of Africa is not the result of more variable rainfall but of failure to access the water that is available. Only 2–3 percent of Africa's water is used (Woodhouse 2009). Despite current efforts to tap water resources and adapt to climate change, competition for water for household and industrial use will steer water away from agriculture over the next few years in almost 60 percent of the world's most vulnerable countries (Ruttan 2002). Weather data, along with improved irrigation management and system engineering, are more important than ever.

This note also discusses disease and pest control. Pests and pathogens continually evolve, making it particularly difficult for small-scale farmers to increase productivity. Without inputs like pesticides and the knowledge to use them correctly, pests and diseases reduce global harvests by upward of 30 percent for maize, rice, and potatoes (Oerke 2006). ICT devices like mobile phones and radio frequency identification technology are making it easier for farmers to know which diseases or pests to watch for and how to handle them if they are found. Pest eradication takes national and collective efforts. With ICT, governments find it easier to reduce crop losses from flies or rodents and livestock losses from disease like bovine spongiform encephalopathy (less formally known as “mad-cow disease”).

PREVENTING DISEASE AND PEST DAMAGE

Plant protection is important to save crops from diseases and pests. Increasingly, ICT is used to help farmers reduce or more

efficiently use the total amount of pesticides employed in crop protection. Farmers often are unaware of or cannot accurately assess plant diseases, which may reduce agricultural productivity and raise costs if pesticides are overused. Concerns for animal health are similar. Herdsmen and fishermen spend resources and time treating sick animals or identifying disease outbreaks. Using various types of ICT, producers can better identify, track, and protect their crops, animals, and livelihoods.

One example involves fishing communities, which face major challenges in both wild and managed fisheries. They can use ICT to prevent fish diseases and protect local fishing grounds from unwanted visitors. Illegal, unregulated, and unreported fishing poses serious obstacles to sustaining fish production. Tools like GPS and mobile phones help fishers and governments locate poachers and report abuse (image 5.5). The South Pacific Forum Fisheries Agency, for example, now has a vessel monitoring system, which observes fishing grounds throughout the area, identifying and fining illegal fishers. The Sustainable Fisheries Livelihoods Program has helped Guinean fishing communities perform similar policing; local fisherman used hand-held GPSs to calculate the position of poachers and then radio them to the coastguard. Benefits of these technologies improve productivity indirectly by protecting the fish population. In Guinea, for example, incursions by industrial criminal vessels went down from 450 to 81 after just two years (FAO 2007).

Protecting farm animals from disease and other ailments also improves through ICT (see IPS “Radio Frequency Identification

IMAGE 5.5. Mobile Applications Help to Monitor and Protect Fishers



Source: Edwin Huffman, World Bank.

to Prevent and Treat Cattle Disease in Botswana.” in Topic Note 5.2). Sensors and other remote technologies can be implanted in an animal, providing herdsman with the exact location, health, and situation of livestock like cows, pigs, or sheep. In addition to enabling easier identification and tracking, in the future, some instruments may offer animal response systems.

ICT is now being used in integrated pest management systems to improve farm management in a variety of ways. The Low Frequency Array Project (<http://www.lofar.org>) piloted in the Netherlands uses sensors to monitor and treat potato crops at risk for the fungus *Phytophthora infestans*, which causes late blight. Because the development of late blight depends heavily on climatic conditions (OECD 2009), capturing climatic conditions like humidity and leaf temperature can help farmers prevent an onset of the disease by optimizing fungicide applications when climatic conditions warrant it. The project used three instruments: sensor nodes, a server, and a decision support system. One hundred and fifty sensor nodes, called TNodes, send soil information every 10 minutes through a TinyOS operating system to the server where data are stored (Baggio 2004). Users can access this information directly, or receive texts or emails from the linking decision support system (LOFAR n.d.). The decision support system gathers information from the server along with other meteorological data from weather stations to produce maps of the temperature distribution within fields. The system sends alerts to the farmer that identify the patches of land most susceptible to the fungus.

Information technologies are vital for disseminating crop protection advice, but “crowdsourcing,” (using ICT to leverage widespread collaboration) can prevent diseases from spreading in the first place. If sufficient numbers of farmers can text information on potential crop disease symptoms to researchers and receive appropriate disease control advice, researchers can also track and potentially forestall epidemics. If farmers or cooperatives have access to the Internet, online bulletin boards or mailing lists can spread information on disease incidence quickly. Online decision support systems⁵ that link data to possible action, such as the one used in the Low-Frequency Array Agro Project, are becoming more popular because clients require minimal software, which reduces management and distribution costs.

Additionally, it is useful to link weather information to pest or disease development over time. The Pacific Northwest Integrated Pest Management website, through Oregon State University (<http://oregonstate.edu/dept/nurspest/>), collects temperature and precipitation data from 380 weather stations and links it to

BOX 5.7. Crowdsourcing Prevents Cassava Losses in Tanzania

In Tanzania’s Lake Zone, farmers from 10 districts who participate in the Digital Early Warning Network have been trained to recognize symptoms of cassava mosaic disease and cassava brown streak disease. Armed with mobile phones, farmers “crowdsource,” or send out monthly text messages, to researchers about disease incidence and receive disease control advice in return. When more than 10 percent of the members of a group spot a disease that was not present previously or has increased in prevalence, the project team visits the area to verify the information and advise farmers what to do. Each group of farmers—60 overall—is given a topped-up phone card to text researchers. They meet monthly to discuss observations and send the text messages. The network is part of the Great Lakes Cassava Initiative, which aims to improve the livelihoods of more than a million farmers in six countries of the Great Lakes region by tackling issues that affect cassava yields.

Source: Ogodo 2009.

pest phenology models for 22 insects, 2 diseases, and 2 crop species (Bajwa and Kogan n.d.). Pest alerts and control techniques are announced and shared through social media like Twitter and email subscriptions. Similar alerts can be carried out through SMS in developing countries (box 5.7).

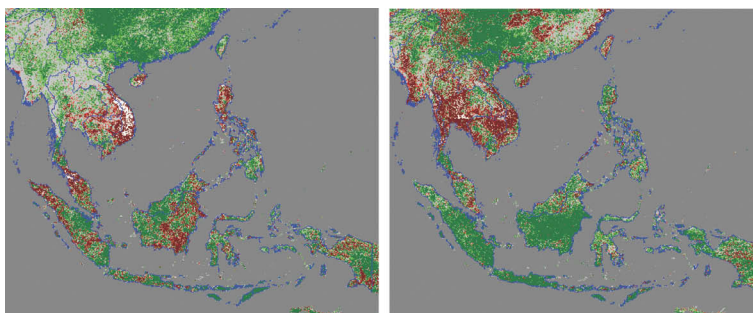
WEATHER FORECASTING

Since 2000, new types of ICT have given farmers and partners better opportunities to manage climate risk. WSNs and satellite images capture raw data that can be transformed into information useful for agriculturalists, helping them optimize decisions related to choosing crops (based on water requirements), planting (timing and planting density), buying inputs, and applying fertilizer. Climate information can also improve insurance markets.

Remote sensors are presently the chief source of climate data. FAO’s Global Information and Early Warning System on Food and Agriculture tracks data and trends related to food security, price risks, and natural disasters. FAO analysts monitor climate conditions and changes around the world using four satellites—FAO’s ARTEMIS (Africa Real Time Environmental Monitoring Information System), Europe’s METEOSAT, the United States’ NOAA (National Oceanic and Atmospheric Administration), and Japan’s GMS (Geostationary Meteorological Satellite). Every 10 days, ARTEMIS and METEOSTAT provide images that help to

5 See <http://www.dssresources.com>.

IMAGE 5.6. Satellite Image of Vegetation Changes from 1998 to 2004 (Red Indicates Decreasing Vegetation and Green Indicates an Increase)



Source: FAO (<http://www.fao.org/giews/english/spot4/sea/index.htm>).

estimate rainfall for Africa. FAO maintains a database of these images from the past two decades, which provides an opportunity to monitor significant changes in weather over time (image 5.6). GMS produces similar information for Southeast Asia as well as information on crop densities at the subnational level (FAO 2010b). Beyond reflecting past trends and predicting future ones, these satellites and others can provide up-to-date forecasts for farmers. These satellite images and others are free on FAO's website.

This proliferation of weather information has made mediation software extremely relevant to the productivity discussion. For example, MetBroker (<http://www.agmodel.org/projects/metbroker.html>), software that pulls weather data from various sources and “hides” the differences between them, is run on a computer permanently connected to the Internet. From 5,000 stations from 14 databases in 7 countries, MetBroker averages forecasting data and makes it consistent (Laurenson, Otuka, and Ninomiya 2001). This approach has two benefits: Researchers and modelers can access data from various harmonized sources for growth prediction models, and farmers can receive accurate, real-time weather information to make farming decisions. Clients—whether farmers or modelers—can request a wide array of climate-related information from MetBroker, including rainfall prediction, air temperature, solar radiation, soil temperature, and leaf wetness (Laurenson, Otuka, and Ninomiya 2001). Some mobile technologies permit farmers to access MetBroker and request information on weather conditions for a certain region, specific stations, and for a restricted period, even with low bandwidth. MetBroker provides an option for summarizing data as well; users can opt to receive daily temperatures instead of hourly ones or receive expert summaries of weather information instead of complete data sets.

Another weather forecasting service, this one in Turkey, relies on simple SMS information to help farmers prevent losses to frost and pests in their orchards. Prior to the project,

producers could not obtain weather information on time to cope with conditions that might harm their orchards. (See the IPS, “Weather Forecasting Reduces Agricultural Risk in Turkey,” in Topic Note 3.1.)

BOX 5.8. Modeling India's Groundnut Yield through Climate Information

In India, rainfed agriculture supports more than 60 percent of the population. In the semiarid Anantapur region, rain typically falls from May to November, yet it varies significantly from week to week, resulting in frequent wet and dry spells. If a dry spell occurs at a critical planting stage, groundnut yields decrease significantly.

Attempting to identify the most promising planting times, researchers used the PNUTGRO model to simulate groundnut growth and yield. The model included vegetative and reproductive development, carbon balance, nitrogen balance, and water balance. The team collected climate data from the Anantapur Agriculture Research Station, which has maintained records since 1962. Using maximum and minimum temperatures, radiation, and rainfall data over three decades, they found that the period between July 15 and August 10 is associated with very high yields. Even more important, planting in two additional periods was also associated with high productivity, suggesting that missing the earlier planting time does not mean that yields will be low for the entire season.

Like all models, this one is limited: it cannot be used to assess the profits or risks associated with management strategies in times of crisis (like the El Niño weather pattern). Nonetheless, analysis of yields associated with different climatic conditions can help to improve farming strategies for specific seasons and raise red flags for potential weather disasters after investments have been made.

Source: Gadgil, Seshagiri Rao, and Narahari Rao 2002.

Mediation software was also essential for modeling groundnut yields in India (box 5.8). Among other things, the models can help identify the best times to plant to evade drought.

Other forms of electronic weather information have potential to increase productivity, primarily by reducing risk. Many of these systems are being tested in OECD countries. A system called eWarning (http://www.landbrugsinfo.dk/Planteavl/Sider/pl_11_543.aspx) was created through PlantInfo (www.plantinfo.dk), a Danish initiative supporting decision making in national plant production. eWarning provides farmers with real-time weather information sourced by the AgriMeteorological Information System and Danish Meteorological Institute. In this particular system, weather information, including precipitation and temperature, is divided into 10-square-kilometer plots to provide farmers with specific climatic details on specific plots.

In eWarning and other systems, farmers request information through SMS in two forms. Push-type messages are regular, automatic updates obtained through a user subscription. Pull-type messages are sent only when a user requests them. When the user sends a letter (like “P”) in a message, the eWarning system will respond with information on precipitation for the user’s geographical location. Surveys show that the push-type message is most popular, providing farmers with an hourly forecast up to four times per day (Jensen and Thysen 2003).

A Yakima software firm, in partnership with Washington State University, is customizing a weather website for specific locations to provide weather alerts to farmers in the United States. These alerts include frost warnings, wind speed with recommendations for pesticide spraying, and information on disease outbreaks. After a farmer has registered for the

service online, he or she can request information and specify the method to receive it (via text, email, or recorded voice message). Eventually, the service will offer climatic information in Spanish, making it easier for native Spanish speakers to make interpretations and decisions (Lester 2010). In the future, similar types of ICT can be used in rural areas of developing countries.

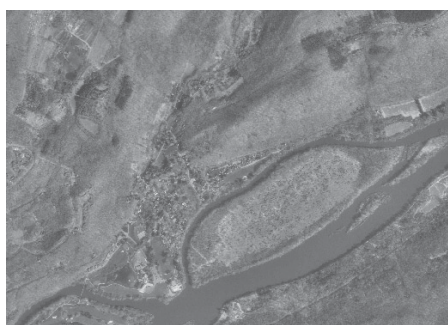
IRRIGATION MANAGEMENT

Major water resource constraints and climate change make it increasingly important for developing countries to develop sound water-use policies and well-functioning, well-managed irrigation systems. Innovative water management systems and related types of ICT are helping to improve water use and expand intensive irrigation facilities. Though the number of technologies for irrigation is vast, this section focuses on remote sensors, satellite imagery, and GPS cameras. Each of these technologies helps to connect the farmers to irrigation infrastructure and guide governments in designing and implementing irrigation strategies.

ICT can help address some of the challenges inherent in creating and sustaining irrigation systems in rural areas. The functioning of water-user associations and their productivity improve with the use of ICT devices, like mobile phones and personal digital assistants (PDAs), which increase the quality and frequency of producers’ communication and interaction. Sharing information about emergency maintenance problems, entitlement rights, and management schedules is facilitated through ICT, which allows real-time responses even between users from distant communities.

Digital orthophoto quads (DOQs), a feature of GIS, are digital maps that combine the geometric information of a

IMAGE 5.7. Two Examples of Digital Orthophoto Quads



Source: United States Geological Survey.

regular map with the detail of an aerial photograph (Neale 2003) (image 5.7). DOQs provide spatial illustrations of terrain, including elevation and property boundaries, which can help delineate irrigation canals and drainage systems. Given the high and increasing value of rural land, it is worth noting that the resolution and georeferencing possibilities of most satellite remote sensing systems are not yet adequate to demarcate property accurately. Nonetheless, achieving greater accuracy and confidence in property boundaries is essential to limit the land disputes that ensue when new irrigation schemes are designed and built. DOQs can help to achieve this higher level of resolution, but sometimes at higher costs than other high-resolution imagery. (See IPS “Digital Orthophoto Quads Form a Database for the Dominican Republic” in Topic Note 5.2.)

LiDAR (laser scanning) is a new technology for obtaining a highly detailed digital terrain model or, if equipped with an aerial camera, for topographic mapping. A digital terrain model is basically a digital representation of an area’s terrain on a GIS that provides accurate position and elevation coordinates. It is compatible with other digital spatial data, is more accurate, and has a higher resolution than satellite images. Elevations can be accurate within 5 centimeters, but accuracy typically is closer to 10 or 20 centimeters. In comparison, digital aerial cameras only provide only about a 20-centimeter horizontal resolution.

Because of its detailed imagery, a digital terrain model can be used for meticulous engineering designs, such as those for roads, drainage, gravity-fed irrigation works, and detention reservoirs. These models can also be used more broadly to manage land and water (for example, in flood control). When combined through GIS with other data such as soil types, these models can help to identify areas with potential slope instability and erosion, which are important for reducing soil degradation and its negative impact on soil fertility. At the field level, digital terrain models can monitor and improve areas affected by waterlogging or flooding. Overall laser scanning has considerable potential for planning irrigation schemes, designing infrastructure, managing irrigation operations, and modeling. Laser scanning is most useful for large areas because the aerial operation is expensive. The cost of laser scanning also depends on the accuracy of the data required, the location of the area of interest, and the level of the data products (such as GIS layers).

Satellite data can also prove useful in managing irrigation schemes, such as the enormous Office du Niger project in

Mali (see IPS “Using Landsat to Assess Irrigation Systems in Mali,” in Topic Note 5.2). This irrigation scheme, one of the largest in West Africa, produces 40 percent of Mali’s rice crop and is key to national food security.

An equally intriguing ICT for irrigation management, specifically for monitoring the construction of irrigation systems, is GPS cameras. The cameras are relatively cheap and user friendly; when a project worker photographs infrastructure, the camera records the date, time, longitude, and latitude automatically.

Afghanistan’s national Emergency Irrigation Rehabilitation Project (funded by the World Bank) was delayed owing to increases in conflict in certain regions, but now GPS cameras provide “remote supervision.” As the irrigation project unfolds, water users can photograph the construction process to make contractors more accountable and prevent financial resources from being wasted. Users can report infrastructure problems to the government without needing to travel through potentially dangerous regions.

Project workers have photographed over 650 locations where irrigation construction projects are being implemented. These photos, which are emailed or delivered by hand to ministry offices, serve as the baseline for progress (World Bank 2010b). A crucial point is that the technology also enhances the participatory process, which may improve user associations’ productivity once the irrigation system is complete.

LESSONS LEARNED

This note has described the many ways that ICT enables real-time adjustments in agricultural practices to prevent losses after investments have been made. These technologies also have considerable potential to help small-scale producers use scarce resources—water, nutrients, and others. Greater certainty about the weather, access to water, and disease outbreaks can lead to better decisions and higher productivity. These types of ICT also face important challenges, however, and a number of considerations are important in improving their effectiveness, especially for smallholders.

Strategies to improve agricultural practices change dramatically over time, just as strategies to manage irrigation have evolved from a nationally operated to user-operated model. ICT devices aimed at preventing crop or livestock losses must adapt in line with these strategies so that

users receive current information, communicated in the most cost-effective way.

Local knowledge is critical to improving smallholders' productivity. ICT not only creates opportunities to disseminate information but also offers ways of capturing local expertise. Vast differences in ecological and agronomic conditions make farmers' knowledge indispensable. ICT should be used to form two-way communication networks, ensuring that local knowledge is acquired and utilized.

The collective action problem is quite apparent in relation to the technologies described here. Water management and disease control require hundreds or even thousands of farmers to perform the same tasks in unison. By strengthening information sharing, ICT devices like mobile phones will increase the potential for collective action. Self-policing may also be crucial to the technology's success.

ICT devices that are used to disseminate information like weather forecasts must match capacity in the focus area. Some phones handle complex messaging; others do not. Local types of ICT may need to improve before some preventive technologies can work in developing countries. Taking stock of the technical capacity in rural areas will clarify infrastructure needs.

Gender is an important consideration when using ICT to prevent crop loss. Women are often already involved in maintaining water resources (for domestic and agricultural use) in their families. Involving them in water management or pest control projects increases their time to attend to other important activities like education and generating income. It also often results in more effective management.

Timing is a major concern in weather, water, disease, or pest ICT. If information is sent too late, farmers may not have time to adjust their farming strategy. If information arrives too early, farmers may make changes that prove unnecessary or even damaging.

Information must be relevant and clear. Too much text or scientific data can conceal the message and cause confusion. Only the most appropriate and contextually based information (like forecasts) and updates should be provided. By continually interacting with farmers and monitoring their responses to information, project managers can clarify which information needs to be sent and which does not.

Keeping information current is expensive. Collaborating with various agencies and creating common systems and

technologies can help achieve economies of scale that reduce costs (IICD 2006).

Just as they can be overwhelmed with too much new information, farmers can be overwhelmed with new technology and become reluctant to use it. Advances in ICT are best suited to helping farmers improve their management of one or two farm components at a time. Development partners and governments need to prioritize which yield technologies or agricultural strategies they would like to introduce and use ICT to disseminate them to a broad population.

Limited financial resources are also a potential limitation to using these technologies. Large agricultural firms and smallholders alike need to control agricultural water, diseases, or pests. Incentives for the private sector to partner with government in large-scale ICT projects may enable the investment to reach smallholders as well.

INNOVATIVE PRACTICE SUMMARY **Radio Frequency Identification to Prevent and Treat Cattle Disease in Botswana**

Implemented by Inala Identification Control (IIC) in South Africa, the Livestock Identification Trace-Back System in Botswana is one of the largest and more innovative forms of ICT for animal husbandry, involving over 300 million cattle.⁶ The system, which uses radio-frequency identification (RFID), serves many purposes, including meeting beef import requirements for the European Union (EU), the destination for 80–90 percent of Botswana's beef exports. The system also improves veterinary services and livestock health.

A bolus with a unique ID number and a transponder are inserted into each animal's rumen. In the field, 300 fixed readers scan cattle ID numbers and relay information to databases in 46 district offices. The bolus collects information that allows both herdsman and the government to monitor new registrations, look for possible disease outbreaks, identify lost or stolen cattle, track weight gain, and plan for animal treatments. The database also provides the opportunity to monitor trends over time.

Technology like this offers many benefits. The bolus is safe for animals, is protected from criminal tampering, and can be recycled, which keeps costs low. The bolus also saves time: Ear-tags, the traditional form of identification, required

6 This section draws on Burger (2004).

herdsmen or veterinarians to handpick cows through a lengthy process. This system speeds up the identification process. Herdsmen can optimize feeding schedules, select certain bulls for breeding programs, and keep updated health records, which improves productivity directly by reducing susceptibility to disease and planning for yields.

INNOVATIVE PRACTICE SUMMARY

Digital Orthophoto Quads Form a Database for the Dominican Republic

Digital orthophoto quads (DOQs) can do much more than provide digital maps. By tracking the photos, it is possible to create water databases that are crucial to the success of irrigation. The databases can provide real-time information on heavily and sparsely irrigated locations, statistics on water use (and subsequently water users), drainage problems, and even salinity issues.

This kind of database featured in a program to improve users' management of irrigation systems (PROMASIR) in the Dominican Republic in partnership with the Inter-American Development Bank and Utah State University.⁷ By combining DOQs with other information (such as information on property ownership), the database enables water users to search for other water users, observe property boundaries, review monthly crop and water statistics, and obtain estimates of irrigation water demand in certain areas. Users have access to more accurate information to use when updating their infrastructure as well as more insight into potential maintenance problems (such as a system breakdown upstream). Assigning water rights and water fees is also easier with databases. In areas with greater demand, prices can be expected to rise. Finally, a system like this can also prevent conflicts over water, because all users have access to the same factual information, such as price information and plot size.

An important point, however, is that smallholders who typically use agricultural water to meet their own needs for sustenance may not be accustomed to the kinds of collective action needed to develop and sustain large water management networks. They may maintain an individual farm mentality, even when technologies like DOQ databases are available.

7 This section draws on Neale (2003) and World Bank (2006). PROMASIR is the Programa de Mejoramiento y Administración de Sistemas de Riego por los usuarios.

INNOVATIVE PRACTICE SUMMARY

Using Landsat to Assess Irrigation Systems in Mali

The Office du Niger, a vast irrigation scheme dating to the 1920s in Mali, delivers water from the Niger River to approximately 80,000 hectares of rice fields. The irrigation scheme is divided into five administrative zones, each responsible for its own water management. The scheme's senior staff use data from Landsat (which uses sensors to record reflected and emitted energy from Earth) and other sensory data (including air temperature and humidity) to analyze cropping intensity, assess water productivity, and monitor equity in water distribution.⁸ The data are also used to compare the productivity of fields at the head (beginning) of the water source with the productivity of the fields at the tail (the most distant point from the water source).

Landsat has the ability to "see" a variety of colors as well as near-infrared, mid-infrared, and thermal infrared light, which helps to distinguish differences between land plots and water sources. Initial results from Landsat images revealed critical similarities and differences between administrative zones, which irrigation managers can use to determine and address the causes of yield variation (for example, low yields in fields near the tail). To gain even greater clarity on why irrigation may succeed or fail in a given location, remote sensing and GIS images, such as those used in Mali, can be coupled with other statistics like administrative boundaries, crop data, and poverty levels in GIS maps.

REFERENCES AND FURTHER READING

- AfSIS (Africa Soil Information Service). 2009. *Digital Soil Mapping*. <http://www.africasoils.net/methods/dsm>, accessed November.
- Baggio, A. 2004. "Wireless Sensor Networks in Precision Agriculture." Swedish Institute of Computer Science. <http://www.sics.se/real-wsn05/papers/baggio05wireless.pdf>, accessed April.
- Bajtes, N. 2001. "Options for Increasing Carbon Sequestration in West African Soils: An Exploratory Study with Special Focus on Senegal." *Land Degradation and Development* 12: 131–42.
- Bajwa, W. I., and M. Kogan. n.d. "Internet-Based IPM Informatics and Decision Support." IPM World Textbook. <http://ipmworld.umn.edu/chapters/Bajwa.htm>, accessed November 2010.
- Balmford, A., R. Green, and J. Scharleman. 2005. "Sparing Land for Nature: Exploring the Potential Impact of Changes in Agricultural Yield on the Area Needed for Crop Production." *Global Change Biology* 11 (10): 1594–605.

8 This section draws on World Bank (2010c) and NASA (n.d.).

- Burger, T. 2004. "LITS: Tracking Botswana's Livestock Using Radio Waves." *ICT Update*, January 6. <http://ictupdate.cta.int/en/Feature-Articles/LITS-tracking-Botswana-s-livestock-using-radio-waves>, accessed November 2010.
- Burney, J., S. J. Davis, and D. B. Lobella. 2010. "Greenhouse Gas Mitigation by Agricultural Intensification." *Proceedings of the National Academy of Sciences* 107 (26): 12052–57.
- Che'Ya, N. N., A. R. Shariff, M. A. Soom, S. K. Bejo, A. R. Mahmud, and F. A. Aziz. 2009. "Generating Online GIS Decision Support System for Paddy Precision Farming." Global Spatial Data Infrastructure Association. <http://www.gsdi.org/gsdiconf/gsd11/papers/pdf/225.pdf>, accessed April 2011.
- CIMMYT (International Maize and Wheat Improvement Center). 2005. "Wheat and Water Win." <http://www.cimmyt.org/en/newsletter/86-2005/295-wheat-and-water-win>, accessed February 2011.
- . 2007. "Wheat Farmers See Infrared." *E-News* 4 (7). <http://www.cimmyt.org/en/newsletter/63-2007/182-wheat-farmers-see-infrared>, accessed February 2011.
- Dargie, W., and M. Zimmerling. 2007. "Wireless Sensor Networks in the Context of Developing Countries." Paper presented at the 3rd IFIP World Information Technology Forum, Addis Ababa.
- Depienne, F. 2007. *Wireless Sensor Networks Application for Agricultural Environment Sensing in Developing Countries*. Semester Project Report, Ecole Polytechnique Fédérale de Lausanne.
- Derpsch, R., and J. Benites. 2003. "Situation of Conservation Agriculture in the World." Proceedings of the Second World Congress on Conservation Agriculture: Producing in Harmony with Nature, Food and Agriculture Organization (FAO), Rome.
- Drechsel, P., L. Gyielea, D. Kunzeb, and O. Cofiea. 2001. "Population Density, Soil Nutrient Depletion, and Economic Growth in Sub-Saharan Africa." *Ecological Economics* 38 (2): 251–58.
- Edgerton, M. D. 2009. "Increasing Crop Productivity to Meet Global Needs for Feed, Food, and Fuel." *Plant Physiology* 149: 7–13.
- FAO (Food and Agriculture Organization). 2000. *Agriculture: Towards 2015/30*. Rome: Global Perspectives Study Unit.
- . 2007. "Information and Communication Technologies Benefit Fishing Communities." *New Directions in Fisheries* 7.
- . 2008. FAOSTAT database. <http://faostat.fao.org/default.aspx>.
- . 2009. *The State of Food Insecurity in the World*. Rome: FAO.
- . 2010a. *Food Outlook*. Rome: FAO.
- . 2010b. "Global Information and Early Warning System." <http://www.fao.org/giews/english/index.htm>, accessed December 2010.
- . 2011. *State of Food and Agriculture*. Rome: FAO.
- Fukatsu, T., M. Hirafuji, T. Kiura, A. Imada, and S. Ninomiya. 2004. "Long-Term Monitoring System Using Field Monitoring Servers." Proceedings of the 2004 AFITA/WCCA Joint Congress on IT in Agriculture, 685–91. http://model.job.affrc.go.jp/fukatsu/paper/AFITA2004_fukatsu.pdf, accessed April 2011.
- Gadgil, S., P. Seshagiri Rao, and K. Narahari Rao. 2002. "Use of Climate Information for Farm-Level Decision-Making: Rain-Fed Groundnut in Southern India." *Agricultural Systems* 74: 431–57.
- GARMIN. n.d. "Garmin." <http://www.garmin.com/garmin/cms/site/us>, accessed December 2010.
- GIS.com. n.d. "The Guide to Geographic Information Systems." gis.com, accessed December 2010.
- Govere, J., J. Nyoro, and T. Jayne. 1999. "Smallholder Commercialisation, Interlinked Markets, and Food Crop Productivity: Cross-country Evidence from Eastern and Southern Africa." Paper presented at the 4th Agricultural Transformation Conference, Nairobi.
- GPS.gov. (n.d.). "Global Positioning System: Serving the World." gps.gov, accessed December 2010.
- Hartemink, Alfred E. et al. 2010. Chapter 33: "Global Soil Map.net—A New Digital Map of the World." In *Digital Soil Mapping, Progress in Soil Science* edited by J. L. Boettinger et al. Dordrecht: Springer Science and Business Media B.V.
- Hoffer, R. 1978. "Biological and Physical Considerations in Application of Computer Aided Analysis Techniques to Remote Sensing." In *Remote Sensing: Quantitative Approach*, edited by P. Swain and S. Davis, 237–86. New York: McGraw-Hill.
- ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 2010. "Satellite Imagery for Smallholder Farmers in Mali." ICRISAT Happenings. <http://test1.icrisat.org/Happenings/happenings1431.htm>, accessed December 2010.
- IICD (International Institute for Communication and Development). 2006. *ICTs for Agriculture Livelihoods: Impact and Lessons Learned from IICD Supported Activities*. The Hague: IICD. <http://www.iicd.org/files/IICD-agri-impact-2006.pdf>, accessed April 2011.
- Jensen, A., and I. Thysen. 2003. "Agricultural Information and Decision Support by SMS." In Proceedings of the EFITA Conference, July, Debrecen, Hungary, 286–92. http://www.kiwanja.net/database/document/report_agriculture_support_SMS.pdf, accessed April 2011.
- Kabashi, A. H., K. Walker, J. Underwood, N. Wirastuti, and J. Elmirghani. 2009. "Wireless Sensing for Development: An Integrated Design Approach." Paper presented at the 3rd International Conference on Next Generation Mobile Applications, Services, and Technologies, Cardiff, London Knowledge Lab. <http://www.lkl.ac.uk/projects/vesel/files/ngmast09.pdf>, accessed April 2011.
- Lal, R. 2004. "Soil Carbon Sequestration Impacts on Global Climate Change and Food Security." *Science* 304 (11): 1623–27.
- . 2010. "Managing Soils and Ecosystems for Mitigating Anthropogenic Carbon Emissions and Advancing Global Food Security." *Bioscience* 60 (9): 708–21.
- Lal, R., M. Griffin, J. Apt, L. Lave, and G. Morgan. 2004. "Policy Forum: Managing Soil Carbon." *Science* 302: 393.

- Laurenson, M., A. Otuka, and S. Ninomiya. 2001. "Developing Agricultural Models Using MetBroker Mediation Software." *Journal of Agricultural Meteorology* 58 (1): 1–9.
- Lester, D. 2010. "Sensors, Software Send Ag Alerts to Farmer Phones." *Seattle Times*, March 4. http://seattletimes.nwsources.com/html/localnews/2011254603_apwafarmtechnology.html, accessed April 2011.
- LOFAR (Low Frequency Array). n.d. "Fighting Phytophthora Using Micro-Climate." <http://www.lofar.org/agriculture/fighting-phytophthora-using-micro-climate/fighting-phytophthora-using-micro-climate>, accessed April 2011.
- Manchanda, M., M. Kudrat, and A. Tiwari. 2002. "Soil Survey and Mapping Using Remote Sensing." *Tropical Ecology* 43 (1): 61–74.
- Mathur, S. 2003. "Carambola Fruit Fly Campaign: Latin America." ICT for Development. <http://www.cominit.com/en/node/121310/307>, November 2010.
- Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-Being*. Washington, DC: World Resources Institute.
- Munyua, H. 2007. *ICTs and Small-Scale Agriculture in Africa: A Scoping Study*. Ottawa: International Development Research Centre (IDRC).
- NASA (National Aeronautics and Space Administration). n.d. "The Landsat Program." <http://landsat.gsfc.nasa.gov/>, accessed January 2011.
- Neale, C. 2003. "Putting the Dominican Republic on the Map." *ICT Update*, June 13. <http://ictupdate.cta.int/en/Feature-Articles/Putting-the-Dominican-Republic-on-the-map>, accessed October 2010.
- OECD (Organisation for Economic Co-operation and Development). 2009. "Smart Sensor Networks: Technologies and Applications for Green Growth." STI Digital Economy Paper 167. 10.1787/5kml6x0m5vkh-en, accessed April 2011.
- Oerke, E. 2006. "Crop Losses to Pests." *Journal of Agriculture Science* 144: 31–43.
- Ogodo, O. 2009. "Cassava Disease Monitoring Goes Mobile." SciDev Net. <http://www.scidev.net/en/agriculture-and-environment/news/cassava-disease-monitoring-goes-mobile.html>, accessed November 2010.
- Palace, B. 1996. "Data Mining." Technology Note prepared for Management 274A. Anderson Graduate School of Management, University of California, Los Angeles. <http://www.anderson.ucla.edu/faculty/jason.frand/teacher/technologies/palace/index.htm>, accessed December 2010.
- Porcari, E. 2010. "Smallholder Farmers and ICT-KM." *i4d Quarterly Journal*, January–March, 15–16. <http://www.i4donline.net/jan-march-2010/jan-mar-2010.pdf>, accessed July 2011.
- Pretty, J., A. Noble, D. Bossio, J. Dixon, J. R. E. Hine, and F. W. T. Penning De Vries. 2006. "Resource Conserving Agriculture Increases Yields in Developing Countries." *Environmental Science Technology* 40: 1–6.
- Qaderi, M. M., and D. M. Reid. 2009. "Methane Emissions from Six Crop Species Exposed to Three Components of Global Climate Change: Temperature, Ultraviolet-B Radiation, and Water Stress." *Physiologia Plantarum* 137 (2): 139–47.
- Raloff, J. 2010. "Food Security Wanes as World Warms." *Science News*, December 1. http://www.sciencenews.org/view/generic/id/66902/title/Food_security_wanes_as_world_warms, accessed January 2011.
- Rosegrant, M. W., S. Msanguu, T. Sulser, and C. Ringler. 2006. "Future Scenarios for Agriculture: Plausible Futures to 2030 and Key Trends in Agricultural Growth." Background paper for *World Development Report 2008*, World Bank, Washington, DC.
- Rossiter, D. 2004. "Digital Soil Mapping." Global Workshop on Digital Soil Mapping, International Union of Soil Sciences, Montpellier.
- Ruttan, V. 2002. "Productivity Growth in World Agriculture: Sources and Constraints." *Journal of Economic Perspectives* 16 (4): 161–84.
- Scharf, P. C., and J. A. Lory. 2006. Best Management Practices for Nitrogen Fertilizer in Missouri. Colombia: University of Missouri.
- Shapouri, S., M. Peters, A. Summer, S. Rosen, and F. Baquedano. 2010. "Food Security Assessment 2010–20." Economic Research Service, United States Department of Agriculture, Washington, DC. <http://www.ers.usda.gov/Publications/GFA21/GFA21.pdf>, accessed April 2011.
- Smith, E. A. 2010. "Sustainability and Global Seafood." *Science* 327 (5967): 784–86.
- Smukler, S., and C. Palm. 2009. *Agriculture and Climate Change: An Agenda for Copenhagen*. Washington, DC: International Food Policy Research Institute (IFPRI).
- Traoré, P. S. 2010. "The View from Above: VHRI Gives West African Farmers Data on Soil Fertility and Land Size." *ICT Update*, February 23, <http://ictupdate.cta.int/en/Feature-Articles/The-view-from-above>, accessed July 2011.
- Wark, T., P. Corke, P. Sikka, L. Klingbeil, Y. Guo, and C. Crossman. 2007. "Transforming Agriculture through Pervasive Wireless Sensor Networks." *Pervasive Computing* 6 (2): 50–7.
- Woodhouse, P. 2009. "Technology, Environment and the Productivity Problem in African Agriculture: Comment on the *World Development Report 2008*." *Journal of Agrarian Change* 9 (2): 263–76.
- World Bank. 2006. *Reengaging in Agriculture Water Management*. Washington, DC: World Bank.
- . 2007. *World Development Report 2008: Agriculture for Development*. Washington, DC: World Bank.
- . 2010a. *Agriculture Action Plan 2010–2012*. Washington, DC: World Bank.
- . 2010b. "In Afghanistan and India, Low-Tech Approaches Aid Monitoring." June 1. <http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:22598031~pagePK:64257043~piPK:437376~theSitePK:4607,00.html>.
- . 2010c. "New Uses for Global Forecasts: FY 10 ECA Innovation Grant." Istanbul: World Bank.

———. 2010d. "Project Information Document: Kenya Agricultural Carbon Project." <http://web.worldbank.org/external/projects/main?pagePK=64283627&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P107798>, accessed April 2011.

World Bank Ghana Office. 2010. "First Soil Carbon project in Africa: Kenyan Farming Project Could Be Model for the Region." *Modern Ghana*, November 8. <http://www.modernghana.com/news/303612/1/first-soil-carbon-project-in-africa-kenyan-farming.html>, accessed April 2011.

PERSONAL COMMUNICATIONS

H. Agah, senior rural development specialist, World Bank. Interview with C. Belden, Agriculture and Rural Development, World Bank, March 22, 2011.

T. Jantunen, March 9, 2011.

I. Ortiz-Monasterio, agronomist, Global Conservation Agriculture Program and International Maize and Wheat Improvement Center, February 15, 2011.

Module 6 ICTS, DIGITAL TOOLS, AND AGRICULTURAL KNOWLEDGE AND INFORMATION SYSTEMS

JEEHYE KIM (World Bank Group) and DAVID NIELSON (World Bank Group)

IN THIS MODULE

Overview. Research, extension and advisory services, and learning activities are the major knowledge and information services for agriculture. Each of these services increasingly employs information and communication technology (ICT) and digital tools to promote and exploit rapidly expanding access to information, advice, consultation, and data. This module discusses the use and impact of ICT and digital tools in research, extension and advisory services, and activities related to agricultural learning.

Topic Note 6.1: ICT, Digital Tools, and Agricultural Research. Throughout the agricultural research process—from engaging partners and stakeholders, through data collection and analysis, collaboration and knowledge access, publishing and dissemination, to feedback and interactions with rural and other end-user communities—ICT and digital tools are making agricultural research more effective.

- **Fujitsu Launches New “Akisai” Cloud Initiative for the Food and Agricultural Industries and Research**
- **KAINet Kenya Knowledge Network Anchored in Partnerships and Collaboration**

Topic Note 6.2: ICT, Digital Tools, and Agricultural Extension and Advisory Services. ICT and digital tools appear to have the potential to transform extension and advisory services in several ways—including changing the way in which extensionists do their work, but also changing the ways extension institutions are organized and staffed. The emergence of public and private innovators and start-ups with business models built around ICT-enabled advisory services signals the types of transformations that are likely to come. This note examines how traditional and new types of ICT are used to reach rural communities, enable rural communities to create and share their knowledge, and connect rural communities with knowledge institutions and other sources of information and advice.

- **E-extension with a Business Orientation in Jamaica’s Rural Agricultural Development Authority**
- **Videos on Rice Seed Production Bring Multiple Benefits to Bangladeshi Women**
- **Participatory Video and Internet Complement Extension in India**

Topic Note 6.3: ICT, Digital Tools, and Agricultural Learning and Education Systems. Learning through ICT can provide fresh approaches that place producers and their communities at the center of designing and implementing the learning experience. ICT can also make it easier to maintain quality by supporting feedback mechanisms and ensuring appropriate accreditation and certification processes. This note also explores some of the adaptations and strategies required for e-learning to succeed in rural areas of developing countries.

- **Lifelong Learning for Farmers in Tamil Nadu**
- **Innovative E-Learning for Farmers through Collaboration and Multimodal Outreach**

The authors of the original Module 6 were Stephen Rudgard (FAO), Peter Ballantyne (ILRI), Riccardo Del Castello (FAO), Philip Edge (Consultant), May Hani (FAO), Ajit Maru (GFAR), Estibalitz Morras (FAO), Karin Nichterlein (FAO), Enrica Porcari (CGIAR), Sophie Treinen (FAO), Venkatraman Balaji (Commonwealth of Learning), and K. Balasubramanian (Commonwealth of Learning). The reviewer of the current Module 6 is David Spielman of IFPRI.

OVERVIEW

Information and communication technology (ICT) and digital tools are fundamentally transforming the operating environment for agricultural knowledge and information systems. These technologies and tools can expand access to information and knowledge, and promote communication and cooperation among the actors in agriculture. Mobile phones

in particular can drive participatory communication, including communication with those on the margins of traditional research-extension processes, and phones are often the key instruments enabling organizations to deliver services to larger numbers of rural people than they could reach before. ICT is also integral to the business models of the public and private “info-mediaries” and “information brokers”—such as extension agents, consultants, and companies contracting farmers—that are emerging to broker advice, knowledge, collaboration, and interaction among groups and communities throughout the agricultural sector. All of these developments offer opportunities to significantly enhance the effectiveness and reach of agricultural research, extension and advisory services, and learning programs, as well as opportunities for profound and transformational changes in how such programs are structured.

ICT AND DIGITAL TOOLS IN AGRICULTURAL KNOWLEDGE AND INFORMATION SYSTEMS

As ICT has developed and become more pervasive, it has become a source of essential tools for agricultural research, extension and advisory services, and e-learning systems. First and foremost, the increased coverage of telecommunication networks means that more technologies and applications long regarded as potentially useful in rural communities are finding their way into the hands of more rural users, even in remote areas. Exceptional increases in the speed, reliability, scope, and accuracy of communication and information exchange—through text, voice, and other applications—have created new opportunities for farmers to connect with their partners (other farmers, researchers, extension and advisory service providers, agribusiness, or others important to farmers’ lives and enterprises) in ways that enhance their productivity and incomes.

A second way in which ICT has become essential for agricultural research, extension, and e-learning systems is through cloud computing services (box 6.1). Cloud computing presents vast possibilities to manage big data about agriculture and render it directly and practically useful to agricultural policy makers, researchers, extensionists, farmers, and agribusiness. Cloud computing offers “a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction” (Mell and Grance 2011). Over the past few years, these services have been the lowest-cost option for nearly all types of data center computing and are

BOX 6.1. Cloud Computing Improves Open Access and Open Data in Agriculture while Integrating New Technologies for New Uses

Pioneered by Amazon Web Services, cloud computing (the practice of using a network of remote servers hosted on the Internet to store, manage, and process data) has played an important role in improving global access to knowledge resources and data. The use of cloud computing in agriculture goes beyond access to data and servers. Merged with a number of technologies, such as radio-frequency identification (RFID) tags the cloud enables tagging, downloading, analyzing, and synthesizing immense data sets. Instead of waiting for an expert to analyze such data, systems can automate the practical analysis and interpretation of current and past data and formulate user-friendly and actionable recommendations for farmers and other participants in agricultural value chains. Considering that few individuals (including farmers) are IT experts and that many are not even adept users, Software-as-a-Service platforms (licensing and hosting the tools) and cloud computing services (providing remote access to hardware and software) might prove a good fit for agricultural producers and corporations.

Source: Authors.

already becoming cost-effective for high-performance computing, like video and image processing, bioinformatics, and most types of scientific data analysis. Agricultural research institutes, such as the member centers of the Consultative Group on International Agricultural Research (CGIAR), are shifting to cloud computing, anticipating that it will cut the cost of scientific computing and present new opportunities for international agriculture. The extent to which cloud computing will influence the overall effectiveness and impact of agricultural research and extension and advisory services remains to be seen—but many see tremendous potential in this regard.

A third transformative development for agricultural research, extension and advisory services, and e-learning for public agricultural agencies and farmers themselves is the emergence of online or mobile tools that facilitate open access to agricultural knowledge and information and encourage public involvement in its use. Governments, organizations, and even the private sector share data and reports with the public and one another through ICT. As ICT has alleviated the difficulties inherent in interactions among people

in dispersed locations, knowledge sharing and multistakeholder engagement are widely acknowledged to have increased. Research can involve more expert opinion and diversity (box 6.2). Advisory services can tap a much wider range of current expertise and provide advice in a much more targeted way to those who need it. With Internet access, e-learning can function without a formal distance education program, and Web platforms such as agropedia (discussed in Topic Note 6.3) make it much easier to develop and transmit content for e-learning programs. At the same time, the capabilities for data collection and analysis that are becoming available raise new issues about protecting the privacy of farmers and other actors in the agricultural sector. These issues will need to be managed if the full potential of big data in agriculture is to be realized.

Finally, new forms of knowledge sharing are possible through ICT (image 6.1). Knowledge brokering has always been an integral part of agricultural innovation systems. The creation

BOX 6.2. Agricultural Research Center Facilitates Open Access and Global Platform for Sharing Knowledge

Providing free Web-based access to research is a priority for international research and development centers. Housing more than 5,700 research documents—including journal articles, conference papers, theses, and monographs—an Open Access Repository launched by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) provides an easy interface for researchers, practitioners, and Web-connected farmers to use, build on, and share research conducted at ICRISAT. Since the Open Access Repository was created in May 2011, more than 144,000 documents have been downloaded by people from more than 70 countries.

ICRISAT also uses the Web-based KSI Connect platform to spotlight interesting research projects, cutting-edge research, and stories at ICRISAT for both an in-house and a global audience. This platform allows experts across the globe to share their project experiences and cutting-edge research activities contributing to global food security. Since its launch in July 2012, KSI Connect has hosted more than 100 videos, and the website receives more than 3,000 users every month.

Source: ICT Update (February 2013) on CTA's website (<http://ictupdate.cta.int/mobileen/Feature-Articles/The-right-information-at-the-right-time>).

IMAGE 6.1. Specialized Knowledge on Farm Practices Can Result in Profitable Enterprise



Source: Rikin Gandhi.

and passing of information between farmers and extension agents, farmers and researchers, and researchers and extension agencies, among others, is critical to increased productivity through the adoption of better farming practices and technologies.

Knowledge sharing is becoming a specialization—one that is often marketable and sometimes profitable. As digital literacy and the availability of ICT increase, farmers, traders, and others in developing countries are offering and receiving hypercontextualized information for a fee. This private activity can widen the availability and improve the relevance of information in rural areas and reduce reliance on public extension agents. Compared to traditional public advisory services, private sector involvement has often proven more effective in providing specific, well-defined, high-quality information needed by producers).

KEY CHALLENGES AND ENABLERS

The topic notes and innovative practice summaries in this module demonstrate the potential and the challenges for ICT and digital tools to dramatically increase access to knowledge and information in the agricultural sector, opening the way for substantially improving the effectiveness and value of agricultural research, extension and advisory services, and learning. Two key enablers—the policy environment and collective action (among research institutions, extension agents, governments, and farmers)—are critical to using various types of ICT, such as mobile phones and the Internet, to bring about the many

BOX 6.3. Key Elements of ICT Systems for Agriculture

Policies. Generate or adapt institutional and national strategies and policies to make the introduction of ICT innovations more frequent and more effective.

Institutions. Adapt organizational structures at all levels to accommodate changes in ICT systems and information management processes, develop new incentive structures to encourage all innovation actors to contribute novel outputs or to stimulate collaboration, and develop innovative business models, particularly where they relate to mobile devices and telecommunications.

People and communities. Develop and diversify the skills and competencies of stakeholders at every level and in every aspect of the agricultural sector in applying and adopting ICT for their activities in farming and agribusiness. Invest in the skills of new intermediaries, such as innovation brokers (often agricultural advisers and extensionists), who specialize in linking actors and resources to foster ICT-related investments and activities that boost productivity and profitability at the farm level and in other parts of agricultural value chains.

Content. Ensure relevant local content and stimulate open access to the increasing volume of agricultural research results so that all can benefit. Develop and comply with coherent standards that continue to improve the interoperability and exchange of data among stakeholders.

Processes. Use ICT to facilitate and open up inclusive multi-actor processes in which knowledge flows efficiently and can be put to use by different stakeholders. Facilitation will be needed at various levels to bridge divides and gaps in access to ICT and in institutional strength.

Technologies. Invest in greater connectivity, data and information generation and handling capacity, hardware, software, and improved human-computer interfaces to serve all aspects of the agricultural and agribusiness sectors. Ensure that rural ICT infrastructure and connectivity are enhanced. Specific actions are needed to overcome barriers to technology use, such as those related to culture, language and literacy, and gender. A recurring challenge is the fast pace of change and development in ICT.

Monitoring and evaluation. Develop new and improved tools and approaches to assess information and knowledge interventions more effectively.

Capacities and training. Invest in the technical and organizational capacities of individuals and institutions so they appreciate and use ICT devices as tools to enhance knowledge creation, transformation, and innovation. These capacities are more than just technical; appropriate mind-sets and incentives are essential to encourage information and knowledge to flow.

Source: Authors.

relatively small, scattered agricultural innovations that can together have a major impact. Policy change can spur the development of the infrastructure for ICT-enabled information sharing. Collective action facilitated by digital tools can enhance productivity in the sector enormously.

Just as roads are essential for rural development, digital connectivity is becoming essential for research, extension and advisory services, and e-learning. Not all types of ICT available for agricultural information systems will work in rural areas. An analysis of the technical capacity (infrastructure, connectivity, accessibility, affordability, and equipment) as well as staff capabilities (in software development, IT understanding) in line departments, local government

offices, or research centers is a critical prerequisite for implementing effective technical services. Public-private partnerships can be forged, particularly for commercially oriented extension, advisory services, and e-learning (see “Lifelong Learning for Farmers in Tamil Nadu”), to improve telecommunications infrastructure, identify sustainable business models, and aid in capacity building and training. Box 6.3 reviews the key elements of ICT systems for agriculture that require attention.

National ICT policy can create an enabling environment for the use of ICT and digital tools (World Bank 2015), but the overall conduciveness of the enabling environment depends on more than national policy alone.

It is also affected by the policies prevailing at the organizational level. Researchers may want to disseminate results more widely and increase their usefulness, for example, but they can be inhibited by organizational IT and intellectual property policies that limit opportunities to tap into the open access movement.¹ If national research systems do not digitize their research results and create repositories for them, they make it difficult for their researchers to share findings in a wider network. Extension and advisory programs, other agricultural services, and producers may suffer the consequences of not having access to important research results. Appropriate institutional policies and general e-readiness are essential to build innovation cultures where ICT thrives and is put to good use—but their development requires an appropriate policy environment that safeguards researchers' incentives to develop innovative products that will have value for the sector and its participants.

Effective management and collaboration are essential for building research networks, data repositories, and expert query systems and for engaging in large data collection efforts. In addition to committing resources, agricultural research services must create the right climate and culture, including at the senior management level, to support collaborative planning, knowledge sharing, communication, cross-functional teams, and a critical review of current information and communication systems.

Advisory services can dramatically improve the effectiveness of their efforts by using ICT to nurture and facilitate knowledge sharing and brokering (including brokering new partnerships). The nature of farmer engagement, two-way communication, information requirements, and complex extension networks all make the design of advisory service programs critical to their ultimate success. In designing advisory programs that use ICT, the basic requirements must be considered, including ICT policy, rural connectivity, user fees, the information and communication needs of potential stakeholders, functional linkages, existing communication channels and knowledge sources, lessons related to previous information dissemination and networking efforts, farm diversity, and demographic, political, and environmental demands (image 6.2).

¹ The urge to protect research results can be strong, especially if they represent a potential source of income for impoverished national research programs. Many public organizations, lacking expertise in intellectual property management and protection, opt for the most restrictive policy on information sharing, even though they recognize that it is detrimental to innovation.

IMAGE 6.2. ICT must be Complemented by Other Inputs, Such as Improved Seedlings



Source: Dominic Sansoni, World Bank.

ORGANIZATION OF THIS MODULE

This module focuses specifically on how ICT can be used in three major, interrelated components of agricultural knowledge and information systems: research and knowledge sharing systems; advisory services; and e-learning. Each of these components is discussed in a topic note.

Topic Note 6.1 focuses on the use of ICT in research and ICT-enabled information systems for agricultural development. Investments in infrastructure and digital research collaboration, along with rapid developments in mobile devices and connectivity in rural areas, are changing information and knowledge flows. This note focuses more on general research processes than on specific applications, describing how ICT is altering research collaboration and data collection, analysis, storage, and dissemination. For example, the note describes efforts by individuals and research organizations to make formal and informal research outputs (peer-reviewed journal articles and unpublished literature) freely and openly available on the Internet using low-cost technologies.

Topic Note 6.2 describes how ICT contributes to efforts in many countries to employ new operational and institutional modalities to make advice and information more accessible to producers. The discussion is organized around broad functions of ICT in supporting this new notion of advisory services: the need to provide localized, customized, and highly accessible information; the need to archive and provide reference information for a wide array of actors in the sector (from fertilizer application rates to quality standards for food processors and exporters); the need to facilitate networks (local, regional, global) for collaborative, interdisciplinary approaches to problem solving and research diversification

through shared knowledge bases, online forums, and collaborative spaces; and the need to empower and “give voice” to rural communities.

Topic Note 6.3 focuses on electronic learning, especially its potential for building capacity in extension and advisory service providers and in producers. E-learning potentially enables

any actor in the innovation system to reach large numbers of producers, involving them as partners and adult learners in designing and implementing the learning experience. The use of ICT devices such as mobile phones makes it possible for learning to occur without classrooms or fixed schedules, although face-to-face interaction and incentives for using the new knowledge are important for e-learning to succeed.

Topic Note 6.1: ICT, DIGITAL TOOLS, AND AGRICULTURAL RESEARCH

TRENDS AND ISSUES

Agricultural research is a key knowledge- and information-intensive activity for improving the productivity and sustainability of the agricultural sector. The effects of ICT have permeated the agricultural research process and the partnerships that define, sustain, and direct it toward development goals. For example, ICT is making agricultural research more inclusive and at the same time more focused on development goals, because it changes how, where, and to whom information flows. Information can flow in many directions; it can be highly dispersed and accessible, and it can be highly targeted, location specific, and location aware (Ballantyne, Maru, and Porcari 2010).

ICT is not only becoming integral to the mechanics of the research process. It is also associated with the collaborative context in which the research process unfolds, and it is critical to the communication and accessibility of the data, information, and knowledge that researchers and their partners create.

ICT devices and techniques offer new potential to developing national institutions, such as research centers, and networks to participate in a worldwide digital knowledge economy. Movements of information are almost instantaneous and can be transmitted across the world at no or minimal costs (Mark 2014). Open repositories and Web tools create opportunities for the more digitally connected stakeholder groups in research agencies and academia to generate, capture, store, analyze, and share virtually the entire range of research content, such as academic theses, data, images, researcher profiles, and so on. These technologies have also created more informal ways of communicating research outputs.

COLLABORATION IN AGRICULTURAL RESEARCH

The need for collaboration cuts across the entire agricultural research process, from the conceptualization of a research program to the application of its results. In agricultural research for development, for example, priorities are often based on the needs of small-scale farmers with very limited resources. ICT is making it easier for research organizations to link with these stakeholders and document and understand their needs, thus enhancing the relevance and effectiveness of their research. ICT also makes it possible to consult a much wider and more dispersed network of stakeholders (such as producer groups, technical experts, private sector actors, research administrators, and policy makers) prior to developing a research program (box 6.4).

An integral part of “who to include in the collaborative research process” is “where to do the research.” The local nature of agriculture, from the environment’s effect on crops and biodiversity or the social and cultural norms that influence the agricultural sector (e.g., in one location women are quite active as small-scale farmers and traders; in another, they never work alone in the field and are forbidden from selling produce to strangers), suggests that it is usually necessary to pick locations appropriate to the locale in which the results are to be applied.

Here again, ICT has proven quite useful making these links. For example, in developing new varieties with specific traits needed by small-scale farmers (such as drought tolerance or resistance to a particular disease), plant breeders have relied for years on ICT to collect, analyze, and validate data to identify field testing sites that are representative of conditions in small-scale farmers’ fields. In Tanzania, researchers have added to their capacity to track and monitor the development of cassava mosaic disease and cassava brown streak disease

BOX 6.4. ICT Engages Stakeholders in Formulating an Ambitious Research Program

In the summer of 2010, four international agricultural research centers in the Consultative Group on International Agricultural Research (CGIAR) came together with partners to develop an innovative, inclusive research program on livestock and fish. Before the program could be developed, a very wide range of stakeholders (from governments, funding agencies, the private sector, and research, extension, and advisory services) participated in extensive consultations, not only in person but also online. Their efforts were supported by a wiki to share documents and other resources in a transparent, efficient, and cost-effective manner; a blog where assumptions and questions were posed and comments received; and several online surveys developed using the SurveyMonkey tool. The process and documentation were fully open. All documents, presentations, and interviews were publicly available.

Fostering broad and deep engagement among numerous stakeholders to develop a very large research program is not a simple or brief task. For this particular program, the e-consultation began in July 2010 and consisted of eight rounds of questions, each focused on a different aspect of the proposed research. The initial proposal emerged after five rounds of consultation, each including a survey (a series of statements with which participants were invited to agree or disagree) and an opportunity to submit open-ended comments. Three more phases of the e-consultation followed in February 2011. During this time, revisions to the initial proposal based on an external review were shared and tested in public through the e-consultation forum.

Between July 2010 and March 2011, the various e-consultation tools and resources were viewed more than 25,000 times. The organizers received 465 comments and other feedback on questions and surveys. The consultations raised a number of concerns and suggestions that were instrumental in strengthening the proposed program throughout its development. This type of consultation is becoming widely used and is integrating a much broader and more diverse set of views, perspectives, and insights into CGIAR planning processes than ever before.

Source: Program proposal (<http://livestockfish.wordpress.com>).

BOX 6.5. Rural Tanzanians Update Researchers on Spreading Cassava Diseases

Pandemics of cassava mosaic disease and cassava brown streak disease are reaching East and Central Africa. The costs of sending researchers to monitor disease development are high. Yearly visits have barely kept pace with these spreading diseases, yet early warnings of new outbreaks and greater community involvement in their control would considerably slow their progress.

The Digital Early Warning Network (DEWN) provided training and mobile phones to farmers in northwestern Tanzania so that they could recognize symptoms of the two diseases and text their findings to researchers. Information obtained from farmers was used to generate maps. One of the most significant findings was that brown streak disease reported by farmers was confirmed by researchers' visits to two districts where it had not previously been reported. This finding allowed project teams to concentrate disease mitigation efforts on these areas.

DEWN has provided an innovative, informative, and relatively cheap means of involving communities in monitoring and maintaining the health of their crops. Research has been enriched and cost-effectively extended through greater connectivity with the voices and knowledge of farming communities. DEWN was primarily piloted by the Lake Zone Agricultural Research Institute in Tanzania with the International Institute of Tropical Agriculture.

Source: Adapted from http://measict.weebly.com/uploads/3/2/4/3/3243215/meas_tanzania_-_rapid_appraisal_of_the_ict_for_agricultural_extension_landscape_-_jan_2013.pdf.

because ICT offers a means of cooperating with the distant farming communities whose crops are at the front lines of these pandemics (box 6.5).

Communication in agricultural research has traditionally focused on disseminating “end results”—by publishing results in peer-reviewed journals, monographs, proceedings, and so on. To make research more relevant, open, and accessible, some organizations use ICT to enhance knowledge sharing much earlier in the research process, during program formulation, design, and as part of ongoing planning and review. Increasingly, researchers are using digital social media tools, which are easy to access and use, to extend and open up communication and knowledge sharing throughout the research process.

To disseminate information on such approaches and tools, the CGIAR has assembled a Knowledge Sharing Toolkit in conjunction with the Food and Agriculture Organization (FAO), the KM4Dev Community, and the United Nations Children’s Fund (UNICEF). The toolkit consists of knowledge sharing tools and methods to promote collaboration at each stage of the research project cycle. Online tools include collaboration platforms, wikis, blogs, photo sharing, podcasting, Google documents, discussion forums, intranets, content management systems, and instant messaging. Each tool is described, with links to relevant resources and suggestions for use, on the website. Figure 6.1 illustrates how the CGIAR ICT-KM Program perceives the relationship between the research cycle and the various knowledge sharing and collaboration tools highlighted above.

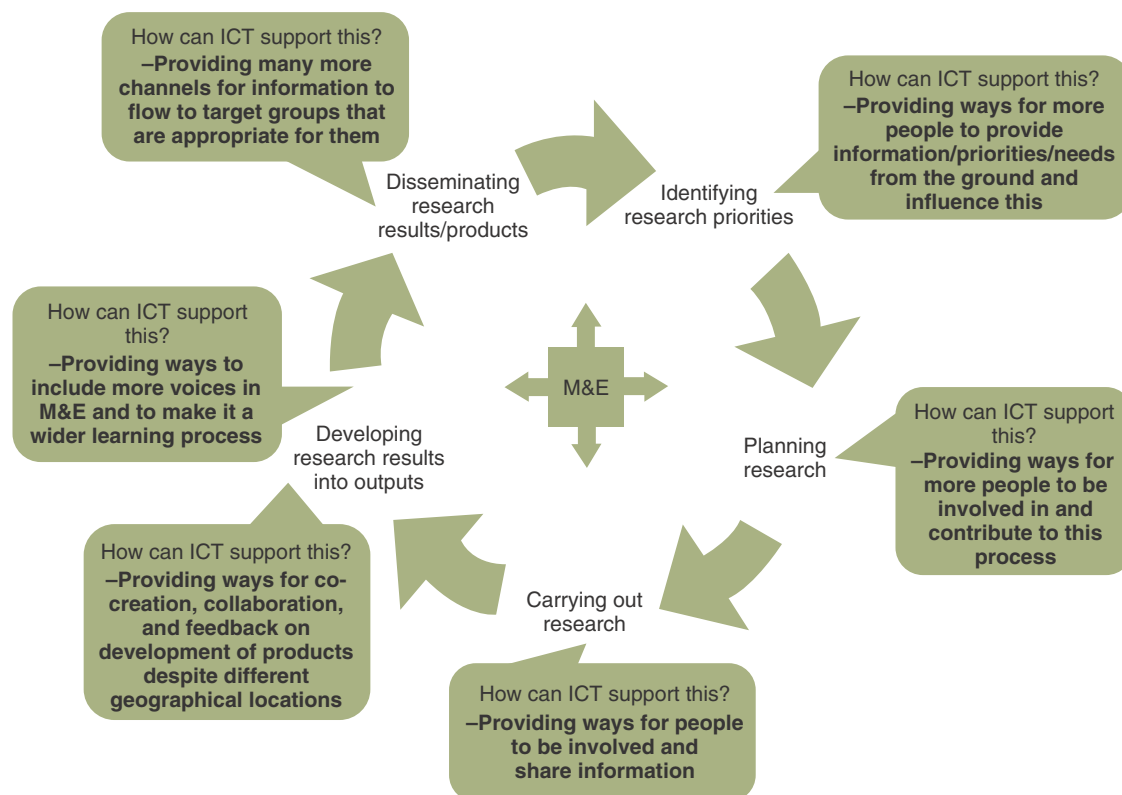
COLLECTING AND ANALYZING RESEARCH DATA

ICT is widely used to collect data, with the choice of technology depending on the kind of data needed. Surveys can be administered electronically. Information from online research collaboration can be recorded and analyzed using a variety

of ICT and digital tools. Mobile devices of all kinds record research data—smartphones, mobile phones using SMS text messages, personal digital assistants (PDAs), global positioning system (GPS) units, and specially designed equipment to measure indicators of soil nutrient levels, among others. Electromagnetic and photographic data are recorded by sensors in satellites and aircrafts and on the ground. Small transmitters are used to collect, store, and send data, including data from radio-frequency identification (RFID) tags (Simon et al. 2014).

Mobile technology has also created opportunities for crowdsourcing from farmers. Rather than perform data collection by hand or through paper surveys, researchers can collect data through SMS or mobile digital data collection tools (box 6.6). Data on pest outbreaks, for example, can be recorded by asking farmers to text information to a premium number. Scientists and governments are able to monitor farming activities and local problems remotely and to predict regional and national challenges with greater certainty. SMS and other mobile data collection tools have also eased data entry. Paper surveys, which require enormous amounts of labor after the initial data are collected,

FIGURE 6.1. Knowledge Sharing and Collaboration Tools in the Research Cycle



Source: Manning-Thomas 2009.

Note: M&E = monitoring and evaluation.

BOX 6.6. Open Applications for Mobile Digital Data Collection

Mobile data collection for humanitarian and public health projects started to take off with the invention of the Open Data Kit (ODK), a collaboration between Google and the University of Washington. ODK allows smartphone users to submit information to a central server (ODK Aggregate), drastically scaling back the need for using and collecting paper-based forms. A number of open standards have been developed around open data collection, including OpenRosa, XForm, and XLSForm. Years later, methods have been validated, innovations have progressed, and others have built on the ODK platform, including formhub, Ona.io, and KoBo Toolbox.

formhub

The Columbia University Sustainable Engineering Lab (SEL) initially created formhub as an internal system to assist small-scale, offline data collection. The SEL team then created formhub.org and provided formhub free to users as a hosted Software-as-a-Service (SaaS) platform. It was an instant hit, and there are over 3 million form submissions. A number of virtualboxes have been created so users can download formhub and run it on their own, just as if they were using the ODK platform.

On to Ona

A number of formhub developers joined together and created Ona, which is based in Nairobi and New York City. Recognizing that their customers needed a hosted mobile data collection system, they immediately began work on improving the scalability of formhub and rebranded it as ona.io, which is currently available both as a free service and paid plan.

KoBo Toolbox

Built for the most demanding contexts where Internet connectivity is the exception, not the rule, KoBoToolbox is a flexible, free, and easy-to-use software for mobile digital data collection (and surveys). The software requires no special programming skills or equipment. Surveys can be conducted entirely offline, regardless of what kind of device is used to collect the data. For that reason, the toolbox is particularly helpful for researchers who collect data through face-to-face interviews for large-scale, social science population surveys. In coordination with the United Nations and the International Rescue Committee, KoBoToolbox launched a new phase in September 2014 to make electronic data collection more standardized, more reliable, and easier to use in humanitarian crises. Many additional features are being developed as growing numbers of researchers contribute their expertise to this open source effort.

Enketo

Enketo is a Web-based data collection client that allows data to be collected offline through a Web browser on any device. It adjusts for different screen sizes and touchscreen ability. When users visit the survey page the first time, Enketo automatically “installs” the survey in users’ browsers, allowing them to collect data with the device both online and offline. It automatically syncs to the server when an Internet connection returns. One of the first fully offline-enabled SaaS solutions, Enketo is available for deployment with independent ODK and formhub installations and is automatically embedded in Ona.io and KoBoToolbox. A new, fully open source version of Enketo called Enketo-Express is under development to allow organizations to collect information from computers that are not connected to the Internet.

Source: Extracted from mHealth Platform Compendium.

are being replaced with devices connected to software packages that automatically transfer the data to databases and statistical programs. iFormBuilder is an innovative application that collects rural survey data.

In addition to collecting primary data, researchers often rely on secondary data to complete their analyses. For example, several organizations offer archival GIS data, including remote sensing data, at increasingly better resolutions and

sometimes free of charge.² Other organizations (public and private) offer crop genome sequencing data. In the future, as biotechnology and agriculture increasingly overlap, results of nanotechnology applications in agricultural production and food processing and packaging will increasingly be collected and shared through ICT (Interagency Working

2 See CGIAR Consortium for Spatial Information (“What Is CGIAR-CSI?” http://csi.cgiar.org/WhatIsCGIAR_CSI.asp).

Group on Manufacturing R&D, Committee on Technology, and National Science and Technology Council 2008).

The use of ICT to analyze research data appears virtually universal, although some research systems are limited by the infrastructure and applications available to them. Options range from custom software developed for a particular research project or organization to more generic packages such as GenStat Discovery Edition, a version of the widely used GenStat software for statistical analysis that is available free of charge to noncommercial users in developing countries.

One chief impediment to the wider use of analytical software in research for development is the lack of funding. The 13th edition of GenStat costs about US\$330, for instance, but other software, especially for sophisticated genomic and proteomic analyses, may be even more costly, especially for public research programs in developing countries. To enable resource-constrained institutions to participate in innovation systems, various cost options need to be discussed. Perhaps software can be procured at a humanitarian-use discount or through cofinancing by development partners, or perhaps an agreement can be reached for large-scale licensing at a discounted rate, specifically to meet the needs of developing countries.

Some of the most innovative current uses of ICT in data analysis are for modeling, simulation, visualization, and cloud computing (do Prado, Barreto Luiz, and Chaib Filho 2010; Hori, Kawashima, and Yamazaki 2010; Li and Zhao 2010). For instance, ICT is vital for developing models of crop performance in environments where yields are reduced by climate stress and increasing climatic variability. Such models offer an important means of evaluating the potential for new cultivars to adapt to climate stress and climate change and to assess food import needs and export potential.

Another example of innovation is the free tools for analyzing virtual proteomics data developed by researchers at the Medical College of Wisconsin's Biotechnology and Bioengineering Center.³ The tools are used in combination with other free software and Amazon's cloud computing service, giving researchers access to considerably more computing power than they may have at their own institutions. Proteomics (the study of proteins expressed

by an organism) has numerous applications in plant breeding research, such as improving the understanding of how plants respond to disease, but until recently few research institutions in developing countries have been able to afford the ICT infrastructure to analyze proteomics data.

MAKING DATA AND INFORMATION ACCESSIBLE

A primary output of the research process is knowledge. Given the transition from print to digital information, one of the most useful investments that an agricultural research institution can make is to invest in organizing and providing access to its digital information and data resources. New storage technology, particularly cloud storage, is making it far less expensive to store and share data and other information.

Complete and easily accessible open repositories or archives of research outputs are the standard to which research institutes aspire. The concept is based on the use of free software such as Dspace, which allows an organization to set up a repository of its documents and outputs. These repositories allow content to be uploaded and made accessible in full; they also allow metadata to be harvested and shared using open standards. As these collections grow, they become permanently accessible indices of an institution's research and nodes in a globally searchable knowledge base for agriculture.

Alongside these repositories, many related specialized systems focus on, for example, theses or academic learning materials, specific subject areas (aquaculture, forestry, and so on), and national aggregations of data from different sources. Parallel systems facilitate the curation, sharing, and sometimes analysis of data in various forms (box 6.7). All of these systems build on basic connectivity and ICT infrastructure, both within institutions and outside them, through the adoption of applications that enable global sharing and aggregation, harvesting, and distributed management of data.

A number of examples of data storage and sharing follow, and many more could be cited. They are similar in several ways. First, they use open standards and common taxonomies that allow metadata to be shared across organizations and systems. Second, they are often based on free or low-cost specialized applications provided by third parties. Third, they depend on the distributed actions of organizations and initiatives that are working toward common objectives and are committed to making information and data widely

3 "Cloud Computing Lowers Cost of Protein Research" (2009). http://www.redorbit.com/news/health/1669050/cloud_computing_lowers_cost_of_protein_research/.

BOX 6.7. Dataverse: An Open Application for Storing and Analyzing Data

Dataverse, initially unveiled in 2007, is an open application to publish, share, reference, extract, and analyze research data. It makes data available to others and allows them to replicate work by other researchers. Developed by the Institute for Quantitative Social Science at Harvard University, the software can be freely downloaded for local use, or data can be hosted by the project.

Dataverse has been continuously improved. The latest iteration, Dataverse 4, was launched in early 2015 and used to share research on 213 cases of Ebola in Sierra Leone globally, more safely, and more rapidly. The team behind this development is already working on ways to improve the streaming of large-scale data to accelerate research output. The next complete overhaul, due in 2016, will address the challenges of confidentiality.

Sources: Authors; see also Simon 2015.

accessible through the Internet. Fourth, they have chosen to use systems that not only store content but also curate and index content in ways that add value to this public good. Finally, they all rely on increasing (remote) storage and connectivity capacities.

Research institutes and other agricultural entities participating in research projects or dissemination projects usually select a single approach to organize their research electronically. These forms of organization include subject, national, regional, institutional, and crowdsourcing approaches (or a variety of these approaches). The approach selected to organize repositories is a critical determinant of its user- and management-friendliness.

Subject Approaches

The Global Forest Information System (GFIS), organized by the global forest community, is an open system to which information providers, using agreed-on information exchange standards, may easily contribute content related to forests through a single gateway. GFIS relies on the adoption of open tools and content by its many collaborators. It uses RSS as the primary device to aggregate and re-present content acquired from different sources.

National Approaches, Pioneered and Partnered with Ministries

The Government of India, in partnership with the World Bank Group, began funding the National Agricultural Innovation

Project (NAIP) in 2006. This six-year project, led by the Indian Council of Agricultural Research, sought to quicken the pace of agricultural development by exploring and applying agricultural innovation in collaboration with a variety of public and private stakeholders. NAIP has established over 50 research alliances between public organizations, commercial enterprises, and farmers, focusing applied research initiatives on technological innovation in poor rural areas. The project and its partnerships have led to a wide expansion of stakeholder engagement, more frequent monitoring and evaluation of technological outcomes, and improved knowledge brokering.

The project component most relevant to this module focused on managing change and information in the national agricultural research service by strengthening the use of ICT for research and technological innovation, increasing public awareness of ICT, experimenting with e-learning models, and opening opportunities for stakeholder collaboration and exchange using electronic tools and Web platforms. The project connected over 300 institutions on the Web, working toward building an enormous ICT network for agricultural research and dissemination. A central portal for the network will serve as the platform for knowledge building and sharing and will maintain 42 open source and subscription-based agricultural libraries. Formal links between libraries in the national research system and other agricultural libraries will be forged. This project component also includes the development of virtual classrooms.

Brazil's national agricultural research system, EMBRAPA (the Brazilian Agricultural Research Corporation), recently contributed 470,000 bibliographic records to WorldCat, "the world's largest library catalog," reflecting the scale and publishing power of this research system. EMBRAPA also maintains substantial repositories of its research outputs in full text. Its ALICE repository provides full access to formal research outputs in the form of book chapters, articles in indexed journals, articles in proceedings, theses and dissertations, technical notes, and more. A complementary resource is Infoteca-e, which collects and provides access to more practical information on technologies produced by EMBRAPA. This information is intended for farmers, extensionists, agricultural technicians, students and teachers from rural schools, cooperatives, and others concerned relatively directly with agricultural production.

In Jordan, the National Center for Agricultural Research and Extension, the Ministry of Agriculture, and FAO have joined forces to set up the National Agricultural Information

System portal. The portal provides updates and news as well as access to full-text reports and publications.

Regional Approaches

Similar in concept, in that it seeks to link local project actors, the International Fund for Agricultural Development (IFAD) joined with the International Development Research Centre to use ICT to support learning and networking across a number of IFAD-supported rural development projects in Asia (initiatives were launched in Africa, Latin America, and the Middle East as well). The ENRAP⁴ project, which ended in 2010, promoted knowledge networking and Internet applications at the local, national, and international levels in the Asia-Pacific region. ENRAP supported local electronic newsletters and the dissemination of agricultural market information, and shared electronic libraries as a means of increasing effective use of the Internet and electronic communication by project staff and, ultimately, by project communities. The project focused especially on methods and practical solutions to foster participation at the grassroots level. The first phase of ENRAP began with an emphasis on ICT. Subsequent phases focused more on the knowledge and content that needed to be shared, as well as on building capacities in knowledge production, especially the use of digital video as a supplement and alternative to written documentation of project experiences.

Institutional Approaches

In Chile, the digital library of the Fundación para la Innovación Agraria (Foundation for Agricultural Innovation) incorporates new types of ICT to manage and diffuse public information. It assembles all of the reports and publications, photos, videos, and presentations produced by the foundation.

In 2009, the International Livestock Research Institute (ILRI) used free DSpace software to set up an open repository of its research outputs. In the first 18 months, some 4,500 outputs were included in the service. Since the system uses open standards, the contents are harvested across the Internet and can be reused in other services—Google Scholar, the CGIAR Virtual Library, FAO's International System for Agricultural Science and Technology (AGRIS), and others. The same platform has been used to develop a shared service across several CGIAR centers and initiatives.

In Uganda, the Makerere University Institutional Repository (Mak IR) provides the full texts of scholarly articles and books, electronic theses and dissertations, conference proceedings, and technical reports, including those produced by its agriculture and veterinary sciences faculties.

A final example comes from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). ICRISAT conducts genomics research to enhance the efficiency and effectiveness of crop improvement. In the course of this work, it learned that the rate-limiting step in genomics was no longer data generation but the speed at which data were captured, validated, analyzed, and turned into useful knowledge. For that reason, ICRISAT initiated its Global Theme on Biotechnology, a program that focuses on building and sharing ICT tools to accelerate these stages of research. The program develops information systems for data capture, storage, retrieval, and dissemination.

The program also develops software based on open source technologies; this software is all in the public domain ([http:// www.icrisat.org/bt-software-downloads .htm](http://www.icrisat.org/bt-software-downloads.htm)). Applications have been downloaded several hundred times by users from other institutions. For example, a Library Information Management System (LIMS) facilitates molecular genotyping through modules that make it possible to track samples, schedule jobs, generate reports, and perform other tasks. LIMS has been adopted by other research facilities and customized by a private sector partner. Information is shared through ICRISAT's Integrated Crop Resources Information System (ICRIS). Available on the Internet with password-protected access, the database provides genotype, marker, and phenotype information. An integrated decision support system, iMAS, has also been developed to facilitate marker-assisted plant breeding by integrating freely available software for designing experiments, mapping quantitative trait loci,⁵ and providing decision guidelines to help users interpret results.

Crowdsourcing Approaches

Researchers and others are not just sitting back and waiting for others to provide tools to share data and information.

4 Originally Electronic Networking for Rural Asia Pacific.

5 A preliminary step in identifying and sequencing genes related to variations in physical characteristics of an organism arising from the interactions of multiple genes and/or interactions between genes and their environment.

BOX 6.8. Reference Management Software

Reference management software, or citation management software, enables researchers to organize their research and produce a reference list nearly automatically from the software packages that are integrated with word processors. More than 30 reference management tools are listed on the Web. Many provide access to an academic social network free of charge, and many offer both free and premium services. Using such software, researchers can organize their research, collaborate with others, and discover the latest research in their areas. With Internet connectivity, scientists can manage their personal research profiles and presence and co-create a literature base on a subject or around an event. Extensive comparisons of various features of reference management software are available online.

Source: Wikipedia, https://en.wikipedia.org/wiki/Comparison_of_reference_management_software.

Researchers with Internet access are making their own specialized literature bases available online (box 6.8). They are also assembling them into quite sophisticated resources that become new research products in their own right. An example is WikiGenes. This collaborative knowledge resource for the life sciences is based on the general wiki idea but employs specifically developed technology to serve as a rigorous scientific tool. The project provides a platform for the scientific community to collect, communicate, and evaluate knowledge about genes, chemicals, diseases, and other biomedical concepts in a bottom-up process.

Such open collaboration is possible only because of the Internet and the way it allows distributed systems for the aggregation, review, and dissemination of knowledge and, most important, the active support of a large community (Hoffmann 2008). Tools like these are a form of “expert crowdsourcing” online.

Crowdsourcing through ICT can also be effective in research projects that involve rural inhabitants. Asking farmers to send information via mobile phone can be an effective way of gathering data with reduced costs and labor. In areas where mobile phones are ubiquitous, it also allows for increased participation from a variety of farmers or farmer groups (see Module 15).

Preferential Access Schemes for Research in Developing Countries

Even with rapid increases in Internet access and connectivity, developing-country researchers continue to face barriers in gaining access to scientific publications and literature, particularly the literature that is available only through a paid subscription. In recent years, commercial publishers have begun to provide better access to their products for some developing countries through initiatives like Access to Global Online Research in Agriculture (AGORA), which provides free or very-low-cost access to 2,400 journals on food, agriculture, and related sciences to institutions in 107 countries; the Programme for the Enhancement of Research Information (PERI), which supports the efforts of developing-country institutions to form consortiums to pay for heavily discounted subscriptions; and The Essential Electronic Agricultural Library (TEEAL), which provides a package of content that institutions can run on their own networks.

Although Internet connectivity gives scientists access to the resources provided, evidence shows that individuals require significant investments in information literacy to maximize their use of these tools. Scientists may rely on their traditional information-seeking strategies and remain unaware of new electronic resources. Their parent organizations need to encourage the use of e-resources and provide appropriate bandwidth and training.

Gaining Access to Private Sector Innovation and Research

Initiatives like Coherence in Information for Agricultural Research for Development (CIARD) (box 6.9) and AgriProfiles (box 6.10) are important to make publicly funded research results accessible (image 6.3). It is quite another challenge to gain access to the results of research financed by private companies. In general total agricultural R&D spending by the private sector exceeds R&D spending by the public sector in the world’s wealthier countries. Because they operate for profit and need to recover their R&D investment, private companies seek intellectual property rights for their innovations, which typically may prevent public access and, at times, even collaboration. This issue is multidimensional, extending beyond the scope of this module, and it is treated in more depth elsewhere.

Some systems permit research results from private firms to be shared. Innovations covered by patent rights allow the patent holder 20 years to exploit the commercial potential of

BOX 6.9. Driving Developing-Country Access to Research Results: CIARDRING

Public knowledge and research results have a limited impact on agricultural and rural development when they are not easily or widely accessible. The Coherence in Information for Agricultural Research for Development (CIARD) initiative—pioneered by the Food and Agriculture Organization (FAO), the Global Forum on Agricultural Research, the Consultative Group on International Agricultural Research (CGIAR), and other partner organizations—aims to overcome this barrier by increasing awareness of how new types of ICT and associated institutional changes expand options to manage and present information differently and economically. One of the principal tools created through CIARD is the CIARD Routemap to Information Nodes and Gateways (CIARDRING). CIARDRING:

- Provides a map of accessible information sources with instructions for searching them effectively.
- Provides a data set–sharing platform for agriculture.
- Provides examples of services that follow good practices for interoperability.
- Clarifies the level and mode of interoperability of information services.
- Provides instructions for building enhanced integrated services that repackage information in different ways.

This functionality makes CIARDRING a true map for users to discover, access, and use sources of agricultural information.

Source: CIARD (<http://www.ciard.net/>).

BOX 6.10. AgriProfiles, a Global Search Portal of Profiles of Experts and Organizations

Started at Cornell University in 2003, VIVO is a research-focused discovery tool that enables collaboration among scientists across all disciplines at Cornell University. Users can browse information on people, departments, courses, grants, and publications, following an ontology-based navigation system.

In 2012, Cornell University, the Global Forum on Agricultural Research (GFAR), and FAO launched AgriVIVO. AgriVIVO, funded through GFAR, adapted the

(continued)

BOX 6.10. continued

VIVO model to reflect the ways that agricultural research is organized. It also incorporated data on agricultural research management from institutional and community sources.

In 2014, after consultation with other VIVO partners, the portal changed its name to AgriProfiles. Reflecting the concept of distributed but interlinked databases, and operating in an open data environment as part of a wider effort to bridge separately hosted directories and online communities, AgriProfiles aggregates profiles of agricultural experts and organizations across regions, countries, and institutions. An AgriProfiles data provider may be any institution, project, or platform managing profiles of people and/or organizations and contributing data to the global AgriProfiles. Some of these data providers contribute data to Agriprofiles directly from internal databases or files. Others have their own “AgriProfile” website, where their data are searchable and in many cases have their own system for letting users update their profiles. Among the data providers are hubs such as Agricultural Information Management Standards (AIMS) and e-agriculture.

Source: <http://www.agriprofiles.net/page/background>.

IMAGE 6.3. Accessing Private Sector Research Could Have Wide Impacts on Poor Agriculture



Source: Jonathon Ernst, World Bank.

the patented innovation, in exchange for publicly disclosing the innovation in a patent database. This practice is meant to enable other researchers to build on the initial innovation. The largest searchable patent databases include PATENTSCOPE from the World Intellectual Property Organization, with

close to 2 million patent applications submitted worldwide. The Patent Full-Text Databases (from the U.S. Patent and Trademark Office) and Espacenet (from the European Patent Office database) offer 60 million patent documents from over 80 countries.⁶

Initiatives like the African Agriculture Technology Foundation (AATF), the International Service for the Acquisition of Agri-biotech Applications (ISAAA), and the Public Intellectual Property Resources for Agriculture (PIPRA) enable developing countries to maximize access to promising technologies and innovations developed by the private sector. Such efforts are built on smart access to relevant developments in the private sector, insights into local research interests, and brokering between the various parties. A review of these initiatives would be very valuable.

LESSONS LEARNED

As part of a personal research toolkit or dashboard for scientists and those they work with, ICT is essential to delivering today's research. Lessons learned in using these types of technology for agricultural research are summarized here; the discussion also highlights the key enablers for designing and implementing ICT-enriched research initiatives.

First, ensure that each researcher has basic levels of e-literacy and ICT access. It is critical to convince managers and funders that ICT is “basic” to research, not just a desirable add-on. Beyond the level of the individual scientist or researcher, many opportunities for using ICT in research require significant institutional investments to have a real impact on research itself or the targets of research.

The lack of systematic investment in ICT by research institutions and their funders often holds researchers back from adopting and using ICT (Balaji 2009; FARA 2009; GCARD 2009; Karanja 2006; Kashorda and Waema 2009; RUFORUM 2009; UNCTAD 2010). Like funding for agricultural research more generally, investments in ICT for agricultural research must increase, and this issue should be at the forefront of the agricultural research discussion. Thinking carefully about how ICT might contribute to research projects is critical to tapping the wide range of opportunities available throughout the research process.

Unfortunately, beyond the use of ICT for everyday communication and Internet access, research institutions may offer few incentives to undertake ICT-enabled research that deviates from traditional paths and uses newer types of ICT, especially if that research involves gaining access to proprietary information and ICT tools (or even paying fees for ICT services). This lack of incentives represents a major challenge to using ICT for agricultural research, especially in rural areas where difficulties like the lack of electricity and weak telecommunications connections abound.

As for open access to research products, low investment in technical infrastructure, in sustaining research capacity, and in research itself has left many countries on the margins of global digital society and innovation, most notably in Sub-Saharan Africa (Karanja 2006; Kashorda and Waema 2009; RUFORUM 2009). Such marginalization reduces awareness of and the capacity to adopt the international standards and methodologies required to participate in open digital information sharing. In this context, the efforts made by organizations to overcome institutional inertia, join together, and develop collective and accessible research information repositories and services are immensely important. Although each institution will have its own priorities and constraints, all can subscribe to common approaches.

An additional major challenge in research is for organizations and individuals to truly grasp the emerging possibilities and be willing to use them. One aspect of this challenge is awareness: Which of all the possible tools and investments will work best, and where? Who has the skills to make them work? What “fallout,” positive and negative, will the organization experience if they are used? What is the best portfolio of ICT-related investments for my particular set of individual, project, or institutional goals and challenges? The use of new types of ICT is also a risky and change-making business. Just adopting a new tool can trigger major changes in workflows, procedures, processes, culture, and hierarchy that force a wider assessment of business processes. Legacy IT systems as well as institutional processes and power relations are often threatened.

Finally, taking full advantage of ICT and digital tools in agricultural research is a challenge for even the smartest, best-funded scientific institute. A research organization that has been transformed through ICT needs people and leadership with skills to develop a vision for e-research and align ICT investments with research and innovation processes, ensure that staff acquire the necessary skills,

6 For a 2010 review of patent databases, see “The Patent Librarian’s Notebook” (<http://patentlibrarian.blogspot.com/2010/02/patent-database-review.html>); IFPRI, Bioversity, and other CGIAR research centers have published more general reviews of intellectual property and related issues in agricultural research.

redesign institutional processes, adopt open standards and access to knowledge, change staff mind-sets, give staff access to ICT tool sets, invest in technological infrastructure and networks, and innovate and experiment—among other needs. Devising and developing the optimal ICT investment portfolio for a national research institute or network is a major challenge.

INNOVATIVE PRACTICE SUMMARY **Fujitsu “Akisai” Cloud Initiative for the Food and Agricultural Industries and Research**

Since 2008, with an updated version launched in 2012, the Fujitsu Group has been field-testing the Akisai cloud for food and agriculture. Based on the concept of “utilizing ICT to ensure plentiful food supplies in the future,”⁷ Fujitsu’s service is the first of its kind worldwide, designed to provide comprehensive support to all aspects of agricultural research and management. This SaaS-based solution leverages cloud computing to support agricultural administration, production, and sales for field crops, horticulture, and animal husbandry. To date, this initiative has demonstrated substantial results, leading to transformational changes in companies’ work patterns, improved productivity, and the training of a new generation of farmers.

With the on-site utilization of ICT as a starting point, the service aims to connect distributors, agricultural regions, and consumers through an enhanced value chain by providing SaaS applications for end users such as farmers, researchers, and agribusiness operators, among others. The SaaS-based agricultural production management solution enables end users to:

- Visualize processes at farm sites, by using mobile devices to collect, store, and analyze data in the cloud, such as the results of daily on-site operations and planting information. Fujitsu’s solution enables customers and researchers to visualize quality and cost figures for each of their planted fields. By leveraging these accumulated data, farmers can look back on the results of previous plans and modify the farming schedule in the future, enabling enterprise-style agricultural management that improves both earnings and efficiency.

- Support the creation of a fixed-time, fixed-quantity, fixed-quality, and fixed-price supply model (intensive management for food-related industries), by centrally managing data in the cloud (production schedules, production history, harvest volume, and planting information) from the several hundred to several thousand contract farm product suppliers across Japan. Because the status of products can be ascertained from the production stage, contract producers can manage their operations to support procurement based on the fixed-time, fixed-quantity, fixed-quality, and fixed-price model.

By offering the cloud service for agriculture, Fujitsu aims to promote a shift toward a new enterprise-like agricultural research and management approach that improves agriculture and food markets by ensuring a plentiful, safe supply of food at all times.

INNOVATIVE PRACTICE SUMMARY **KAINet Kenya Knowledge Network Anchored in Partnerships and Collaboration**

The Kenya Agricultural Information Network (KAINet) project, supported by FAO, encourages and assists Kenyan agricultural organizations to capture and share information in a series of repositories. The network, launched in 2009 and supported by the Ministry of Agriculture, provides training and support. The network’s website allows researchers to query the resources of all member institutions at once. The repositories include around 4,000 full-text digital documents generated by the institutions, with around 40,000 metadata records that conform to international coherence standards to facilitate access and sharing. The network is guided by a national stakeholder forum, a board of trustees, and a network management committee.

Like the thematic service GFIS, mentioned earlier, KAINet relies on distributed action by different organizations, their compliance with standards, and sufficient connectivity for the harvesting and virtual querying of the databases. The collaboration between national institutions and international partners under the project ensured the effective use of national resources and leveraged knowledge of international best practices.

An important aspect of KAINet is that it is integrated into national and institutional policies and strategies. Its outputs and resources, such as the institutional and

7 <http://www.fujitsu.com/global/about/resources/news/press-releases/2012/0718-01.html>.

national repositories of agricultural information, complement national and global initiatives aimed at sharing information. Its training programs support the development of human capacity in information and communication management.

Experiences with KAINet have been carefully documented. Among the lessons and enabling factors that emerged, a major lesson is that piloting the network with a limited number of national institutions allowed the partners to learn and devise workable solutions before expanding the network. The management and steering committees played important roles in promoting the network, involving the management of partner institutions in its development, and guiding project activities. Linking the project to the priorities and plans of partner institutions added credibility to KAINet, ensuring

that it would enhance existing work and not remain an isolated initiative. The initial planning and partnership-building phase was critical for success, because it provided an understanding of the institutions' information and communication management needs and helped partners develop a basis for collaboration.

The development of adequate capacities in information and communication management (including physical infrastructure) was essential for developing open repositories, and these capacities should preferably be built early in a networking project. Because networking contacts were the basis for collaboration and project operations, telephone and email groups were essential for constant communication among partners.

Topic Note 6.2: ICT, DIGITAL TOOLS, AND EXTENSION AND ADVISORY SERVICES

TRENDS AND ISSUES

Rural people must be able to respond quickly and effectively to the opportunities and challenges of economic and technological change, including opportunities to improve agricultural productivity and food security. Innovation is more successful when producers can communicate with and be heard by their peers, local authorities, and institutions. Producers also require relevant knowledge and information, including technical, scientific, economic, social, and cultural information. To be useful, this information must be available to users in appropriate languages and formats. At the same time, it must be current and communicated through appropriate channels.

This topic note outlines key issues involved in using ICT to convey demands for rural advisory services and deliver those services effectively. Although there is convincing evidence that ICT can revitalize interactions between research and extension/advisory services in ways that respond to farmers' demands, the use of ICT is merely one element in the wider transformation of a traditional, top-down, technology-driven extension system into one that is more pluralistic, decentralized, farmer-led, and market-driven. One role of ICT is to contribute to the many reforms that are urgently needed to empower and support small-scale farmers as developing countries seek to respond successfully to food

security, market development, and climate change challenges (Christoplos 2010).

In the context of rural advisory services, ICT devices and techniques have four broad functions. First, they can deliver or provide access to information. They should address the need for localized and customized information—adapted to rural users in a comprehensible format and appropriate language—to give small-scale producers as well as providers of advisory services adequate, timely access to technical and marketing information, as well as information or support related to new technologies and good farming practices (image 6.4). It is not just a matter of getting information out. A key aim is to give rural people the facilities and skills to find the information and answers they need.

A second, broad function of ICT is to organize the knowledge base for extension and advisory services. ICT should help document and store information for future use. In many cases, information and knowledge on technologies and good practices is available only in hard copy or in people's heads, and data are incomplete, scarce, or inaccurate. Local and indigenous knowledge is often transmitted orally, records are often unavailable, and information is dispersed only to nearby family and friends. All of this knowledge, like the knowledge that emerges from research, needs to be documented and organized for reuse. The challenge is evident from the

IMAGE 6.4. Matching ICT to the Diverse Needs of Farmers Is Critical



Source: Neil Palmer, CIAT.

scattered nature of the information, its multiple “formats,” and the general lack of attention to documentation and learning in advisory services. Researchers are rewarded for publishing, but extension workers, advisers, and farmers are motivated to deliver “practical” results; documentation is only a potential by-product.

Third, ICT needs to connect people and networks. ICT can facilitate networking—locally, regionally, and globally—and foster collaborative and interdisciplinary approaches to problem solving and research based on shared knowledge and collaboration (Nyirenda-Jere 2010). Many nongovernmental organizations (NGOs), research organizations, and national ministries have used ICT to improve access to technologies and knowledge in their rural advisory services, by means of rural telecenters, community knowledge workers (CKWs), online networks, and various types of forums. They also

need to focus on ways to empower rural communities to connect with one another, not just to the outside world. Facilitating linkages between market actors, extension and advisory services, and smallholders along value chains is also essential.

Fourth, ICT needs to empower rural communities. ICT should help farming communities “gain a voice” to convey needs and demands, negotiate better deals with other actors in value chains, and generally get practical benefits from the services intended for them (and otherwise avoid being exploited). One key to empowerment is for rural people to acquire the ICT skills and tools to tell their own stories, and provide feedback on services received in their own words and languages, in ways that reach and influence others (see Module 8 on farmer organizations for additional information on ICT and collective action).

Throughout the developing world, ICT is being integrated into classic rural advisory services through conventional channels (radio, television, video, print media, libraries) and newer options (text and voice messaging, the Internet, and mobile services). Advice and information provided via ICT is becoming more varied, covering specific technologies and practices; climate change mitigation and adaptation; disaster management; early warning of droughts, floods, and diseases; price information; health and nutrition advice; political empowerment; natural resource management; production efficiency; and market access. It is not a one-way flow: ICT opens up new channels for farmers to document and share experiences with each other and with experts (IICD 2006). See IPS “Participatory Video and Internet Complement Extension in India” and Module 4.

Some of the likely trends in the use of ICT for rural advisory services over the coming years include (Ballantyne 2009):

- Many advisory services may be privatized as the agricultural sector becomes more commercial, as other actors step into this arena, and as clients are willing to pay. Some services—for small-scale producers and natural resource management, for example, which excite less interest from commercial providers—will continue as public services.
- Various types of ICT, including devices and software, will become more available, much cheaper, and more affordable, even in rural areas.
- Connectivity will become more pervasive and more mobile. More devices will be “smart” and perform multiple operations.

- Farmers and rural communities will be regarded far less as “passive” consumers of advice and information; through ICT, as well as other developments, they are becoming active participants in formal rural knowledge and innovation systems.
- Traditional public advisory services will be challenged by the emergence of new actors with alternative ICT-based business models. To remain relevant and competitive, public extension and advisory services will need to reinvent or transform themselves, making the strategic use of ICT part of the change process.
- There will be much experimentation and innovation by governments, NGOs, the private sector, and new infomediaries to develop and test ICT-based services and business models to better reach or engage with rural communities. The challenge will be to scale these out to reach specific target groups or broad groups of marginal communities.

The more complex and dynamic interactions characteristic of innovation systems, including the interactions fostered through ICT, will require farmers and advisory service providers to acquire new skills, both technical and entrepreneurial (Swanson and Rajalahti 2010). In some instances, ICT tools themselves can enable farmers and service providers to attain these skills; in others, special capacity-building efforts will be needed. This discussion is beyond the scope of this topic note, but helpful information is available (see World Bank 2012, especially Module 4).

In the remainder of this note, the discussion of ICT in advisory services contains examples and innovative practice summaries that illustrate practical strategies for integrating farmers’ demands into advisory services and that discuss their relative strengths and weaknesses. The examples and practice summaries also illustrate some of the social and economic outcomes that can arise when ICT supports the wider webs of communication that characterize effective innovation systems.

ICT FOR EXTENSION AND ADVISORY SERVICES

ICT has great potential to transform the way public extension and advisory services are organized and delivered—including interactions with farmers. It is also an entry point for nontraditional actors that see advisory services as an area of intervention and for giving greater emphasis to subjects that are traditionally deficient in extension and advisory services. ICT can also increase women’s access to advisory services. Experience with a vast variety of approaches to the use of ICT in extension and advisory

services is accumulating rapidly—albeit mostly through relatively small-scale programs. Likewise, the literature analyzing these experiences is growing. The findings have been mixed so far, and there is a clear need to use these findings when developing and refining programs using ICT in advisory services. This area requires much more attention, given the growing interest in reinvigorating support for agricultural extension and advisory services—particularly if new and demonstrably more effective and sustainable approaches can be found.

Some developing countries have moved quickly to enable farmers to interact in real time (or close to it) with advisory services through ICT. Until ICT offered farmers a channel for communicating directly with distant technicians and experts, many farmers could wait months or years for an extension worker to provide technical advice, and often that advice did not address their immediate concerns (image 6.5). The following examples highlight some of the ICT applications that advisory services have used to improve their interactions and sharing of technical knowledge with farmers in developing countries. These applications include Web services like “ask the expert,” mobile messaging for advice, radio programs to disseminate technical information, and video. Many of these endeavors are fairly new, limiting practitioners’ ability to analyze their effectiveness.

Informing the Extension Agent and Advisory Service Providers

Two projects improve the ability of extension/advisory service providers to respond to farmers’ needs by improving the quality and relevance of information available to both groups.

IMAGE 6.5. Timely Advisory Services Improve the Effectiveness of Other Technologies



Source: Thomas Sennett, World Bank.

The first was launched in the Arab Republic of Egypt and the second in Uganda.

Egypt launched a Virtual Extension and Research Communication Network (VERCON)⁸ in 2000 to develop and strengthen links among the research and extension components of the national agricultural knowledge and information system. By improving research-extension linkages, the initiative aimed to improve advisory services for Egyptian farmers, especially resource-poor farmers.

VERCON-Egypt introduced and tested several innovative communication tools. One of the most useful tools is the Farmers' Problems Database, created explicitly to address farmers' problems. The Web interface enables extension agents to pose questions on behalf of farmers seeking solutions to agricultural problems; they can also examine answers to questions already posed to researchers. Content is classified into four main categories of problems: production, administration, environment, and marketing.

The online database and tracking system enable farmers' questions to flow from provincial extension centers to the national extension directorate and research system. Producers approach extension centers with problems, and if they cannot be solved using online resources such as extension bulletins or agricultural expert systems, the extension agent develops a full description of the problem and his or her proposed solution, which is forwarded to a specialized researcher, who provides advice to address it (El-Beltagy et al. 2009). The problems and solutions are added to the online database to assist other users of the network who face similar problems.

Aside from addressing farmers' problems, the system provides valuable information to track farmers' problems, including their incidence and significance. The system makes farmers' problems more visible and quantifiable for research planners, and chronic problems can be addressed in research projects. From 2006 to 2008, over 10,000 problems and their solutions accumulated in the interactive database, and over 26,000 farmers benefited from the system (FAO 2008).

In Uganda in 2009, the Grameen Foundation established a distributed network of intermediaries, called CKWs, who used mobile devices to collect and disseminate information to improve the livelihoods of smallholder farmers. The idea

was to extend the reach of centralized expertise and transmit farmers' concerns more clearly. Via mobile phones, CKWs provide information on three-day weather forecasts, seasonal forecasts, good farming and husbandry practices, input supplies, and markets. The subject matter for each of these topics comes from expert partner institutions like the Uganda National Agro-Inputs Dealers' Association and Uganda's National Agricultural Research Organization.

Early findings indicated that women and poorer farmers frequently used the service and that farmers generally acted on the information. At first, however, CKWs required intensive training in mobile technologies, agricultural information, survey techniques, and business skills to be effective.⁹ More analysis of this experience, and of others like it, will be needed to validate these findings.

Using Radio and Video to Reach Rural Farmers

Compared to the most novel and technically sophisticated mediums of communication available, radio remains the most pervasive, inexpensive, popular, and socioculturally appropriate option in many parts of the developing world. Radio is still the only medium for disseminating information rapidly to large and remote audiences, including critical information about markets, weather, crops, livestock production, and natural resource protection. Video has also had substantial impacts in convincing farmers to try new technologies; the images, demonstrations, and audio narrative can make the information easier to understand and apply, especially for audiences with limited literacy.

Rural radio is distinctive in relation to urban radio and most national radio networks. It is directed specifically to a rural audience with particular information needs, and it often includes authentic stories and experiences from communities and successful farmers. Rural radio can motivate farmers, promote the exchange of views, and draw their attention to new agricultural production ideas and techniques. Rural radio can be highly interactive (box 6.11). Communities, far from being passive listeners, actively plan the production of broadcasts that are an expression of community life and concerns.

Rural radio producers must know the rudiments of agriculture, be familiar with farmers' agricultural problems, and have a good general understanding of rural life to ensure that their

8 See <http://www.e-agriculture.org/content/egypt-vercon-virtual-extension-and-research-communication-network>.

9 For results of the initial review, see Grameen Foundation USA (2013).

BOX 6.11. Interactive Radio Programs Perform Governance Roles and Services

The financial, political, and social capital available to radio stations directly affects the kinds of programs and messages that are directed toward farmers. For example, stations managed and funded by the communities they serve may emphasize the local context and locally available resources. Commercial and private stations may be more inclined to enlist agro-dealers or businesses as sponsors of programs, which bias the programming. Public stations, funded by government agencies, may reinforce national policies and may not accommodate the locally specific needs of rural communities.

Radio-based extension activities, particularly interactive programs, can perform several governance roles and services:

- They can help to provide feedback on government initiatives—for example, by monitoring the uptake and impacts of government policies (on land use, crop specialization, and other issues affecting rural areas), including unintended consequences.
- They can provide feedback on land grabbing and land disputes. Radio can offer an inclusive and safe venue for discussing sensitive issues around land and land use changes between various stakeholders, particularly if listeners can contact the station anonymously.
- They can rapidly provide information on natural disasters, food security, and climate-related issues. In Liberia and Sierra Leone, for example, local radio stations played a key role in delivering information to remote villages about Ebola prevention, while also tracking the rate and locations of infection, and advising where to seek treatment.

Source: Rao 2015.

programming is relevant to their audience. Production teams are taught to work with farmers and, to the extent possible, organize broadcasts directly from the field in open-air gatherings in which entire villages or communities participate.

Program content is generated through participatory discussions with community representatives and presented in languages and formats to which the audience relates socially and culturally. For every rural radio project, the

starting point should be a participatory needs assessment to evaluate not only the material needs of communities that will benefit from the project but also the perceptions, expectations, and commitments that community members can bring to the initiative.

Radio overcomes some of the most challenging issues related to using ICT in advisory services:

- **Accessibility.** Radios are relatively cheap to produce and distribute and do not need electricity or special skills to operate. They can also be shared by groups of listeners. A key challenge for rural radio is to reach female producers. Radio programs should target women producers, although ensuring women's access to radios in the household may not be so easy. Often, men own the household radio and choose the programs to listen to, which may not be relevant for women producers.
- **Literacy and language barriers.** Radio requires no reading and generally speaks the language of the community it intends to reach.
- **Geographic coverage.** Radio can easily and simultaneously reach large numbers of isolated communities over vast geographic areas.
- **Local focus.** Radio can focus on local issues in local languages. United Nations Development Programme (UNDP) notes that in Latin America, for example, most radio programs are locally or nationally produced, whereas only 30 percent of television programming comes from the region.

New ICT has benefited radio by offering better and cheaper means of recording, mixing, editing, and transmitting (e.g., the digital audio recorder, audio editing on computers, and the electronic transmittal of sound programs as attachments) (image 6.6). Development practitioners increasingly recognize the potential for combining radio with new Internet technologies and mobile phones, although limitations must be considered, including the lack of telecommunications infrastructure in some areas and the cost of mobile phones and other ICT devices.

Like radio, video has the advantage of attracting people's curiosity, and it appears to be an especially convincing medium when it captures familiar people or situations (as does local participation in radio broadcasts). Advances in ICT have made video much easier and less costly to produce, disseminate, and preserve for all to use (box 6.12). Like radio, video does not demand literacy, and images can

IMAGE 6.6. New Technologies Have Allowed for More Innovative Radio Programs



Source: Farm Radio International.

BOX 6.12. Access Agriculture's Web and Social Media Platforms for Sharing Training Videos

Access Agriculture, an international NGO, showcases agricultural training videos in local languages as well as in English and French. Users can search its website (www.accessagriculture.org) for training videos on agricultural production and download them or order copies on DVD. The audio tracks can also be downloaded by radio stations for wider dissemination.

This Web platform—primarily designed for agricultural R&D staff, service providers, and extension agents, among others—hosts training videos on 14 types of agricultural products, including cereals, vegetables, fruits, livestock, and fish, as well as technical topics related to (e.g.,) integrated pest management, agribusiness, and mechanization.

The development team is now testing Agtube, a social media platform for rural people in developing countries. Individuals (including researchers) and communities can share their experiences on this platform by registering at www.agtube.org.

Source: <http://www.accessagriculture.org/>.

make it easier for viewers with little formal education to understand complex topics. An additional benefit is that video can foster social cohesion in agricultural communities by featuring the actions and voices of marginalized groups (Lie and Mandler 2009).

Through videos developed in collaboration with farmers and shared with local radio stations and farmer organizations across Africa, the Africa Rice Center widely disseminated information about rice production, processing, and marketing opportunities (van Mele, Wanvoeke, and Rodgers 2013). The series of 11 videos (in 30 languages) has reached more than 500 organizations and probably hundreds of thousands of farmers, stimulating learning and experimentation in rice production from field to market. It is likely that the videos continue to be copied and distributed more widely, but this spontaneous diffusion and any resulting innovation are difficult to monitor and evaluate.

The videos appear to have had a tangible impact on the livelihoods of rural women. Because the videos featured women, they reached more women, who were more likely to apply what they learned (Africa Rice Center 2014). For example, women who saw the video on parboiling rice improved their parboiling techniques and marketed their rice through new outlets (Zossou et al. 2012). Others developed a better relationship with the NGO that showed the video, formed producer groups, and gained assistance from the NGO in obtaining credit to purchase inputs for improving rice production. The NGO, in turn, recognized the effectiveness of the video format and began to use more visual aids in its work with women. The fact that the videos showcased women's expertise and innovation convinced some male researchers that they should work more with women farmers. Giving a voice to women and other marginalized groups in this manner and involving them in the development and dissemination of agricultural technology may be an effective means of promoting greater social inclusion.¹⁰

Making Information Accessible through Mobile Phones and Internet

Colombia's Ministry of Agriculture and Rural Development, in collaboration with partners, facilitates AGRONET, the National Agricultural Information and Communication Network of Colombia. AGRONET is a network of agricultural information providers that have adopted a common platform to standardize and integrate resources to offer value-added information and communication services for the agricultural sector using modern and traditional ICT devices.

To send relevant information to producers, AGRONET develops user profiles based on a needs assessment and on

¹⁰ To see the rice videos, visit <http://www.africarice.org/warda/guide-video.asp>.

users' particular productive activities. AGRONET introduces new methods and improved workflows to provide content systemically, and it takes advantage of mobile technologies to reach a growing number of rural users. Producers receive text updates on AGRONET's platform, including changes in its databases and other news and events pertinent to agriculture. The ministry has expanded the service (initiated in 2005) to provide context-specific information on agricultural markets, inputs and supplies, weather alerts, and other subjects. Over the medium term, AGRONET plans to provide a greater wealth of content and information services to producers by adding capacity in digital television.

The government's efforts to reduce the digital divide through public-private partnerships and growing broadband penetration in rural municipalities catalyzed the development of AGRONET's innovative, value-added information services. An assessment by Colombia's e-Government Program ranked the ministry first in online information provision.

ICT THAT PRESERVES AND SHARES FARMERS' KNOWLEDGE

Various types of ICT—including technologies that have been available in rural areas for some time, like radio, and others that have become more common only recently, such as digital video—bring farmers' views and voices into agricultural advisory and research services. ICT is invaluable for eliciting and preserving local knowledge, such as knowledge of the medicinal traits of plants or traditional erosion control practices. The following sections illustrate how rural people in a range of settings have benefited from and enriched advisory services through greater participation and knowledge sharing mediated by ICT.

Using ICT to Share and Elicit Local Knowledge

Many organizations and governments see ICT devices as tools that bring information and modernity to rural areas—that get messages “out” to the hinterlands. Undoubtedly ICT extends the reach of extension and advisory services, but they can become one-way pipelines, pushing information to uninterested communities. A more inclusive approach uses ICT to empower rural people to document their own knowledge so it can be shared with other communities and with extension/advisory service providers. This empowering approach is more challenging, because it depends on the capacities of the communities and their willingness to share their knowledge. For their part, proponents of the approach must be willing to use ICT to enable changes that cannot

be defined before the work is under way. The approach will involve some loss of control and very probably unexpected impacts.

People will use a system for sharing information, including agricultural information, if the content is adapted to local needs, sourced appropriately, and presented suitably. In Costa Rica, a national team conducted a participatory rural communication appraisal in selected regions to engage farmer organizations in sharing their knowledge. In the Brunca region, for example, livestock production dominates agriculture, and farmers identified livestock diseases as an important concern. One participant, a woman, was famous for her knowledge of how to cure sick cows. The organization decided that the best way to document her knowledge was to film her. The videos could be shown at the local livestock auction and remain available digitally on the national PLATICAR (“talk”) Web platform.¹¹

In other regions where the participatory method was used, it elicited information and knowledge on other themes. Farmer organizations producing tuber crops decided to prepare radio programs that were broadcast and then archived on PLATICAR. For rice producers, information sheets were developed on each of the many rice varieties in Costa Rica.

The participatory approach that led to the choice of the most knowledgeable person was the innovation that enabled farmers to recognize that their own local and traditional knowledge was most appropriate for their needs. The innovative decision was to select the best medium for sharing this knowledge, as well as the place and time where it would be shared most effectively. The fact that the information is digitally preserved means that it can be archived and available through PLATICAR. The team that led the participatory process was the key enabler, because it built trust among stakeholders and brokered the sharing of personal knowledge that could benefit the whole group.

Documenting and Mobilizing Indigenous Knowledge

A related information-sharing effort documents indigenous knowledge (image 6.7). As experienced farmers migrate to urban areas, as the local farming population ages, or as climate change and social upheavals uproot agricultural communities, much knowledge can be lost. This knowledge is worth preserving simply for its cultural value, but it is also

11 Plataforma de Tecnología, Información y Comunicación Agropecuaria y Rural (Platform for Agricultural and Rural Information and Communication).

IMAGE 6.7. Farmer-Led Documentation Processes Can Use Digital Tools in Place of Paper



Source: Charlotte Kesl, World Bank.

instrumental in aiding researchers and extension workers to develop and adapt technology and practices for local conditions (and could help communities recover from natural disasters and conflicts).

In Bolivia, the Communication and Training Centre for Natural Resources Management and Sustainable Agriculture (CARENAS) project was initiated in 2003 in the Department of Santa Cruz to strengthen rural communication for sustainable natural resource management and rural development. Representatives of municipalities, farmer associations, and NGOs participated in intensive training for one month in communication methods and techniques, the use of ICT, and the production and use of multimedia materials in the field. The 21 people who passed the course became local audiovisual specialists, who engaged in a participatory process with advisory service workers and farm communities to elicit farmers' traditional knowledge and integrate it with technical knowledge. Based on this interaction, the audiovisual specialists produced initial videos, which were validated through focus group discussions, interviews, and farmer extension meetings. The videos were then shown to the communities and, after participatory evaluation, final versions were produced. They were distributed to 25 communities in 11 municipalities.¹² The videos—which demonstrated such techniques as repairing drainage ditches using nets and vegetative cover, recycling organic waste, and building compost latrines—eventually formed part of a training package consisting of printed guides for trainers and booklets for farmers.

¹² See "Information, Communication, and Training for Natural Resource Management and Sustainable Agriculture—Bolivia" (http://www.fao.org/tc/tcdm/italy/op_bol034_en.asp?lang=en).

In South Asia, in an effort to increase their impact, organizations working with rural communities in Bangladesh and India embarked on a process of Farmer Led Documentation and Knowledge Sharing (MISEREOR 2010). Farmer-led documentation is defined as an empowering process in which local communities take the lead role in the documentation process. The results are used by community members for learning within the community (internal learning) and exchange between communities (horizontal sharing) and among communities, development agents, and policymakers (vertical sharing).¹³ This process of engaging with farmers to document their knowledge and experiences showed that a "people-led development process does not only help increase yields or conserve the local biodiversity; it can also help farmers to get access to the resources they need and can contribute to strengthening local organizations, networks, and alliances.... Most important of all,...it leads to empowerment" (MISEREOR 2010).

ICT TO MONITOR AND EVALUATE AGRICULTURAL INTERVENTIONS AND RESEARCH

Monitoring and evaluating the outcomes of research results (such as new varieties and management practices), the construction of agricultural infrastructure (often involving contractors), or the impacts of extension and advisory programs or new technologies in a decentralized rural setting can greatly benefit from ICT. ICT can transform monitoring and evaluation, which are often afterthoughts in agricultural interventions because of the difficulties associated with analyzing impact. Monitoring and evaluation are expensive (entailing the costs of traveling, producing materials, hiring experts, and analyzing data), especially for poorly resourced public agencies. It is often a challenge to measure impact accurately because many variables cannot be controlled, including unanticipated changes in weather, conflict, natural disasters, or community or farmer health. ICT can address some of these challenges by reducing the paper trail, increasing farmers' responses (and the diversity of respondents), improving remote observation, and expanding data accuracy. It should be emphasized that methods for employing ICT and digital tools in M&E are at a very early stage of development and adoption. Much more needs to be learned about how these tools can best be employed.

¹³ The farmer-led documentation approach was promoted by Participatory Ecological Land Use Management (PELUM), Promoting Local Innovations (PROLINNOVA), and OXFAM Novib. See www.prolinnova.net/fld.php.

India has pioneered the use of ICT in many agricultural interventions and is often at the forefront of technological innovation for smallholder farming. To track research being conducted in India, the Indian Agricultural Statistics Research Institute developed the Project Information and Management System for the Indian Council of Agricultural Research (PIMS-ICAR). This data management system was created to prevent duplication between research projects, monitor research initiatives and their progress more effectively (and simultaneously at the national and state levels), evaluate research outcomes, and contribute to smoother management processes. Users involved in research projects can upload information on new projects and update information as the project moves forward. Users can also browse through projects, which helps to spur innovation and creative thinking while preventing overlap. Research directors and managers can then manage and monitor agricultural interventions and research remotely and with fewer costs. In addition, the management system can archive research data and final reports.

In another project, which monitored drought vulnerability, local participants played key roles in validating and evaluating the effectiveness of the information provided. The Virtual Academy for the Semi-Arid Tropics (VASAT¹⁴) uses components such as PC-equipped rural information centers, community radio, and mobile telephony in conjunction with human-centered efforts to anticipate and monitor the effect of drought at the micro level. Since 2005–06, activities under this initiative have taken place in Niger and in India. In both locations, rural organizations established community-based information centers with international support. The focus was on helping rural communities anticipate droughts and to help them develop and arrive at decisions that can mitigate the impact of droughts when they occur.

In the VASAT initiative, a blend of remote sensing and agro-meteorology techniques was used to develop highly localized, village-by-village forecasts of drought vulnerability. These forecasts were presented as simple color-coded maps of the locality (a cluster of adjoining villages). Red/amber indicated severe vulnerability to droughts (including drinking water scarcity), whereas green indicated that business as usual could continue. Yellow indicated that the village needed to give attention to altering cropping patterns and pay attention to fodder supplies. Developed for the coming season from global and regional rainfall forecasts, these

maps and a set of recommended actions are shared with rural communities through the information centers. Every village has at least one individual who is trained in reading the vulnerability maps.

Analyses of the effects of this intervention reveal that after two seasons, a large number of individuals started to use the color-coded maps as reliable information resources. In 2009 in India, a particularly serious drought was forecast at the micro level, although not at the aggregate level. Rural families prepared for the anticipated drought by storing fodder and not sowing water-intensive crops such as rice. Through these actions, they mitigated the effects of the ensuing drought, which was serious, lasting more than halfway into the season. Using ICT to monitor weather patterns as well as farmers' responses helps VASAT determine the correlation between the two. In this intervention, it was significant that women were key factors in absorbing and relaying information about vulnerability to drought. They were also meticulous data providers for experts to refine or correct the vulnerability forecasts.

Pajat Solutions Ltd., a company founded in 2009 and financed by the Finnish Funding Agency for Technology and Innovation, among others, has also pioneered ICT for monitoring and evaluation. It has developed Poimapper for use on GPS-enabled mobile phones to collect geotagged data and photos, which can then be uploaded to a central database through cellular or bandwidth networks. Data collected for a particular intervention can be mapped on a computer; multiple data sets can be layered to create more informative maps. This tool can be used to monitor a variety of projects, including projects to develop infrastructure such as wells or to manage forests (see Module 15). It may also be used to monitor the effects of agricultural interventions by mapping data on increases or declines in crop yields or frequencies of livestock disease.

In Africa, organizations have used mobile phones to collect information from farmers about how they can improve their programs, as illustrated in box 6.13.

LESSONS LEARNED

Lessons from the examples presented in this note and accompanying innovative practice summaries are relevant to many projects that use ICT to improve advisory services. The lessons highlight the many challenges that remain, and the discussion that follows describes options for addressing them.

14 <https://core.ac.uk/download/files/449/12107443.pdf>.

BOX 6.13. Mobile Phones as Tools for Farmer Surveys and Feedback

Voice of the Farmer (VoF) is a pilot project testing a structured approach to using mobile phone technology to obtain broad-based, low-cost, and frequent feedback from farmers in Kenya, Tanzania, and Uganda. The pilot was conducted between January 2010 and March 2011 by Synovate Panafrica, with funding from the Bill & Melinda Gates Foundation.

The approach was designed to help organizations collect a steady supply of empirical, actionable data more rapidly and cost-effectively. Feedback from target constituencies enables organizations to assess whether they need to change their activities and approach to better meet their constituents' needs. In the shortest possible time, findings can be available to participating organizations through an online portal.

How has VoF been used? Some organizations used VoF data to monitor progress in implementing projects. Others used the surveys to help guide the content of products they planned to develop. One organization used VoF to get a better idea of how to focus its monitoring and evaluation surveys. Another used VoF primarily for quick marketing surveys to receive timely feedback on new products and services. Experience with the pilot project indicates that VoF has potential as an efficient, low-cost solution meeting a number of needs in private, public, and civil society organizations.

Sources: Authors; see also <https://www.facebook.com/synovate.panafrica>.

Because advisory services are one of the most direct lines to poor farmers, it is critical to determine the main objectives of services and the most appropriate ways to use ICT to meet them. If the primary aim is to get information to farmers, then multiple channels and media should be used to reach many groups. The quality and relevance of the content/advice to be provided is also important, as is the level of community "connectivity" to the providers' messages. Conversely, if the aim is to maximize farmer-to-farmer documentation and sharing, then the emphasis is likely to be much more on capacity building and issues of culture, language, and various forms of literacy.

The technological component of an ICT for advisory services should be developed locally, in collaboration with users, and drawing on local, national, and international content as

appropriate. The focus should be on what the technology needs to deliver, not its capabilities.

Accountability improves when participants are aware of what is expected from them in terms of their roles and their commitments of human and financial resources and time. This clarity is especially important for national advisory services, where stakeholders are diverse and systems are decentralized. Regular face-to-face meetings are also crucial to capitalize on information exchange and stimulate new ways of working together and sharing lessons learned.

Any technology used for advisory services must be user-friendly, accessible, and serve farmers' needs quickly and sufficiently. Trust, useful information and knowledge, and appropriate support are critical to user sustainability. Two steps to ensure sustainability are to conduct a sound prior analysis and to involve the end users. These steps will help providers determine whether the users can pay for the service and, if so, how much; understand the culture surrounding the use of technology in a given location; identify social and political challenges that may arise during implementation; and determine what kinds of applications will serve users best, based on their agrarian activities.

Special efforts have to be made to guarantee that both men and women participate in and benefit from information and communications for advisory services (Module 4). The opportunities offered by ICT can significantly enhance information provision to rural women in developing countries. Without equal access to information, women are at a disadvantage in making informed choices about what to produce and when to sell their products. The availability of ICT is no guarantee that women will have equitable access to the technology and its benefits. More often than not, ICT devices (radios, phones) remain under the control of men, preventing women from tapping knowledge and information relevant to their needs. Gender-disaggregated data, monitoring, evaluation, and better targeting will improve these outcomes.

INNOVATIVE PRACTICE SUMMARY **E-Extension with a Business Orientation in** **Jamaica's Rural Agricultural Development** **Authority (RADA)**

Driven by the need to transfer improved and adapted technologies to farmers participating in a modern agricultural industry, in 1998 the RADA of Jamaica began to automate its

operations to deliver more effective extension and advisory services. In the last 10 years RADA has emphasized even greater use of ICT by purchasing equipment and developing specialized tools to support its increased extension staff and reach producers more efficiently.

The Agricultural Business Information System (ABIS) is RADA's flagship ICT effort. ABIS puts the management of agricultural information to work to develop a more business-oriented approach to agriculture. With data on registered farmers and other stakeholders, crops, livestock, and farm practices, as well as a repository of technical information, ABIS is a primary source of information on the agricultural sector and point of contact with advisory services. It facilitates disease and pest tracking, weather forecasting, and trade between buyers and sellers of agricultural produce, and it facilitates production through its Agricultural Resource Planning Tool. The system registers producers, records crop estimates (monthly), records receipt books sold to farmers (to prevent agricultural theft), records field service reports, tracks specific farmers (produce and farm practices), and provides technical guidance to stakeholders. Information publicly available from ABIS on request includes information on the availability of produce and contact information for producers; number of farmers, registered by parish; aggregate/summary crop, livestock, and property reports; and demographic data on farmers (age and gender).

The richness and granularity of ABIS data sets have been commended. The system's usefulness and value-added opportunities have created increased demand for its services internally and externally. ABIS now supports other government agencies, including the Agricultural Marketing Information Division, Praedial Larceny Prevention Unit, Jamaica Agricultural Society, Coffee Industry Board, and Ministry of Tourism and Entertainment, as well as other stakeholders, such as the Mona School of Business and Management. Additional human resources have been required to modify and enhance ABIS and to support, manage, and coordinate demand for ABIS services.

Training for extension officers relies on Web-based resources and other types of ICT, and extension officers use laptop/notebook computers and multimedia technologies to share technical information with producers. The combination of laptop/notebook computers and devices with wireless broadband connectivity has increased RADA's capacity to collect data in the field, strengthened the reporting and monitoring capabilities of extension staff, and helped to mitigate disease and pest outbreaks. Digital photography captures and communicates events of interest in a timely manner.

RADA also uses text messaging to relay important alerts and bulletins to farmers (more than 75 percent of farmers registered with ABIS have provided phone contact information). These alerts are particularly critical for rapid communication during the hurricane season. RADA is mindful of the challenges that some farmers may face in retrieving text messages and therefore encourages family members, especially younger ones, to help producers take advantage of this important communication channel. The authority is also pursuing voice messaging to train and communicate with farmers.

As RADA celebrates its 20th anniversary of providing extension services to the agricultural sector, ICT remains at the center of its operational strategy to continue the mission of Repositioning Agriculture through Dynamic Action (RADA). Table 6.1 provides examples of some of its achievements to date.

INNOVATIVE PRACTICE SUMMARY

Videos on Rice Seed Production Bring Multiple Benefits to Bangladeshi Women

It is easier for men to access information than it is for women. A study by Access Agriculture asked if farmer-to-farmer videos could help overcome this gender bias, and what women would do with new knowledge.

In Bangladesh, videos on rice seed were filmed with farmers and then shown in many villages. Researchers interviewed

TABLE 6.1. Objectives and Achievements of ICT to Support RADA Extension Services

ASPECT	OBJECTIVE(S)	OUTCOME/ACHIEVEMENT/STATUS
Text messaging facility	Increase mobile communication with farmers	Over 160,000 alerts sent to farmers about adverse weather and best agricultural practices
Farmer registration	Register farmers island-wide into a Web-based database	Over 176,000 farmers registered to date
Production of farmer identification cards	Identification of registered farmers receiving services	Over 100,000 cards printed and distributed
Closed User Group (CUG) cellular phones	Increase capacity of extension services to communicate with farmers	128 CUG phones distributed to extension staff

IMAGE 6.8. Women Who Saw Instructional Videos Produced Healthier Seeds, Earned More, and Gained Confidence in Seeking and Sharing New Information



Source: Paul Van Mele—Access Agriculture. <http://www.accessagriculture.org/>.

IMAGE 6.9. Increased Household Rice Stocks in a Video Village in Northwestern Bangladesh



Source: Jeff Bentley—Agro-Insight.

140 randomly selected women in 28 video villages and 40 women in four control villages in northwestern Bangladesh about changes in their lives over the past five years. The women had watched the videos six times on average.

The women who watched the videos (image 6.8) conducted more experiments, adopted more innovations, helped to

innovate, and found ways to sell seeds and to bargain for better prices. The women reduced their seed rate by almost half (lowering their production costs). The seeds they produced were brighter, with fewer signs of diseases or pests, and easier to sell. There were no changes in the control villages.

Rice yields increased by 15 percent, which improved the women's social and economic status. Over 20 percent of the households attained rice self-sufficiency, with no changes in control villages. Twenty-four percent more of the video-viewing households became surplus producers (image 6.9). They sold more rice, seedlings, and paddy. The women's husbands began consulting them more often about rice seeds and on spending household income.

Households that owned their own land (in other words, that were not sharecroppers) and households that received help from household members were more likely to increase their income. Women who watched the videos many times were able to marshal more support and raise their incomes more. They also more confidently sought and shared new knowledge with service providers and others in the community.

In sum, if they had land and labor, women who watched the videos were able to increase their income, their social standing, and their ability to innovate. Knowledge is power (but so is land).¹⁵

INNOVATIVE PRACTICE SUMMARY

Participatory Video and Internet Complement Extension in India

Digital Green started with the support of Microsoft Research in India. It disseminates targeted agricultural information to small-scale and marginal farmers in India through digital video. The system includes a database of digital videos produced by farmers and experts. The topics vary, and they are sequenced in ways that enable farmers progressively to become better farmers.

Unlike some systems that expect ICT alone to deliver useful knowledge to marginal farmers, Digital Green works with existing, people-based extension systems to amplify their effectiveness. The videos provide a point of focus, but it

¹⁵ These findings are based on a small sample; additional analysis may be needed to establish causality. Nevertheless, they suggest the types of impact that may be sought through video extension, as well as the types of innovation required for extension and training programs to address the needs of women (or other marginalized groups).

is people and social dynamics that ultimately make Digital Green work. Local social networks are tapped to connect farmers with experts; the thrill of appearing “on TV” motivates farmers. Although Digital Green requires the support of a grassroots-level extension system and other partners, it is effective because its content is relevant and it maintains a local presence. This local presence makes it possible to connect with farmers on a sustained basis. The key elements of the model are:

- **Digital video.** Digital Green relies on advances in digital videography, including low-cost camcorders and digital solutions for editing video, which greatly reduce the costs of developing local video content.
- **Mediation.** Video demonstrations are not a complete extension solution. They lack the interactivity that is the hallmark of good extension and advisory services. Digital Green relies on a local facilitator, whose role is to pause or repeat video to engage the audience in discussion and capture farmers’ feedback.
- **Partnerships.** Digital Green emphasizes the development and delivery of digital content as a way of improving the cost-effectiveness of organizations involved in agricultural research and/or providing extension and advisory services. The goal is to strengthen existing institutions and groups, not to create new ones.
- **Community-based content.** Content must be relevant to local conditions (crops, climates, soils, farming practices, and so on). The use of video

provides opportunities to customize materials. When videos feature farmers’ fellow villagers, farmers often instantly connect with the message. Digital Green has an open model to disseminate content, so it is freely available to everyone to use.

- **No need for connectivity.** Digital Green operates in environments with limited infrastructure and financial resources. High-bandwidth Internet access is not necessary for successful and sustainable video, because the content can be supplied on DVD or downloaded on mobile devices.
- **Feedback.** By enabling anyone to be a content producer and consumer, Digital Green gives even isolated communities a voice. It also uses other audio- and video-based mechanisms to support reporting and build trust among virtual communities of participants.

Various technological innovations and tools underpin Digital Green’s approach. For example, its COCO (Connect Online, Connect Offline) software supports data tracking for organizations with sizable field operations, even where Internet service is intermittent and/or poor. Because COCO is a stand-alone application in the Internet browser, no additional software has to be installed or maintained on a device. It has an open source, customizable framework and can be used without support from professional IT or engineering staff. The Analytics Dashboard provides nearly real-time insight into field operations, performance targets, and basic measures of return on investment relevant to an organization.

Topic Note 6.3: ICT, DIGITAL TOOLS, AND E-LEARNING AND EDUCATION IN AGRICULTURE

TRENDS AND ISSUES

Increasing agricultural productivity in a climate-smart way requires a continuous investment in developing human capital in agriculture, through formal and informal learning and education. Human capital is critical at the farm level, in the public agencies that support agriculture, and in the private sector actors that drive agricultural value chains. Formal learning consists of specific courses of study of varied length and complexity in the educational system. This system develops the skilled experts needed in every aspect of agriculture—the people working in the varied agricultural

research disciplines and areas of technical expertise; innovation brokers; and developers of food processing systems and standards, financial and risk management instruments, rural infrastructure, and information and knowledge management systems—and thus the list is as extensive as the agricultural innovation system is comprehensive.

Informal learning occurs through the varied interactions in an agricultural innovation system and is particularly important in agricultural extension and advice (Mekonnen, Gerber, and Matz 2016). The role of agricultural education and training in

an innovation system is discussed in detail in Module 2 of *Agricultural Innovation Systems: An Investment Sourcebook* (World Bank 2012). This topic note focuses on the role of e-learning, particularly in extension interactions. The advent of radio was just the beginning of an exponential increase in the use of ICT to facilitate learning. Learning delivered through the newer ICT devices and formats (computers, mobile devices, the Internet, DVDs, and so on) is termed “e-learning,” and its potential to facilitate “distance learning” and “distance education” (instruction and learning outside the traditional classroom setting) was recognized immediately (image 6.10).

The World Bank defines e-learning as “the use of electronic technologies to deliver, facilitate, and enhance both formal and informal learning and knowledge sharing at any time, any place, and at any pace.” This form of learning can make agricultural innovation system more inclusive by bringing elements of traditional learning and mentoring to a wider audience and empowering people through learning communities.

In theory, e-learning enables governments, agricultural advisory services, NGOs, farmer organizations, and private companies—in fact, any actor in the innovation system—to reach large numbers of producers, and for producers to interact with everyone else. Content can be updated quickly and accommodate rapidly changing needs. E-learning can also provide fresh approaches that are learner-centric, engaging producers and their communities as partners and adult learners in designing and implementing the learning experience. In addition, e-learning can make it easier to maintain quality by supporting feedback mechanisms and ensuring appropriate accreditation and certification processes.

IMAGE 6.10. E-Learning Creates Opportunities for Rural Participation



Source: Curt Carnemark, World Bank.

These features make e-learning especially attractive to extension and advisory services, especially for expanding extension workers’ and farmers’ knowledge and skills. Extension education has long been challenged by the use of a formal didactic framework that expects students to fit with the established courses (Kroma 2003). Public sector extension has been limited by the challenges accompanying declining investments, the high proportion of farmers in relation to trained extension workers, and the need to incorporate adult learning strategies and indigenous knowledge into their activities (World Bank 2012).

ICT (and e-learning) may make it possible to surmount some of the barriers to effective extension training and outreach in developing countries, but significant adaptations will be needed. E-learning originated in a postindustrial setting among a relatively well-educated population with reasonably good infrastructure for accessing digital services. Investments in digital content for e-learning were an agreed-on priority that resulted in the development of a host of advanced platforms and applications for learners and facilitators/teachers.

The innovative practice summaries in this topic note indicate some of the adaptations and strategies required for e-learning to succeed in rural areas of developing countries, especially communities with limited literacy (digital and otherwise) and inadequate access to digital resources. Both examples come from India. The first summary describes an e-learning initiative in which farmers use mobile phones to gain specific skills that enable them to benefit more substantially from services such as commercial banking and extension advice. The second describes the development of a Web-based platform called agropedia for storing and sharing agricultural information in a range of formats and languages. The platform—which incorporates Web 2.0 elements such as wikis, blogs, and commentary spaces—provides much-needed content for e-learning for farmers and extension workers. Through these features and multiple access points (including mobile phones and landlines), the platform connects researchers, extension personnel, and farmers in various information-sharing and e-learning activities.

LESSONS LEARNED

The experiences summarized here offer important social and technical perspectives on e-learning for rural people and extension workers in developing countries. ICT can facilitate a learner-centric process if it is adapted carefully to the particular social, economic, and political context

(including constraints on learners' time and travel). A multistakeholder partnership is essential for promoting learning among the farming community through ICT, and agricultural institutions need to produce more extension-oriented digital content. Content for e-learning must be highly granular for rapid uptake and must be linked to specific learning outcomes. E-learning does not require the complex online workflows associated with standard learning management systems, but a priority in promoting e-learning in agricultural innovation systems is to build ICT capacity in personnel at all levels of agricultural education, training, and extension.

Finally, ICT and virtual interactions are not sufficient to form cohesive learning communities. Peer-to-peer contact significantly improves learning, and mobile phones can provide useful support. In the initiative focused on life-long learning for farmers, for example, mobilization, social capital, and social networking played major roles. The use of ICT for learning influenced development outcomes because the learning experience was tailored to women's cognitive social capital and reinforced by links with commercial banks.

INNOVATIVE PRACTICE SUMMARY **Lifelong Learning for Farmers in Tamil Nadu**

Lifelong Learning for Farmers (L3F) is an application of Open and Distance Learning for Development by Commonwealth of Learning¹⁶ in Commonwealth countries (Balasubramanian and Daniel 2010). Banks, universities, and marketing agencies are the partners in the L3F initiative. Using open and distance learning and ICT, the initiative aims to strengthen the self-directed learning process among men and women in the farming community and to create linkages between various stakeholders. The objective is to enhance farmers' skills and knowledge in partnership with financial and research institutions.

L3F is based on the following premises:

- Unexploitative, mutually reinforcing contractual relationships between rural producers and the formal public and private sector will promote rural entrepreneurship.
- Learning and extension can be a self-sustaining process in which secondary stakeholders support L3F within a win-win framework. For instance, if the

provision of rural credit is accompanied by appropriate capacity building, rural credit will perform much better in terms of productivity, returns, and nonperforming asset levels. Such gains will lead financial institutions to support L3F.

- Capacity building will also enlarge the market for bank credit among small-scale and marginal farmers and among other marginalized groups of the rural poor, particularly women. Modern ICT can play a major role in supporting capacity building, which in turn would enhance the market for such technologies.

The rural poor stand to gain in this process, along with the participating financial institutions, research institutions, and ICT companies. In addition to using ICT to build capacity, financial institutions can use the technology to reduce the transaction costs of lending. Integrating these functions can improve the likelihood that the L3F process will be replicable and sustainable.

INTEGRATING MOBILE PHONE-BASED LEARNING AND CREDIT FOR WOMEN LIVESTOCK PRODUCERS

VIDIYAL, an Indian NGO, uses L3F to promote community banking among 5,000 women organized into self-help groups (SHGs). During 2008, nearly 300 women from the SHGs became partners and decided to build their capacity through open and distance learning related to various aspects of sheep and goat production. As poor laborers, most of the women felt that attending classes or watching multimedia materials restricted their ability to work and attend to household chores. They asked VIDIYAL and COL to explore the use of mobile phones as a learning tool, because they would not need to be confined to any particular place or time during the learning process.

Through face-to-face and computer-based learning, COL and VIDIYAL encouraged the women to develop a business proposal for rearing sheep and goats. They developed a business proposal in which each member would obtain credit for buying nine female goats, one buck, and one mobile phone. The local bank agreed to the proposal and sanctioned a loan of US\$270,000. The credit and the legal ownership of the assets are in the names of the participating women.

The 300 women bought simple mobile phones, and VIDIYAL entered an agreement with IKSL, one of India's major mobile network operators, to send audio messages to the

16 <https://www.col.org/>.

women's phones free of charge and enable free calls among group members. The company felt that this strategy would enhance its mobile service in the long run.

VIDIYAL and some of the participating women were trained in developing audio content for mobile phone-based learning (image 6.11). Learning materials are prepared within the broad principles of open and distance learning to meet learners' time and geographical constraints. VIDIYAL developed the materials in consultation with the Tamil Nadu Veterinary and Animal Sciences University and contextualized them to the local culture and dialects.

The learning materials convey information in short, concise messages. Three to five audio messages are sent to participating women every day. Each message runs for 60 seconds.

Women preferred to receive the messages in the mornings while going to work or performing their household tasks—for example, while grazing the livestock. The women reported that they learned and practiced the messages and recorded them in their diaries. Illiterate women sought the help of literate family members to record the messages. Most of the respondents' families supported their learning objective, which benefited the entire family by expanding their knowledge base in relation to small livestock production.

Other multimedia learning materials were shown during SHG meetings and telecast over local satellite channels run by the SHGs. Once a week, SHG members met and shared experiences. The horizontal and vertical transfers of knowledge have encouraged self-directed learning among the members (Balasubramanian, Umar, and Kanwar 2010).

PRELIMINARY IMPACT

An important contribution of L3F is that it establishes links between research and education institutions, organizations providing extension and advisory services, and the primary stakeholders. The participatory preparation of learning materials fosters intensive interaction between all of these groups. A consortium of agricultural and veterinary universities supports the farmers' and women's groups in developing business plans and providing learning materials on seeds, animals, and other subjects. The women's association assesses the problems in a particular area, aggregates the queries, and sends them through video emails to the

universities. Designated professors at the universities provide answers through video emails that are stored in a digital library for farmers and others to access easily. Similarly, the FAQ system used in mobile phone-based learning is linked to the universities, research institutions, and extension organizations.

In this learning process, information flows both ways as farmers contribute their informal learning and tacit knowledge to the other partners. Through mobile phones and computers, the students and researchers interact with SHG members (farmers and women) to understand their indigenous knowledge. SHG members participate in university research by managing research plots, providing data, and analyzing results. Undergraduate and graduate students undergo field training under the supervision of the women farmers. Universities use the distance learning materials developed by the women's groups and farmer groups as reference materials for diploma courses in agriculture and horticulture.

The social capital and capacity building accumulated through L3F and the interaction it induces have led to some interesting results. Around 5,000 women and men are involved in structured learning courses accessed through their mobile phones. During 2009–11, commercial banks extended approximately US\$1.0 million in credit to 2,000 L3F participants. Over the same period, the total turnover of the supported enterprises was US\$3.14 million. The higher rate of credit repayment among L3F participants encourages support from the banks (COL 2010). Studies by COL indicate that the quality of the sheep and goat enterprises operated by L3F participants is significantly better than those of nonparticipants in the same region (Balasubramanian and Daniel 2010).

LEARNING THROUGH INTERACTIVE VOICE EDUCATIONAL SYSTEM

Recognizing the potential of mobile phone-based learning, COL asked the University of British Columbia to develop an audio-based Learning Management System and Learning Content Management System. The university created a prototype called Learning through Interactive Voice Educational System, which not only enables audio-based learning materials to be automated but also helps process the tests, feedback, and responses through appropriate databases (Vuong et al. 2010). This system should improve quality assessment and certification in an informal learning environment.

IMAGE 6.11. Women Use Mobile Phones to Learn Better Goat Production Techniques

Source: Commonwealth of Learning.

INNOVATIVE PRACTICE SUMMARY

Innovative E-Learning for Farmers through Collaboration and Multimodal Outreach

The limited availability of digital content relating to agricultural extension and advice reduces the opportunity to build sustainable, digitally mediated services that bring new benefits to farmers and increase the reach of extension personnel (see Balaji 2009). This gap could be overcome by developing a content aggregation system that receives and provides information in multiple modes, especially through the Internet and voice/text messaging on mobile phones.

Such information could be generated using standard validation procedures in research and education or captured from transactions (such as query response services involving farmers and experts). The same arrangement could provide additional training support to field-based stakeholders in agriculture, especially farmers. The core principle here is multimodality in access to information and training/learning support services.

THE CONSORTIUM FOR AGRICULTURAL KNOWLEDGE MANAGEMENT: RESOURCES FOR E-LEARNING

A key initiative under the World Bank-funded NAIP in India is the Consortium for Agricultural Knowledge Management, which has been active since 2008. The initiative is built around an advanced online content aggregation system called agropedia, which delivers and exchanges information through a Web portal and mobile phone networks accessible to phones with limited or no data capability. Agropedia also provides a subsidiary platform—Agrilore—to support online learning for agricultural extension.

Agropedia was designed to overcome the paucity of useful agricultural extension information in the Web space. Online discussions can be set up to support queries or validation. The platform incorporates Web 2.0 elements such as wikis, blogs, and commentary spaces and receives material in digital formats, including text, still images, audio, and video. A highly targeted search engine allows users to locate content in multiple Indian languages, overcoming a serious challenge in using ICT for development. Agropedia is linked to the principal website of the Indian Council of Agricultural Research.

Agricultural extension workers can use the agropedia platform to create their own groups of contact farmers or peers, facilitating e-learning. These groups can be sent timed text and voice messages, enabling specific interest groups to

receive specific messages and not broadcasts. A farmer or a practitioner in the field can raise a query via voice or text. A virtual call center built into agropedia receives the query and passes it to appropriate extension workers and experts. In this way, trust and/or interest-based messaging networks can be formed and sustained.

Agropedia is an example of how a highly integrated platform can use multiple approaches to connect a spectrum of stakeholders, including research experts validating information, extension personnel in farm research stations and in the field, and farmers. Field-based producers do not need computers to connect to experts and extension personnel. Farmers with advanced practical knowledge and skills are in a position to share their tips and messages with a much wider community and can participate in discussions related to the validation of particular pieces of information.

Agropedia has the equivalent of about 10,000 pages of material on 10 important crops in four languages and has close to 2,000 registered expert users. During two cultivation seasons in 2009–10, the consortium organized mobile phone contacts with about 27,000 farmers in four language regions and conducted 2.2 million text and voice transactions through 687 specific messages. Analysis revealed that farmers in general prefer voice as the transaction medium and that they prefer messages that are no longer than 36 seconds.

The consortium is continuing into its second phase. An analysis of costs and efforts in the first phase (January 2009 to September 2010) revealed that university-based extension personnel could participate in the second phase without requiring additional staff. Since mobile phone and platform-hosting costs are low in India compared to the rest of the world, the analysis concluded that the effort can be mainstreamed as a regular activity in a typical agricultural university. The serious challenge is to strengthen ICT capacity among specialists and personnel at all levels, ranging from researchers to field-level extension workers.

ADAPTING THE E-LEARNING APPROACH FOR FARMERS

An important activity for the consortium is to use e-learning methods to help farmers adapt their crop management practices to cope with droughts. This activity was pursued by Adarsha Mahila Samaikhya (AMS), a community-based federation of women's microcredit groups (in south central India) and ICRISAT, which led the agropedia consortium in 2008–10. As of June 2011, about 7,400 women belonged to

AMS; almost 70 percent came from households below the official poverty line.

ICRISAT helped AMS set up the basic infrastructure connecting the AMS rural operations hub to the Internet, using a low-cost landline. A number of AMS activists were trained in IT. ICRISAT research scholars functioned as trainers and remotely supported extension-related queries from farmers. The scholars escalated queries to senior scientists of ICRISAT if needed. Several AMS activists were trained in the basics of reporting problems related to crop cultivation, using a blend of online/e-learning and direct contact.

ICRISAT scientists and scholars realized that the e-learning methods were originally designed for the classroom milieu and needed to be adapted to new learners with limited or no classroom experience. Based on advice from COL, ICRISAT developed modules based on granules of instruction (concise messages) (see Lifelong Learning for Farmers in Tamil Nadu).

Twenty minutes was set as the maximum amount of time that a farmer would have to attain a learning outcome. Learning outcomes were defined accordingly (e.g., a learning outcome in this context would be to recognize a visible symptom of a plant disease). Women farmers were trained in facilitation to help other farmers state their field problems with greater clarity. Together, these skills were developed in a group of 30 farmers using Internet chat first, bolstered by regular contact sessions. Eight hours of instruction were required over four weeks on average.

PRELIMINARY RESULTS

The results were encouraging. With an untrained interlocutor, a farm problem received a solution from a subject matter specialist in an average of 26 hours, since the specialist needed to keep going back to the farmer for more information. With a trained interlocutor, the average time taken to identify a solution dropped to less than two hours, because the interlocutor was able to elicit important supplementary information (on rainfall, fertilizer and irrigation applications, crop varieties, and so forth). With the same number of extension personnel, more problems could be resolved in the field owing to the improved skills that women interlocutors mastered through e-learning. Key granules with photos were translated by the activists into the local language (Telugu) and issued as pamphlets for distribution among the interested farmers. Over a period of two years, 15 of 30 trained activists received higher-level recognition in the form of certificates from the Indian National Virtual Academy for Rural Prosperity.

Taking this experience into account, agropedia designers developed Agrilore as a repository of agricultural learning objects for use in extension. Three open and distance learning institutions—Indira Gandhi National Open University, Maharashtra State Open University, and the Open and Distance Learning Directorate of Tamil Nadu Agricultural University—are populating this repository with about 500 granules relating to horticulture. They use this information to deliver certificate-oriented learning services to 5,000 farmers in three linguistic regions. This effort is also supported by the World Bank–financed NAIP as a separate activity.

REFERENCES AND FURTHER READING

- Africa Rice Center. 2014. *Annual Report 2014: Partnerships for Impact*. Côte d'Ivoire.
- Balaji, V. 2009. "The Fate of Agriculture." Thinkpiece for CGIAR Scientific Forum Workshop on ICTs Transforming Agricultural Science, Research, and Technology Generation, Wageningen, June 16–17. http://www.india-seminar.com/2009/597/597_v_balaji.htm.
- Balasubramanian, K., and J. Daniel. 2010. "Knowledge Transfer for a Horticultural Revolution: The Lifelong Learning for Farmers Model." Paper presented at the 28th International Horticultural Congress, Lisbon.
- Balasubramanian, P. T., A. Umar, and A. Kanwar. 2010. "Using Mobile Phones to Promote Lifelong Learning among Rural Women in Southern India." *Distance Education* 31 (2): 193–209.
- Ballantyne, P. G. 2009. "ICTs Transforming Agricultural Science, Research, and Technology Generation." Summary of the ICT Workshop at the Science Forum, Wageningen, June 16–17. <http://www.fao.org/docs/eims/upload/278059/Report%20of%20the%20Workshop%20on%20ICTs%20held%20at%20the%20Science%20Forum,%20Wageningen,%202009.pdf>.
- Ballantyne, P. G., A. Maru, and E. M. Porcari. 2010. "Information and Communication Technologies—Opportunities to Mobilize Agricultural Science for Development." *Crop Science* 50 (2): S1–S7.
- Bentley, J. W., P. van Mele, Md. Harun-ar-Rashid, and T. J. Krupnik. 2016. "Distributing and Showing Farmer Learning Videos in Bangladesh." *Journal of Agricultural Education and Extension* 22 (2): 179–97.
- Christoplos, I. 2010. *Mobilizing the Potential of Rural and Agricultural Extension*. Rome: Food and Agriculture Organization. <http://www.fao.org/docrep/012/i1444e/i1444e00.htm>.
- "Cloud Computing Lowers Cost of Protein Research," Red Orbit. April 10, 2009. http://www.redorbit.com/news/health/1669050/cloud_computing_lowers_cost_of_protein_research/index.html.
- COL (Commonwealth of Learning). 2010. "Memorandum Signed by 25,000 Farmers." Burnaby, Canada: COL.
- Cole, S. A., and A. N. Fernando. 2012. "Information Inefficiencies and Technology Adoption: Evidence from Mobile Phone-Based Agricultural Extension." Draft, June 15. <http://www.people.hbs>

- .edu/scole/Papers&Publications/Working/Informational%20Inefficiencies.pdf.
- . 2016. “‘Mobile’izing Agricultural Advice: Technology Adoption, Diffusion, and Sustainability.” Harvard Business School Finance Working Paper 13-047. <http://dx.doi.org/10.2139/ssrn.2179008>.
- do Prado, H. A., A. J. Barreto Luiz, and H. Chaib Filho, eds. 2010. *Computational Methods for Agricultural Research: Advances and Applications*. Hershey, PA: IGI Global.
- El-Beltagy, S. R., A. Rafea, S. Mabrouk, and M. Rafea. 2009. “An Approach for Mining Accumulated Crop Cultivation Problems and Their Solutions.” Paper prepared for the Association for the Advancement of Artificial Intelligence for Development Symposium, Stanford. <http://ai-d.org/proceedings2010.html>.
- FAO (Food and Agriculture Organization). 2008. *Report of the 2nd Expert Consultation on International Information Systems for Agricultural Science and Technology*, Rome, September 23–24, 2007. http://www.iaald.org/sites/default/files/iisast2_report.pdf.
- FARA (Forum for Agricultural Research in Africa). 2009. *GCARD-Africa e-Consultation Report*. Food and Agriculture Organization, Rome. <http://www.fao.org/docs/eims/upload/270028/gcard%20africa%20econsultation%20report%20final.pdf>.
- Farm Radio International. 2011. *Participatory Radio Campaign Evaluation Report 2011*. Processed.
- GCARD (Global Conference on Agricultural Research for Development). 2009. “Regional Consultations: Final Synthesis for Europe.” Food and Agriculture Organization (FAO), Rome. <http://www.fao.org/docs/eims/upload/268570/GCARD%20Consultation%20in%20Europe%20SYNTHESIS.pdf>.
- Graham, Mark. 2014. *The Knowledge-Based Economy and Digital Divisions of Labour*. Oxford: Oxford Internet Institute.
- Grameen Foundation USA. 2013. *Community Knowledge Worker Uganda Program Executive Summary: Lessons Learned 2009–2014*. Washington, DC: Grameen Foundation. [http://www.grameenfoundation.org/sites/default/files/resources/Grameen-Foundation_CKW-Lessons-Learned-\(2009-2014\)_Executive-Summary_0.pdf](http://www.grameenfoundation.org/sites/default/files/resources/Grameen-Foundation_CKW-Lessons-Learned-(2009-2014)_Executive-Summary_0.pdf).
- Hoffmann, R. 2008. “A Wiki for the Life Sciences where Authorship Matters.” *Nature Genetics* 40: 1047–51.
- Hori, M., E. Kawshima, and T. Yamazaki. 2010. “Application of Cloud Computing to Agriculture and Prospects in Other Fields.” *Fujitsu Scientific and Technical Journal* 46 (4): 446–54. <http://www.fujitsu.com/downloads/MAG/vol46-4/paper15.pdf>.
- IICD (International Institute for Communication and Development). 2006. *ICTs for Agricultural Livelihoods: Impact and Lessons Learned from IICD Supported Activities*. The Hague: IICD.
- Interagency Working Group on Manufacturing R&D, Committee on Technology, National Science and Technology Council. 2008. *Manufacturing the Future: Federal Priorities for Manufacturing R&D*. Washington, DC. https://nifa.usda.gov/sites/default/files/resource/nanotech_manufacturing_rd.pdf.
- Karanja, G. 2006. *African Tertiary Institutions Connectivity Survey (ATICS) 2006 Report*. Ottawa: International Development Research Centre.
- Kashorda, M., and T. Waema. 2009. *2008 e-Readiness Survey of East African Universities*. Nairobi: Kenya Education Network.
- Kroma, M. M. 2003. “Reshaping Extension Education Curricula for 21st Century Agricultural Development in Sub-Saharan Africa.” Paper presented at the 19th Annual Conference of the AIAEE, Raleigh, NC. <http://www.aiaee.org/attachments/article/1204/Kroma353.pdf>.
- Li, D., and C. Zhao. 2010. *Computer and Computing Technologies in Agriculture III*. Berlin: Springer.
- Lie, R., and A. Mandler. 2009. *Video in Development: Filming for Rural Change*. Rome: CTA and Food and Agriculture Organization.
- Manning-Thomas, N. 2009. “Changing the Emperor: ICT-Enabled Collaboration Transforming Agricultural Science, Research, and Technology into an Effective Participatory and Innovations System Approach.” *Web2forDev*, June 26. <http://www.web2fordev.net/en/article/changing-the-emperor-ict-enabled-collaboration-transforming-agricultural-science-research-and-techno.html>.
- Mekonnen, Daniel Ayalew, Nicolas Gerber, and Julia Anna Matz. 2016. “Social Networks, Agricultural Innovations, and Farm Productivity in Ethiopia.” Working Paper Series No. 235, African Development Bank, Abidjan, Côte d’Ivoire.
- Mell, P., and T. Grance. 2011. “The NIST Definition of Cloud Computing.” September. <http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf>.
- MISEREOR. 2010. “Strengthening People-Led Development: A Joint Effort of Local Communities, NGOs, and Donors to Redefine Participation.” Aachen. http://www.misereor.org/fileadmin/redaktion/MISEREOR_Strengthening_people-led_development.pdf.
- Nyirenda-Jere, T. 2010. “Unlocking the Promise of ICTs for Transforming Agriculture in Africa.” Technical Centre for Agricultural and Rural Cooperation, Wageningen.
- Rao, S. 2015. “Using Radio in Agricultural Extension.” Note 18. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland.
- Robinson-Pant, Anna. 2016. *Learning Knowledge and Skills for Agriculture to Improve Rural Livelihoods*. Paris: UNESCO.
- RUFORUM. 2009. *Situation Analysis of ICT Capability and Infrastructure in RUFORUM Universities*. Kampala: Regional Universities Forum for Capacity Building in Agriculture. <http://repository.ruforum.org/documents/situation-analysis-ict-capability-and-infrastructure-ruforum-universities>.
- Simon, C. 2015. “Information, Writ Widely.” *Harvard Gazette*, August 21. <http://news.harvard.edu/gazette/story/2015/08/information-writ-widely/>.
- Simon O. L. Mwombe, Fred I. Mugivane, Ivan S. Adolwa, and John H. Nderitu. 2014. “Evaluation of Information and Communication Technology Utilization by Small Holder Banana Farmers in Gatanga District, Kenya.” *Journal of Agricultural Education and Extension* 20 (2).
- Swanson, B., and R. Rajalahti. 2010. “Strengthening Agricultural Extension and Advisory Systems: Procedures for Assessing, Transforming, and Evaluating Extension Systems.” Agriculture and Rural Development Discussion Paper 44, World Bank, Washington, DC.

- UNCTAD (United Nations Conference on Trade and Development). 2010. "Technology and Innovation Report 2010: Enhancing Food Security in Africa through Science, Technology and Innovation." UNCTAD, New York.
- van Mele, P., J. Wanjoeke, and J. Rodgers. 2013. "Innovative and Effective Ways to Enhance Rural Learning in Africa." In *Realizing Africa's Rice Promise*, edited by M. Wopereis, D. Johnson, N. Ahmadi, E. Tollens, and A. Jalloh. Wallingford, UK: CABI Publishing.
- Vuong, S. T., J. Schroeder, M. Alam, A. Tjia, Y. I. Chung, and A. Chen. 2010. "LIVES: Learning through an Interactive Voice Educational System." Paper presented at the IADIS International Conference on Mobile Learning, Porto.
- World Bank. 2012. *Agricultural Innovation Systems: An Investment Sourcebook*. Washington, DC: World Bank.
- . 2015. *World Development Report 2016: Digital Dividends*. Washington, DC: World Bank.
- Zossou, E., P. Van Mele, J. Wanjoeke, and P. Lebailly,. 2012. "Participatory Impact Assessment of Rice Parboiling Videos with Women in Benin." *Experimental Agriculture* 48 (3): 438–47.

Module 7 BROADENING SMALLHOLDERS' ACCESS TO FINANCIAL SERVICES THROUGH ICT

HENRY BAGAZONZYA (World Bank), ZAID SAFDAR (World Bank), and SOHAM SEN (World Bank)

Overview. Four kinds of financial services help farmers to achieve their economic goals: credit savings, transfer and payment facilities, and insurance. The major prerequisites for using information and communication technology (ICT) to deliver these services in rural areas are robust national financial systems (for example, with national payment systems, credit bureaus, ATM switches, central platforms for microfinance) and the infrastructure that allows electronic financial transactions between institutions and individuals. Factors that are critical for ICT to expand financial services in rural areas are a supportive economic policy and regulatory framework; appropriate financial and nonfinancial products; and mechanisms, processes, and technology applications that can deliver products and services, improve transparency and accountability, reduce costs, and become self-sustaining.

Topic Note 7.1: The Use of ICT-enabled Financial Services in the Rural Sector. New channels for delivering financial services (facilitated by ICT), new players, and greater competition enable service providers to offer a larger suite of financial products and services and acquire better financial information, some of which is useful for government regulation and policy development. A number of nonbank institutions have developed innovative approaches to financing agriculture, enabled by or integrated with ICT, including mobile financial services, branchless banking, ATMs, and smartcards.

- **Linking Conditional Cash Transfers and Rural Finance in Brazil**
- **RFID Facilitates Insurance and Credit for India's Livestock Producers**

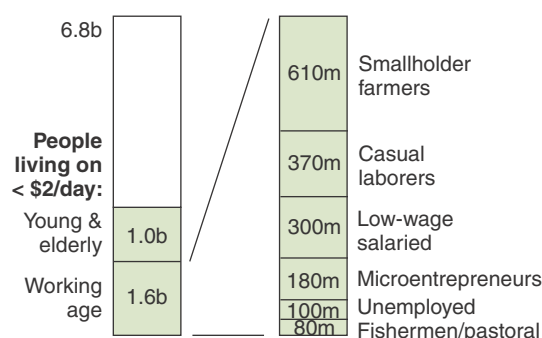
Topic Note 7.2: Policy Strategies and Regulatory Issues for ICT-Enabled Rural Financial Services. Often, governments lag in introducing the policies and regulations needed to extend cost-effective financial services throughout the economy, including underserved rural areas. To design supportive policies, provide the necessary infrastructure, and provide appropriate, affordable financial products meeting local needs, governments must explore partnerships with the private sector and rural communities. In turn, governments can devise and implement policies that give rural communities and private enterprises incentives to participate in the rural financial sector.

- **Kenya's DrumNet Links Farmers, Markets, and Financial Service Providers**
- **A Common Platform Delivers Financial Services to Rural India**

OVERVIEW

Smallholder farmers are the world's largest group of working-age poor (figure 7.1). Much of the world's food supply will continue to depend on their efforts, yet a lack of financial services often stymies their attempts to make productivity-enhancing investments and to smooth their consumption between periods of plenty and scarcity. Capital-constrained farmers minimize risk instead of maximizing returns (for example, by investing in high-quality seeds and fertilizer or growing what is most profitable) (Trivelli and Venero 2007). Box 7.1 summarizes the four kinds of financial services that farmers need to achieve their economic goals.

FIGURE 7.1. Smallholder Farmers Are the Largest Group of Working-Age Poor



Source: Mas 2010b.

BOX 7.1. Farmers Require Four Kinds of Financial Services

- **Credit**—in the form of loans, personal loans, salary loans, overdraft facilities, and credit lines—is often used as working capital at the beginning of the growing season to purchase inputs and prepare land. Farmers also need capital to invest in equipment such as tractors or drip irrigation and to harvest, process, market, and transport their produce. It is important to distinguish between short-term loans, which microfinance institutions usually provide, and the long-term financial services required for agricultural and livestock enterprises.
- **Savings** may be in the form of current accounts, savings accounts, or fixed or time deposits. Farmers have a significant need for savings, because their income is seasonally tied to the harvest, and for much of the year they rely on savings to smooth consumption.
- **Transfer and payment facilities** allow for local and international money transfers, remittances, government transfers, and check clearing.
- **Insurance** may cover crops and livestock as well as human life and health.

Source: Author, based on CGAP and IFAD 2006, 6; Nair and Fissaha 2010.

ICT has now created the potential to deliver a greater diversity of financial products to greater numbers of rural clients than conventional financial service providers have been able to reach. ICT can also enhance the government's capacity to monitor and evaluate financial services provided to rural clients and design effective financial policies and regulations for the rural sector.

A number of agents in rural areas—such as government departments, commercial banks, microfinance institutions, traders, telecommunications companies, community-based organizations, families, and friends—provide financial services, which can include credit, savings, insurance, transfers, and payments. Even so, tailoring and providing financial services for small-scale farmers remains challenging. Rural clients differ from the typical clients of financial service providers. They are located in remote and often sparsely populated areas, and they rarely possess the sorts of physical or financial assets that financial institutions customarily accept as collateral. Typical rural assets, such as livestock,

pose challenges of inventory assessment and management, and collateral substitutes based on warehouse receipts or returns from future crops are unavailable in many countries. Farmers also have a special need for financial products with a time horizon extending over multiple crop cycles.

This module explores how innovative mechanisms and technologies are used in specific situations in different countries to help rural dwellers—mainly farmers, whose businesses do not readily receive financial support—obtain the financial services listed above from commercial banks and other providers. Some of these technologies are already used in microfinance institutions in urban and peri-urban areas. It is important to note that the types of ICT discussed in this module are gender neutral; they are enablers and should be used in contexts where both men and women can participate.

Major prerequisites for using ICT in financial services for agriculture are robust national financial systems and the infrastructure that allows electronic financial transactions between institutions and individuals. Two types of infrastructure and related services facilitate electronic transactions and are vital for extending financial services to rural areas.

The first is ICT infrastructure, such as high-speed Internet and mobile phones, available at affordable prices. This infrastructure is the backbone of electronic financial transactions. The second is financial infrastructure, which includes national payment systems, credit bureaus, ATM switches, or central platforms for microfinance institutions. Financial infrastructure enables financial service and technology service providers, as well as other providers vital for the integrity and stability of the financial system, to connect and perform transactions in real time.

For example, financial infrastructure makes it possible for customers of one bank to use the ATM of a different bank or conduct a transaction (such as writing checks or wiring money) with customers of a different bank. It also channels financial information (such as the creditworthiness of a new customer) to financial institutions.

These services and infrastructure do not benefit merely one operator or financial service provider; they cater to the entire rural and financial sector. For this reason, their provision is often initially regarded as a task for government, although in reality they can be (and often should be) provided by the private sector alone or in partnership with government.

CURRENT ACCESS TO FINANCIAL SERVICES IN RURAL AREAS

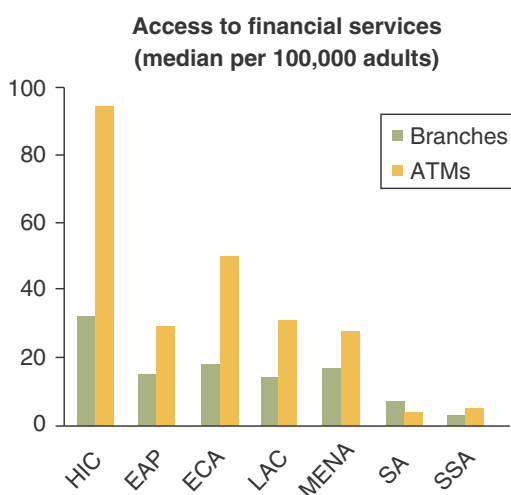
Across developing countries, in urban and rural areas, access to and use of formal finance remains very low in general. The financial access data given in figures 7.2 and 7.3 are not specific to farmers, but they serve as a good proxy, showing that rural reach is a smaller proportion of total reach. Agriculture in particular has been underserved; for example, commercial lending to agriculture is 1 percent of all lending in Africa (Campaigne and Rausch 2010). Often, as a result of poor access to formal sources of finance, farmers are left to borrow at very expensive rates from informal money lenders.

Commercial banks remain the dominant formal institutions providing finance to farmers (figures 7.5 and 7.6). Commercial

banks constitute more than 75 percent of all rural branches of financial institutions worldwide; in comparison, microfinance institutions account for less than 3 percent. Microfinance institutions and cooperatives may situate a larger share of their branches in rural areas—41 percent and 43 percent, respectively (figure 7.4)—but their absolute total country reach is limited (figure 7.2).

The supply of financial products and services in rural areas will remain a challenge until financial institutions can reduce the high operating costs associated with catering to rural clients; however, as this module indicates, ICT applications have demonstrated considerable promise in doing so. The next section briefly describes the factors that have proven critical to using ICT successfully to expand the range of financial services in rural areas. The topic notes that follow provide

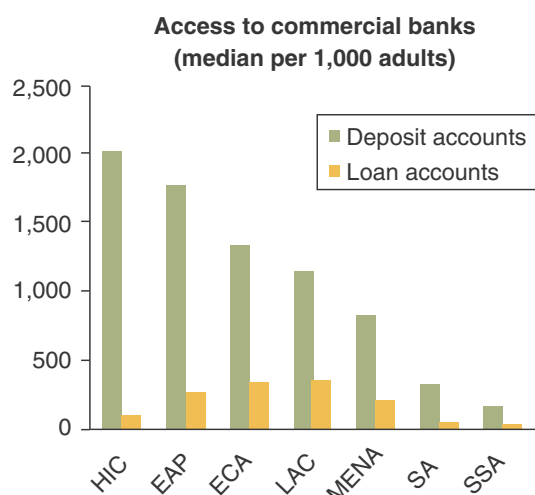
FIGURE 7.2. Low Access to Financial Institutions



Source: CGAP and World Bank 2010.

Note: The abbreviations under the bars are defined in the glossary.

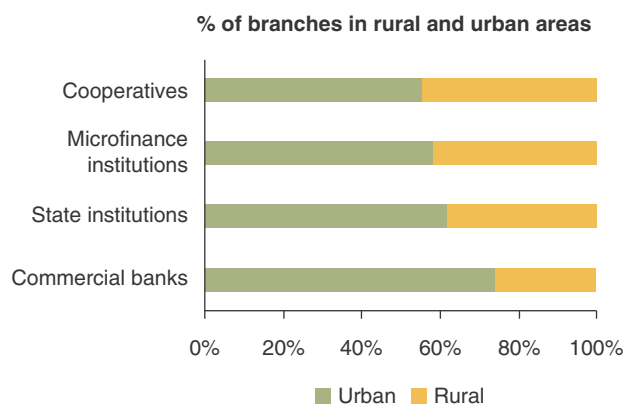
FIGURE 7.3. Low Utilization of Financial Services



Source: CGAP and World Bank 2010.

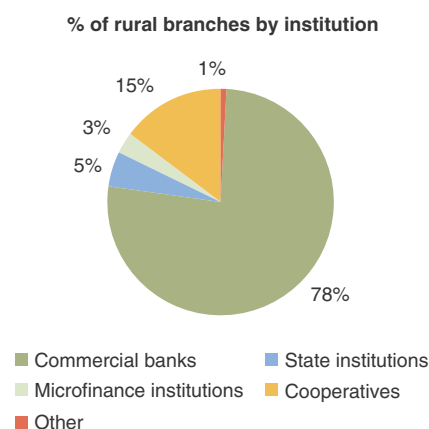
Note: The abbreviations under the bars are defined in the glossary.

FIGURE 7.4. Access Is Worse for Farmers



Source: CGAP and World Bank 2010.

FIGURE 7.5. Commercial Banks Are Main Players



Source: CGAP and World Bank 2010.

greater detail on ICT-enabled interventions in rural finance (Topic Note 7.1) and explore policy and regulatory issues that either positively or negatively influence the expansion of the frontier for rural finance (Topic Note 7.2).

Both topic notes contain summaries of innovative practices that demonstrate how ICT is being used in specific settings to expand financial services while reducing transaction costs and information asymmetries. These approaches are certainly not conclusive (because the ICT is extremely dynamic and constantly changing), yet they provide an indication of alternatives that practitioners can consider when designing projects to improve rural access to financial services in a variety of situations, given the right policy and legal environment.

KEY CHALLENGES AND ENABLERS

Expanding access to rural finance is challenging, and needs to be looked at as a process that includes a combination of factors, including a supportive economic policy and regulatory framework; appropriate financial and nonfinancial products; and mechanisms, processes, and technology applications that can deliver products and services, improve transparency and accountability, and reduce costs. Any proposed technology solution should be self-sustaining, with a clear plan for generating revenue and financing, or it will eventually prove impossible to sustain and replicate elsewhere. The technological applications described in the topic notes meet these criteria. This section reviews the lessons from implementing those applications as well as the enablers that different players can take to ensure that using ICT to help farmers access finance is achievable in the long term.

Federal Economic Policy

Financial markets resemble other markets in that direct government involvement can crowd out private participation. This problem has been perennial in developing countries' rural credit markets, where government agricultural banks offering subsidized credit have been almost ubiquitous. Their presence created a "chicken-and-egg" problem: Governments were reluctant to withdraw from these markets because there was no private sector presence, but the private sector was reluctant to enter when, in addition to other obstacles to rural lending, government competition was a constant threat. In recognition of this problem, a new generation of government agencies was designed to coexist with—or even "crowd in"—the private sector by filling niches or resolving market failures by operating on a more commercial basis than their predecessors.

Agricultural policies may act to suppress private sector development, including the development of private financial services. Governments often use state-owned enterprises to intervene in agricultural product pricing to reduce price fluctuations and provide a floor price, for example. Such interventions can be very costly, are often ineffective, and preempt development of both insurance and storage markets. Farmers will not hedge their production if there is a floor price. Since producers have little incentive to store crops if they do not expect prices to rise over time, the market for storage facilities (and therefore the emergence of a warehouse receipt system and other mechanisms for managing risk) will be suppressed if these price movements are prevented by government intervention.

In sum, the policy environment that enables markets for financial services to develop is one in which minimal government interventions are carried out on a commercial basis, which allows markets to function freely. This restraint will, in turn, provide an opportunity for financiers to provide cost-effective and appropriate financial services without being encumbered by the government. It will also allow the provision of increased-risk management services and ultimately lead to greater availability of financial services.

Legal and Regulatory Environments: Enforcing Contractual Obligations

The largest risk to sustainable financing for agriculture is often attributed to inherent business risks, or the inability of financial institutions to design profitable financial products for the rural population. Yet interventionist government policies—such as subsidized interest rates, forgiveness of debt, and failure to enforce appropriate rules and regulations—can severely limit the effectiveness of an ICT-enabled product that could have made finance accessible to a large number of people. Conversely, an enabling environment and legal framework, enforcement of regulations, and supportive rural infrastructure will eventually lead to lower but sustainable interest rates by reducing transaction costs and risks and increasing competition. All of these outcomes go a long way toward making a sustainable access to finance a reality.

Infrastructure Costs and Shared Platforms

Technology solutions require an investment that can be costly and difficult to justify when implementation is risky, as is typically the case with technology. Investments in technology can be leveraged by financial intermediaries and others within a community to provide additional services on

the same platform, however. Sharing infrastructure such as power, telecommunication, data networks, hosting, application support, or data management drives down the cost of technology, making it affordable to deliver financial products and services to rural areas (see IPS “Passive Infrastructure-sharing in Nigeria,” in Module 3).

This idea of leveraging infrastructure can also be considered in the development of warehouses for collateral-based systems, weather stations for the development of index-based rainfall insurance, and physical infrastructure to facilitate improved functioning of the supply chain. Investments in infrastructure that can be leveraged but require a high initial investment require the participation of both the public and private sectors to ensure ownership on both sides.

Technical Assistance and Capacity Building

Building the capacity to use and adapt ICT to facilitate financial services is important not only for the staff of banks and financial service providers but also for borrowers and, in some cases, for governments. Capacity building for staff increases the chances of innovation and success in extending financing. Capacity building is also important for borrowers. In a number of cases reviewed in the topic notes, particularly the cases involving institutions or agencies other than banks, technical assistance was one of the core components of success. Likewise, capacity building that focused on maximizing the impact of credit through improvements in product quality was essential to successful management of supply chain financing in Kenya (see IPS “Kenya’s DrumNet Links Farmers, Markets, and Financial Service Providers,” in Topic Note 7.2).

Borrowers will need to be educated about new, ICT-enabled instruments for risk management and insurance. There are many ways that organizations and producers can manage risk, and they should learn to select the correct tool or combination of tools that most efficiently and cost effectively match their risk.

Finally, governments will, in some cases, require assistance in capacity building or creating an appropriate legal or regulatory framework. Such assistance may include, for example, support in drafting appropriate legislation and regulations. Variations in the regulation of ICT infrastructure for making cash transfers and providing other financial services have had a considerable impact on the kinds of services eventually provided in rural areas (see “Topic Note 2.3: Mobile Money Moves to Rural Areas”).

Organizational Culture

A dynamic organizational culture allows staff to innovate—by using new technology, for example—and ensures the sustainability of financial innovation. For example, Bolsa Família (see IPS “Linking Conditional Cash Transfers and Rural Finance in Brazil”) involves organizations that train staff well, provide innovative tools for the job, and create dynamic environments with appropriate incentives to motivate staff to work closely with clients. Management’s participation is crucial, particularly for the development and implementation of an ICT-for-finance program. Other case studies (such as DrumNet) underscore the benefits of empowerment. People with a stake in a business will expend much effort to make the business work.

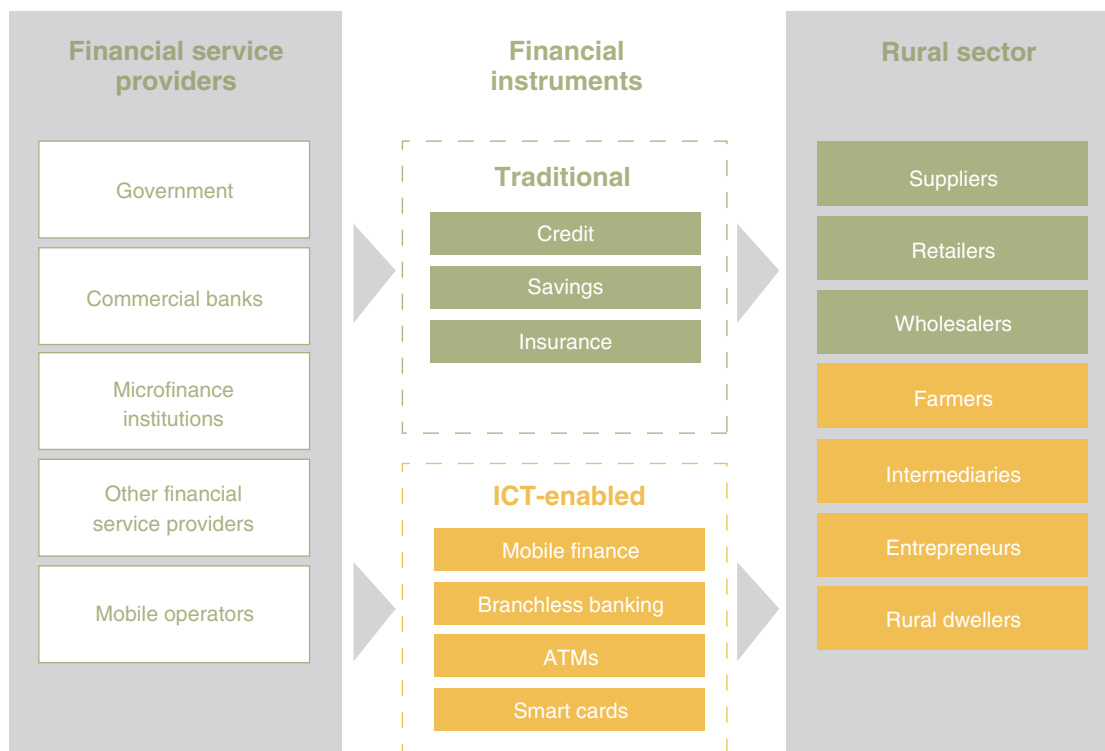
Topic Note 7.1: THE USE OF ICT-ENABLED FINANCIAL SERVICES IN THE RURAL SECTOR

TRENDS AND ISSUES

ICT introduces new channels for delivering financial products and services to the rural sector, and it has the potential to reach farmers, intermediaries, entrepreneurs, and rural dwellers more directly than traditional bricks-and-mortar bank branches or microfinance offices. These new channels enable financial service providers to offer a larger suite of financial products and services and acquire better financial information, some of which is useful to governments as they oversee, regulate, and develop policy for the agricultural and rural sectors. Figure 7.6 illustrates how ICT expands the

traditional relationships and service capacities in the rural finance ecosystem. (As noted, Topic Note 2.3 looks at how ICT infrastructure enables this expansion.)

Interventions using ICT can introduce new players and lead to greater competition in the rural financial sector. Institutions or agencies that are not banks (nonbanks) may start providing rural financial services. Since the early 2000s, a number of nonbank institutions have developed innovative approaches to financing agriculture. They have sometimes adapted microfinance concepts to provide agricultural

FIGURE 7.6. ICT and the Rural Finance Ecosystem

Source: Author.

finance, used good banking practices, and above all, drawn on knowledge of agriculture and ICT to enter and succeed in this market. Many of these new approaches show great promise, but no single approach will work for all situations. Rather, organizations have the most success when they are not dogmatic, apply innovative and comprehensive risk-management strategies and tools, and retain the ability to perform credit analyses of their intended rural clients without political interference.

Nonbanks and banks can provide these ICT-enabled financial services for the rural sector:

- **Mobile financial services.** Given the pervasiveness of mobile phones in developing countries, financial service providers can use them to reach clients in rural areas and provide a broad array of financial products and services, including credit, insurance, payments, and deposits. Financial service providers can tailor financial products offered through mobile phones to rural needs.
- **Branchless banking.** Field agents, equipped with mobile phones or point-of-sale devices, can serve as mobile branches. Agents can provide financial services to smallholders, take deposits, provide financial

information, and keep records of clients' creditworthiness. In this way, branchless banking deepens financial inclusion throughout rural areas.

- **ATMs.** Though ATMs are often associated with debit cards or smartcards, ATMs can serve as cash-dispensing machines in tandem with branchless banking, mobile financial services, and other ICT-enabled financial products. The availability of ATMs in rural areas can place cash-exchange points within reach.
- **Smartcards.** Though not entirely in the category of ICT, smartcards (or stored-value cards) are an alternate means of providing services when mobile financial services are not readily available. Prepaid cards, debit cards, or credit cards provide payment and credit facilities to rural clients. Stored-value cards have historically assumed some level of literacy (in particular, the ability to sign for a transaction), but the advent of smartcards that use biometric devices eliminates the challenges associated with literacy barriers.

As discussed, financial services rely on the availability of an underlying financial and ICT infrastructure, such as payment systems, credit bureaus, central ATM switches, central financial platforms, mobile telephony, mobile data

services, and the Internet in rural areas. Governments have to work with the private sector to ensure that the underlying infrastructure is in place and extended to rural areas. (For a discussion of how various governments have done so, see Module 2.)

EXAMPLES AND LESSONS LEARNED

The following examples highlight successful ICT-enabled interventions selected from a wide range of similar interventions implemented in developing countries. They demonstrate that rural and agricultural finance can be profitable without high government subsidies and discuss the lessons learned in the course of implementing the interventions.

Availability and Transparency of Financial Services

ICT can make financial services more readily available in rural areas through mobile phones, the Internet, point-of-sale devices, and field agents (box 7.2). Electronic banking makes it possible to provide financial services in places that rural clients visit routinely, such as markets and post offices. Electronic conditional cash transfers also make it easier for rural poverty reduction programs to reach specific beneficiaries (see IPS “Linking Conditional Cash Transfers and Rural Finance in Brazil”). Because transactions are conducted electronically using ICT, they promote transparency, accountability, and financial discipline among all account holders, whether they are in farming, business, or government.

BOX 7.2. ICT Increases the Availability of Rural Finance in South Africa

Through its A-Card, South Africa’s uBank (previously Teba Bank) (<http://www.tebabank.co.za/index.php>) offers affordable and accessible financial services to communities, especially in rural areas, that were previously denied access. The card is used with a point-of-sale device that enables customers to access a transactional banking account. The primary banking products and services include standard savings and credit accounts and a facility by which state social grants are deposited directly into a customer’s bank account. The United Kingdom’s Department for International Development, ShopRite, and Checkers partner with uBank in this project.

Source: Cracknell 2004.

Cost and Operational Efficiency

Financial service providers have reduced transaction costs using electronic payment systems, branchless banking, and other ICT-enabled services. Because these services are available to farmers via handheld devices or loan officers based in the field, they obviate the need to visit a bank branch to conduct basic transactions (box 7.3).

Aside from reducing operating costs, the use of ICT within financial institutions or government can also improve operational efficiency, create public platforms for smaller organizations to use, and develop management capacity.

BOX 7.3. In Rural Kenya and South Africa, ICT Applications Reduce the Cost of Financial Services

Kenya: M-PESA. The leader in mobile payments is Safaricom’s M-PESA, a short messaging service (SMS)–based money transfer system that allows individuals to deposit, send, and withdraw funds using cell phones. M-PESA has grown rapidly to reach approximately 38 percent of Kenya’s adult population. The M-PESA model has been copied with little modification worldwide.^a Kenyans use M-PESA to deposit money with a registered agent or phone vendor. The agent then credits the phone account. Users can send between 100 Kenyan shillings (US\$1.5) and 35,000 K Sh (US\$530) via text message to a recipient. The recipient obtains the cash from a Safaricom agent by entering a password and showing personal identification.

South Africa: Wizzit. In South Africa, First National Bank partnered with a mobile phone provider, Mobile Telephone Networks (MTN), to provide services to clients who had no bank accounts but wanted to send and receive money via cell phone. The service, called Wizzit (<http://www.wizzit.co.za/>), has enabled 500,000 South Africans to send and receive money from relatives, pay for goods and services, check balances, and settle utility bills. Previously, South Africans often paid couriers the equivalent of US\$30–50 to deliver cash to relatives. Now such transactions cost only US\$0.50 through mobile bank networks. The greatest impact is in rural areas, where 80 percent of farmers still lack bank accounts. Wizzit accounts, unlike regular bank accounts, do not expire if customers do not use them regularly, which is critical for seasonal activities like agriculture.^b

Source: Author.
(a) Jack and Suri 2009,6;
(b) Kimani 2008.

The need for ICT-based government services becomes more important as the financial sector expands and the sophistication and complexity of financial products grow (box 7.4). The availability of a common information technology (IT) platform enables government at all levels (municipal, state, federal) to obtain accurate information about the availability and affordability of financial services in rural areas, the financial well-being of financial service providers, the indebtedness of citizens, and related information. This information enables policy makers and regulators to make appropriate decisions with respect to the rural financial sector. ICT can make information gathering and monitoring and evaluation possible on a real-time basis.

Governments require information systems for their own management and operations with respect to making policy and regulating the rural financial sector. Such information systems can be linked with financial infrastructure (such as payment systems) and applications that can reach most rural clients.

BOX 7.4. Increased Operational Efficiency in Africa through ICT

IBM and CARE: The Africa Financial Grid. IBM and CARE are designing the Africa Financial Grid, a shared financial service and infrastructure model that will, for example, help microfinance providers reduce their operating costs, streamline lending processes, scale up, and integrate their services with other resources such as credit bureaus, financial institutions, and international payment networks. The Africa Financial Grid will eventually link with telecommunications providers to enable customers to repay loans or carry out money transfers via mobile phones or other devices.

Ghana: E-Zwich payment system. The Bank of Ghana has rolled out a national payment and settlement system in the form of an electronic clearinghouse for all banking and financial institutions called e-Zwich (<http://www.ghipss.net/e-zwich>). The Bank of Ghana has also issued a biometric smartcard, which is a very secure way of paying for goods and services.

Sources: IBM 2007; B&FT 2010.

Improved Risk Management

Through ICT, financial institutions and intermediaries can better manage the risk involved in increased lending, especially in lending to lower-income and rural clients (box 7.5). Credit bureaus and collateral registries can equip financial service providers with better financial information about

BOX 7.5. Financial Service Providers in the United States and Mozambique Use ICT to Improve Risk Management

The United States. In the United States, Sevak Solutions and Financial Ideas are piloting technology that allows credit decisions for microfinance clients to be made electronically, increasing transparency between lenders and lenders. Initial tests will be carried out with U.S. military personnel and their families, some of whom experience financial distress caused by limited financial literacy and predatory “payday” lenders (<http://www.sevakolutions.org/prototypes/finideas.html>). A similar idea could be useful in developing countries, particularly as farmers and rural citizens gain further access to loans and credit.

Mozambique. The Banco Oportunidade (a microfinance bank) introduced its Client Relationship Management (CRM) system, a Web- and cloud-based system that assists with processing and monitoring loans and is accessible to loan officers, managers, and country and regional teams. The CRM uses data from land mapping and farmer and crop profiling conducted with agricultural clients to process loan applications electronically, taking into account the standard data and farmer, crop, and national limits. After a loan is approved, the CRM sends the data to the bank’s accounting system and assists in loan disbursement, monitoring, and recovery, providing real-time information. The CRM has a personal dashboard, specific to each bank team member, which allows inputting and monitoring related to the team member’s specific line management and process control responsibilities.

Sources: Sevak Solutions 2008; Management Reports for Banco Oportunidade in Mozambique.

the market and clients and improve their ability to expand lending. (See IPS “RFID Facilitates Insurance and Credit for India’s Livestock Producers” for more detail on the importance of ICT in managing lending risks.)

Authentication

Using a variety of technologies, ICT can help financial service providers and government authenticate individuals, inventories, and assets in rural areas (box 7.6). For example, biometric technology captures and stores information that is unique to every person, such as fingerprints, retina scans, and facial images. Its increasing availability and decreasing

cost has made it useful in developing countries, where it limits identity theft and facilitates the development of credit markets. The ability to track individuals in a credible way over time provides incentives to individuals to repay loans and reduces the risks faced by lenders. Financial service providers can use biometric tools to provide services to individuals who may not have a national identity card or never learned to sign their names. (See IPS “Using Biometrics to Provide Rural Services,” in Module 12.) Similarly, radio-frequency identification (RFID) can count and track livestock, harvests, and inputs, among other things. Global positioning systems (GPSs), satellite data, and weather-based electronic sensors can collect data necessary to create and price crop insurance policies, particularly index insurance programs.

BOX 7.6. Using ICT to Identify Financial Service Clients in Africa and South Asia

Malawi: Biometric technology in rural credit markets. In 2009, 3,200 smallholder paprika farmers in Malawi who had applied for loans to purchase agricultural inputs were randomly assigned to control and treatment groups. The treatment group was electronically fingerprinted and told that their fingerprints would be stored and used to validate their eligibility for future loans. Repayment rates rose by 40 percent in the treatment group. The increased rate of repayment and the resulting savings from avoiding default could justify the costs of deploying an IT system to collect fingerprints for all loan applicants.

Kenya: Kilimo Salama. The Kilimo Salama index insurance scheme uses weather indicators as a proxy for loss of inputs. The insurer collects premiums and distributes payouts via mobile phone, which reduces assessment and administrative costs. Kilimo Salama also employs a “pay-as-you-plant” sales model, in which insurance policies are sold for each input purchased.

India: Biometric ATMs. ICICI Bank and the Government of India launched an initiative in 2004 to offer banking services to people who earned less than US\$40 per month (<http://www.icicibank.com/>). The service relied on biometric ATMs (based on fingerprint scans) and biometric smartcards that do not require personal identification numbers, which can be forgotten or stolen. The ATMs cost 5 percent of what these wage-earners have been accustomed to pay at kiosks offering similar services.

Sources: Giné 2010 for Malawi; Ogodo 2010 for Kenya; ICICI Bank 2001 for India.

Disseminating Information

ICT applications perhaps best known for their capacity to disseminate information. Online videos, television, and community radio can improve farmers’ financial literacy by informing them about the benefits and risks of credit and various banking transactions. At basic rural Internet kiosks, farmers can acquire accurate financial information, such as market prices, to improve productivity and sales.

Conclusion

These brief examples provide some idea of innovative, on-the-ground initiatives that have brought financial services to rural areas. All of these initiatives hold promise but face challenges, which, in the end, may not enable them to be scaled up or replicated. Even so, they demonstrate that it is possible to provide financing for agriculture on a sustainable basis and at a reasonable cost. Many of these initiatives are based on the premise that the policy environment will allow such innovations to flourish.

The next sections of this topic note explore two innovative practices in greater detail. The first one, Brazil’s Bolsa Família, uses an IT platform to extend financial services to people who have been excluded from using them. The second one, a livestock insurance and credit scheme in India, uses RFID technology to reduce the risk inherent in providing these services to poor producers.

INNOVATIVE PRACTICE SUMMARY **Linking Conditional Cash Transfers and Rural Finance in Brazil**

A 2009 study found that governments worldwide transfer cash to more than 170 million poor people through social protection programs providing cash allowances, health benefits, and pensions (Pickens, Porteous, and Rotman 2009). The number would be much higher if government wage payments were included. In comparison, an estimated 99 million people access microfinance loans, but few of these payments advance the goal of rural financial inclusion. Three-quarters of government-to-person (G2P) payments are delivered in ways that do not allow people to store the payments until they need the money, transfer the money to others, or access them easily (from the perspective of cost and distance).

ICT creates a significant opportunity to exploit the synergy between G2P payments and financial inclusion. The reasoning is that if the government were to facilitate development

of the required infrastructure, institutional capacity, and literacy to deliver government payments into basic savings accounts that poor recipients could access easily, those accounts might also be used to channel a wider array of financial services to the same segment—a segment that currently has little or no access to such services.

While three-quarters of G2P payments have not yet exploited this opportunity, some governments are using ICT to reduce the transaction and administrative costs of implementing government transfer programs that also serve as vehicles for financial inclusion. Examples include Brazil's Bolsa Família ("family allowance") program, implemented through Caixa Econômica (http://www.caixa.gov.br/Voce/Social/Transferencia/bolsa_familia/index.asp); Colombia's ACCION Social (<http://www.accionsocial.gov.co/portal/default.aspx>); Kenya's Hunger Safety Net Program, through Bankable Frontier Associates (http://www.hsnr.or.ke/index.php?option=com_content&view=article&id=81:ending-hunger&catid=38:fp-items); Mexico's Oportunidades program, implemented through McKinsey and BANEFSI (<http://www.oportunidades.gob.mx/Portal/>); Peru's Juntos ("together") program (<http://www.juntos.gob.pe/>); and South Africa's Department of Social Development (<http://www.dsd.gov.za/>) (Rotman 2010b). The Government of India has used the Financial Inclusion Network and Operations platform to deliver social transfers as well (see IPS "RFID Facilitates Insurance and Credit for India's Livestock Producers").

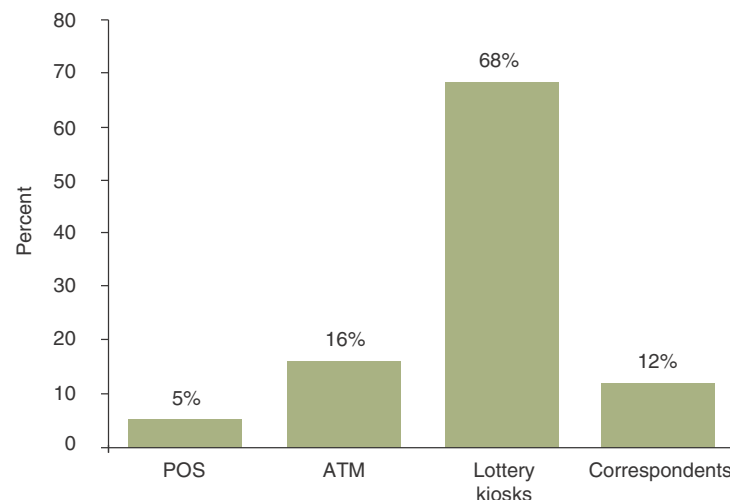
Bolsa Família: The Applications and Their Impact

Of the programs just mentioned, Brazil's Bolsa Família program is exceptional in its scale and impact. Created in 2004, the program consists of monthly cash transfers to poor households with children or pregnant women as well as unconditional transfers to extremely poor households (Anna Fruttero, World Bank, personal communication). In 2007, the program reached 12.4 million households—one-quarter of the country's population.

Of the 13 million Bolsa Família family recipients, 3.84 percent withdraw benefits using their electronic benefit card at one of 13,000 lottery kiosks, correspondents, or point-of-sale terminals belonging to merchants acting as agents of Caixa Econômica, the bank that holds the grant delivery contract (figure 7.7). In 2004, when cards were first issued to Bolsa Família recipients, only 24 percent of customers said that using the card was "easy" or "very easy," but one year later, the number had risen to 96 percent (Pickens, Porteous and Rotman 2009; Anna Fruttero, World Bank, personal communication).

The electronic benefit cards did not quite constitute financial inclusion because the value of the cards had to be used within three months or it would expire. Nor was the value of the card easily transferable. In response, Caixa Econômica decided to migrate the Bolsa Família recipients from the electronic benefit card to a Conta Caixa Fácil ("easy account"), a financially inclusive account that includes a Visa-branded

FIGURE 7.7. Channels for Financial Inclusion for Bolsa Família Beneficiaries



Source: Pickens, Porteous, and Rotman 2009.
Note: POS = point of sale.

debit card. As of October 2009, the bank had converted 2 million recipients to the Conta Caixa Facile. Caixa also has experimented with offering insurance to Conta Caixa Facile holders, is considering microloans, and has developed a financial literacy program for new account holders.

Two Key Enablers, One Key Lesson

Though G2P recipients often have limited schooling and little exposure to banking, these limitations have not prevented them from using electronic infrastructure as long as the services match their needs. In Brazil, two key enablers fostered success with electronic transfers through Bolsa Família. First, the value of the Conta Caixa Facile is significantly enhanced by a wide national network of over 20,000 contact points formed by Brazil's preexisting financial infrastructure of ATMs, bank branches, and point-of-sale-equipped merchants that handle deposits and withdrawals. Second, government policy favoring cash transfer programs such as Bolsa Família drives the growth of the Conta Caixa Facile. The key lesson is that a government transfer program can indeed be a vehicle or instrument for financial inclusion.

INNOVATIVE PRACTICE SUMMARY

RFID Facilitates Insurance and Credit for India's Livestock Producers

Worldwide, 60 percent of rural households are estimated to own livestock (including cattle, goats, pigs, sheep, poultry, honeybees, and even silkworms) and to earn 10 percent of their income from products such as meat, milk, cheese, eggs, honey, raw silk, wool, hides, and skins (FAO 2009,34). Livestock perform numerous vital functions. They are a savings mechanism, a form of insurance, collateral for loans, a source of food security, an aid to farm operations, a means of recycling waste products, and form of controlling insects and weeds, and a powerful source of opportunities for women to earn income (which promotes gender equality) (FAO 2009,33).

For this reason, livestock constitute some of the most important assets of rural households. Their loss through theft, disease, or drought can push households into poverty or deepen the distress of already impoverished households. Insurance products piloted in Mongolia, Kenya, and India seek to mitigate the risk of such losses.

Monitoring the whereabouts and health of livestock poses a significant challenge for both farmers and financial institutions. Insurance companies must be able to validate reports of livestock losses to avoid the moral hazard problems (the false claims) that plague insurance delivery and drive up the cost of insurance for all farmers. Most livestock move around to graze and are therefore susceptible to injury, theft, starvation (when drought reduces foliage and pastures), and drowning in floods. Monitoring animal health is even more important when animals are concentrated in intensive production facilities where the risk of disease is high.

Traditional livestock monitoring is cumbersome and expensive. Farmers must hire or use family labor to herd, pasture, or otherwise keep track of animals to keep them safe. Banks and insurance companies need to spend time and money to find and identify individual animals to verify reported losses or take possession if owners have defaulted on loans.

The use of RFID technology has reduced the cost of monitoring livestock. RFID uses electromagnetic waves to exchange data between a terminal and an electronic tag attached to an object that enables identification and tracking (image 7.1). At a minimum, most RFID tags have an antenna for receiving and transmitting the signal and an integrated circuit for performing specialized functions such as monitoring animals' location, heart rates, or temperatures and storing and processing information on animal weights, feeding histories, and immunizations. The tags can be read by terminals or readers

IMAGE 7.1. RFID Can Be Used to Track Cattle and Manage Herds



Source: Curt Carnemark, World Bank.

from several meters away and beyond the line of sight of the reader. The readers can be used to access the stored information or place additional information on the chip.

The technology allows farmers to better manage their herds and enables farmers, banks, and insurers to locate animals. RFID tags have become 99.9 percent reliable and have dropped in price. Prices vary by location, but a basic RFID chip costs approximately US\$0.15, whereas readers can range from US\$100 to several thousand dollars, depending on their sophistication (*RFID Journal* 2010).

A Business Model for Delivering Cattle Insurance in India

India is the world's largest milk producer, but only 7 percent of India's cattle are estimated to be insured (*Economic Times* 2009). Insurance would not only protect producers from losses but also improve their ability to obtain loans to increase their herds, because commercial banks are more willing to lend toward the purchase of insured cattle.

In September 2009, several institutions in India teamed up to offer cattle insurance to farmers in two districts of the southern state of Tamil Nadu. The Institute for Financial Management and Research (IFMR) Trust, a private trust that has pioneered financial inclusion efforts, joined HDFC Ergo, a commercial bank that provides insurance, and Dairy Network Enterprise (DNE), a supply chain and logistics organization, to design and deliver the new insurance product, which has several unique features.

First, the insurance is cheaper than other insurance offerings, with a premium of 2.9 percent of the insured value—typically 10,000–20,000 rupees (Rs), or US\$200–400, compared to the typical premium of about 4.5 percent. Second, the time needed to issue a policy or indemnity payment is only 72 hours, compared to the norm of 15 days or more. Third, the insurance policy provides access to preventive veterinary services and medicine through DNE to maintain the health of insured animals. Finally, insured animals are tracked using RFID chips in ear tags. The tags cost Rs 60 (US\$1.20) (standard metal tags cost US\$0.30).

Policies are sold through Pudhuaaru Kshetriya Gramin Financial Services (PKGFS), which has 25 branches serving 135 villages in the two remote districts where the new product is being piloted. Each branch has three agents who serve approximately 2,000 households. Policies can be issued rapidly because the PKGFS customer management system is connected in real time and integrated with HDFC Ergo's

policy issuance system. PKGFS and DNE, which manage the RFID technology and health services, must verify that the producer does indeed own the animals he or she wishes to insure and that the animals are healthy. Once this information is verified, PKGFS collects the premium (PKGFS can issue a loan for the premium if necessary) and the producer's information and transmits it to HDFC Ergo, which activates the policy, usually in less than three days (IFMR Trust 2008).

Once a policy is issued, DNE registers the insured animals at the farm, tags them, and records their vital information in a computer database. Then DNE begins regular checkups to ensure that the insured animals remain in good health. Veterinarians update the computer database every time they perform a checkup. In entering this information, they must scan the RFID tag of each animal to collect the unique ID number, which must be entered into the database along with the latest health update. This procedure prevents veterinarians from avoiding farm visits and entering false data into the system.¹ If an animal should die, DNE agents verify the death and notify PKGFS, which connects to HDFC Ergo to ensure payout.

Key Enablers

One key enabler was leadership in coordinating important stakeholders. The partnership between the bank/insurer (HDFC Ergo), the logistics organization (DNE), the rural financial institution (PKGFS), and the coordinating group (IFMR Trust) was critical for ICT-enabled insurance to promote financial inclusion.² The leadership demonstrated by IFMR Trust in assuming a coordinating role cannot be overstated. Elsewhere, such a role might also be performed by the government or a public financial institution.

A second key enabler was the Internet and communications infrastructure. The PKGFS customer management system connected to HDFC Ergo requires Internet and communications infrastructure. Such infrastructure is increasingly accessible in India. According to the World Bank's World Development Indicators, teledensity—a measure of telephone access—is 60 percent (though 100 percent in urban areas and 20 percent in rural areas), and 670 million people in the country subscribe to a mobile phone service. India has 4.5 Internet users per 100 people, double the number for the average least-developed country (though less than one-third of the average for low- and middle-income countries).

1 If services other than routine preventive care are required, the producer must pay for them on top of the insurance cost.

2 This arrangement resembles the arrangements in another successful program, DrumNet in Kenya.

Growth and Lessons

Since its launch in 2009 in Tamil Nadu, the program has expanded to the states of Uttarakhand and Orissa. The mortality rate of cows has improved with the provision of preventive care, especially deworming drugs and vaccinations.

Despite this initial success, two issues remain to be resolved: moral hazard issues and low adoption. With regard to moral hazard, it appears that RFID tags can be removed far too easily from animals' ears, and without a national or even regional animal tracking system, it is possible to have duplicate tags. Australia's National Livestock Identification System tracks all animals, each of which has two RFID chips (one in the ear, one in the digestive system). The point is that RFID technology alone may not resolve moral hazard problems. Using two tags may help, but the key lesson is that an institutional framework in the form of

a national or regional identification system is probably necessary for commercial banks to become sufficiently confident to extend financial services to the poor to buy livestock.

Several factors appear to limit adoption. Given insurance companies' propensity to renege on contracts, producers lack confidence that indemnities will actually be paid. Producers also seem to be confused by the livestock insurance product compared to a cheaper personal accident insurance product offered by PKGFS. Where efforts have been made to explain the difference, a higher rate of adoption has been observed (Gupta 2010). The key lesson is that technology cannot substitute for human capacity. In determining whether insurance products—even efficient, ICT-enabled products—will succeed in a given area, practitioners must consider the prevailing basic literacy and financial literacy rates.

Topic Note 7.2: POLICY STRATEGIES AND REGULATORY ISSUES FOR ICT-ENABLED RURAL FINANCIAL SERVICES

TRENDS AND ISSUES

As noted, a diverse group of stakeholders is involved in providing financial services to rural dwellers. To design supportive policies, provide the necessary infrastructure, and provide appropriate, affordable financial products based on assessments of local needs, governments must explore partnerships with the private sector and rural communities. In turn, governments can devise and implement policies that give rural communities and private enterprises incentives to participate in the rural financial sector.

For example, the Government of India promoted rural digital services by partnering with the private sector to set up village kiosks with IT infrastructure. The kiosks offered a single window for providing government services electronically at the village level (for example, issuing land records to farmers). The kiosks improved citizens' experience in dealing with government, because they reduced the time needed for officials to respond to citizens' requests. They also created a village database that could be used to reach more citizens. Financial service providers could potentially use this infrastructure to follow up on clients from the village.

Another example of effective public-private partnerships between government and ICT providers and community

organizations is in Sri Lanka, which has 600 distance learning centers and e-libraries that penetrate deeply into rural and remote areas, cover 22 of 24 districts in all nine provinces, and link more than 70,000 underserved users to markets and information essential to their livelihoods.³ At the telecenter in Bakalacia, users include farmers checking market prices, entrepreneurs marketing their businesses, community leaders searching for information on how to improve community livelihoods, mothers seeking first aid and connecting to hospitals and doctors in the capital city, children and students interested in learning, and citizens communicating online, requesting government services, or doing word-processing, printing, and copying. Surveys indicate a user satisfaction rate of 96 percent. An estimated 48 percent of users are women; 82 percent are youths up to 25 years of age. These telecenters can also be used for financial services, like point-of-sale terminals.

LESSONS LEARNED

Financing smallholder agriculture is a complex undertaking, easily thwarted by regulatory impediments to the development of new products or service delivery channels. For

³ This section draws on unpublished information from World Bank implementation support missions.

example, some potential financial service delivery channels, such as agency arrangements that operate outside physical branch offices, are not yet allowed in most countries in Africa and in most of Asia. Regulatory support for such arrangements may be needed to alleviate the perception of risk associated with financing agriculture and livestock production. Agents can be based closer to rural communities at a fraction of the cost of bricks-and-mortar banks. From this vantage point, they can assess the risk associated with lending to farmers better than banks or microfinance institutions. Agents can address the scale issues associated with providing financial services in rural areas, such as the small size of most transactions.

The lack of an appropriate regulatory framework also hampers the development of warehouse receipts as an electronic financial instrument.⁴ Many countries do not recognize warehouse receipts as a transferrable financing instrument, even though this product can facilitate smallholders' access to finance and, at the same time, improve the quality of produce, which is often dictated by warehouse managers. Policies and enabling legislation would provide for the establishment of a central registry for warehouse receipts as a title document used by banks to grant loans. Warehouse receipts held by banks would be included as liquid assets under the definition of the national banking act. A fund would be established to collect assets from warehouses to indemnify receipt holders in the event of a loss. Coherent industry standards and certification regulations would be introduced.

Many ICT-enabled applications described in this module (and Sourcebook) require an enabling legal and regulatory environment. In many countries, point-of-sale devices, m-banking, and other innovative applications have yet to be introduced because the corresponding regulations have not been introduced, despite evidence that they can extend cost-effective

financial services throughout the economy, including underserved rural areas.

The two innovative practice summaries that follow demonstrate the importance of public policy and regulatory frameworks in stimulating the use of ICT to improve rural financial systems and services. The first summary describes how ICT minimizes information asymmetries and links farmers directly to markets and to finance. It demonstrates how risk can be managed at the three operational levels of the financial service provider, market operator, and farmer. The second summary offers another example of the benefits that accrue from a common ICT platform to support rural banking in India.

INNOVATIVE PRACTICE SUMMARY **Kenya's DrumNet Links Farmers, Markets,** **and Financial Service Providers**

Small-scale farmers struggle to obtain agricultural loans even where they have good access to commercial banks. Commercial banks are reluctant to lend to them, recognizing the severe barriers and risks these farmers face in successfully producing a crop, marketing it, and repaying loans. Smallholders face risks in transporting produce to markets, finding buyers there, and earning the value they expected at planting. This risk not only introduces uncertainty in their income stream but, as noted, also inhibits their ability to obtain the credit to make the productivity and quality improvements that will break the cycle of poverty.

Much of the risk in accessing markets can be mitigated, and farmers' access to credit can be improved, if farmers can forge better links with agribusiness buyers such as domestic supermarkets, agroprocessors, or (further along the supply chain) exporters. When such links are weak, buyers also face problems in sourcing sufficient produce of the quality demanded by supermarkets or food processors. Farmers often do not know that the market is willing to pay a high price for certain products that meet certain quality standards; even if they do know, they lack the financing to switch to a new and more profitable crop or the knowledge to achieve the desired level of quality.

Better links between farmers and buyers would help to overcome these obstacles, but they are difficult to form. Mistrust between farmers and buyers runs deep. Buyers fail to honor purchasing agreements or do not pay the agreed-on price at harvest. Farmers abandon purchasing agreements and sell their produce to another buyer or on the spot market if they can get a more favorable price. Aside from these

⁴ Warehouse receipts are not covered in depth by this module because of the limited ICT used. Nonetheless, the basics for establishing warehouse receipts as a financing mechanism are not normally addressed, and, as a result, some interventions do not succeed. In addition to proper legal frameworks that protect all parties, there must also be a critical mass of farmers' organizations that can bring produce to the warehouse. The commercial banks and other service providers must be brought into the design from the very beginning, and there must be interest from the private sector to participate in the operations of the scheme. Warehouse receipt mechanisms also often lack the long-term objective of linking the scheme to the overall commodity exchange system, which would then encourage small-scale farmers to participate. Warehouse receipts can be useful with the proper frameworks and implementation, however. The Uganda Commodity Exchange warehouse receipt mechanism, for example, is working well for smallholders.

problems, the practical aspects of working with large numbers of small-scale farmers—organizing them, negotiating prices, sharing information, and managing their agronomic activities—are daunting for agribusinesses. Even if they were easy to resolve, agribusinesses still lack the core capabilities and often the resources to extend financing to all of those farmers.

The less risk exposure a client presents, however, the more banks are willing to lend. If farmers can demonstrate that an agribusiness is willing to purchase what they will produce, a bank will be much more amenable to financing the purchase of inputs and labor for production. The challenge for the bank is then limited to the transaction costs of disbursing funds, ensuring the loans are used for their stated purpose, collecting payments, and bearing the exposure to weather risks (unless there is crop insurance).

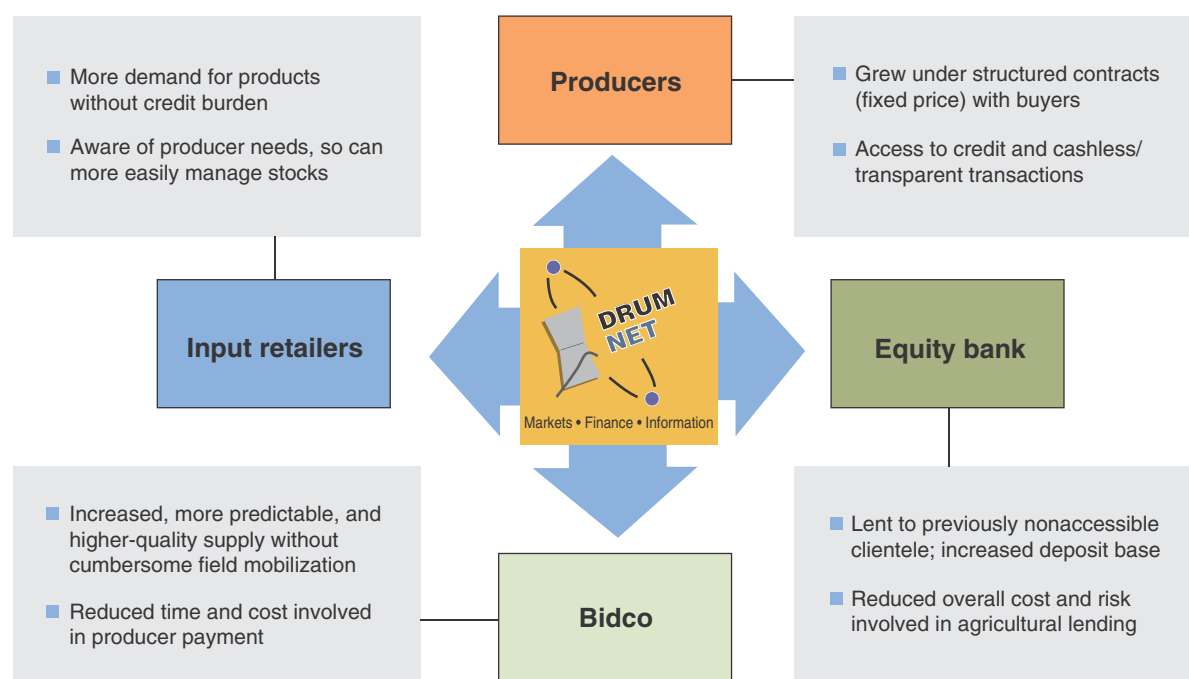
DrumNet is a project of Pride Africa, a nonprofit that has promoted the spread of microfinance across the continent since 1988. Created in Kenya in 2002, DrumNet was designed to provide market, information, and financial services to smallholders, and it has evolved a sophisticated technology platform to deliver these services. The project illustrates that it is possible for a third party to coordinate and link farmers, buyers, financial intermediaries, and operations managers to deliver financing to small farmers, and that ICT has a vital role

in doing so. ICT devices and systems such as mobile phones, smartcards, and management information systems facilitate communication between the parties and help to manage the administrative challenges of tracking large numbers of smallholders, delivering loans cost-effectively, ensuring that funds are properly used, and collecting payments.

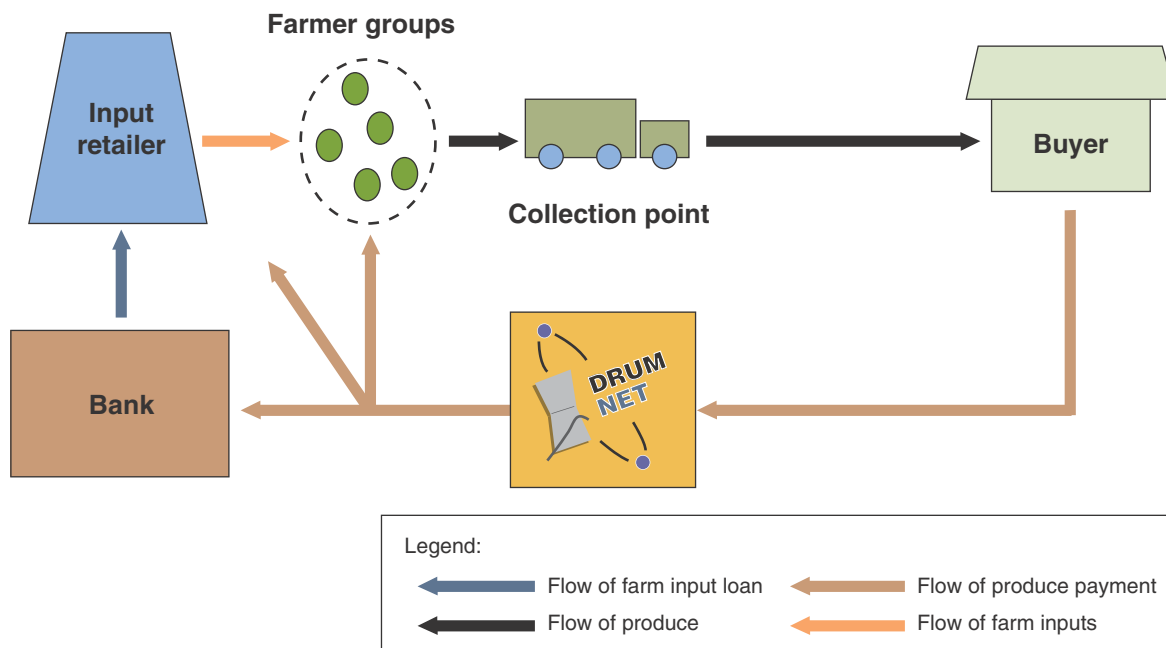
Links with Key Players

DrumNet recognized that it could not improve financing for farmers without linkages with financial intermediaries and buyers (DrumNet 2007). In 2008, DrumNet began a pilot program in the sunflower subsector to facilitate partnerships that would give smallholders access to finance and improve efficiency throughout the supply chain. The agribusiness buyer, Bidco, was the largest manufacturer of vegetable oils, fats, margarines, and protein concentrates in East Africa and needed a steady supply of sunflower seeds. The financial institution was Equity Bank (also involved with to M-PESA, discussed above). Farmers were recruited to grow sunflowers instead of their typical crop. Two additional players proved important to the partnership. Input suppliers had to agree to sell products to farmers on credit and receive payment from Equity Bank instead of cash directly from farmers. AgriTrade recruited farmers and managed sunflower production, harvest, and collection. The benefits foreseen from their collaboration are depicted in figure 7.8.

FIGURE 7.8. Benefits to Stakeholders in DrumNet’s Sunflower Supply Chain Partnerships



Source: Adapted from Pride Africa n.d.

FIGURE 7.9. Flow of Goods, Information, and Money in DrumNet's Sunflower Supply Chain Partnerships

Source: Adapted from Pride Africa n.d.

Services and Revenues

DrumNet negotiated the contracts that brought these parties together and managed the flow of information and financial transactions among them (figure 7.9). Through this arrangement, farmers received credit for inputs from Equity Bank upon signing a fixed-price contract with Bidco. To ensure that the loans would be used for their stated purpose, farmers received no cash from Equity Bank. Instead, through another agreement facilitated by DrumNet, Equity pays input retailers directly for materials purchased by farmers on credit. When the produce is delivered to Bidco, Bidco pays farmers through DrumNet, which first deducts the cost of the loan and transfers it to Equity Bank. The remainder is sent to the farmer's account with Equity Bank (Campaigne and Rausch 2010). DrumNet earns revenue for this service.

Farmer groups (typically consisting of 20–100 farmers in the same area) open an account with Equity Bank through which all payments are made. Individual farmers can be paid in cash, but cash is withdrawn from the bank at the group level to reduce transaction costs. Each member is required to contribute to a Transaction Insurance Fund, which is

25 percent of the value of the input loans and acts as security for them (DrumNet 2009).

ICT Applications

DrumNet provides the ICT platform through which all financial transactions and communications take place. The platform includes mobile phones, SMS, and email to enable the parties to do business. All payments from buyers pass through DrumNet accounts at the bank.

Information is transmitted up and down the supply chain during the crop cycle, primarily via SMS. Bidco is informed about the area planted to estimate production and plans accordingly. The processor monitors crop progress and passes on important crop management information to farmers. Input retailers are updated on which products to stock at what time, and producers learn about collection dates and locations long before harvest.

The input retailers, trained in basic recordkeeping for DrumNet, submit virtual receipts to DrumNet via mobile phone and receive payments into their bank accounts in

two-week cycles through the DrumNet system. Equity Bank is shielded from these many small transactions, as it simply opens a single line of credit in DrumNet's Master Account, receiving regular principal and interest payments from DrumNet from this revolving account. DrumNet's management information system provides the internal controls to track and report on compliance throughout the process. It also retains data to establish user and credit ratings.

Key Enablers

Key enablers are the partnerships between Equity Bank, Bidco, input suppliers, and farmers that enabled the system to work. ICT plays a significant role in sustaining the trust and confidence that make these relationships work. It provides the visibility, communication, and speedy transactions that bind partners together for their common benefit. The DrumNet system allows the various partners to be in touch constantly, reducing the potential for misunderstanding and unilateral decision making. Each partner can view the actions of the other partners. If there is no rainfall, Bidco knows to downgrade production plans, Equity Bank knows and can begin to work with farmers to make refinancing arrangements, and so on. Collaboration replaces confrontation. The speed of payment permitted through DrumNet is also central to maintaining sound relationships. Farmers note that they get paid in days rather than months, as was customary. The same can be said for the retailer and bank or the buyer and bank.

As the previous paragraph implies, another key enabler was infrastructure. DrumNet's ICT platform relies on mobile phones and the Internet. Based on the World Bank's World Development Indicators, it appears that Kenya's infrastructure for both technologies is above average compared to that of other developing countries in Sub-Saharan Africa. Kenya has wireless coverage across 77 percent of its territory (the average for developing countries in Sub-Saharan Africa is 75 percent) and 42.1 mobile subscriptions per 100 people (compared to 33.3 in developing countries in Sub-Saharan Africa). Similarly, Kenya has 8.7 Internet users per 100 people compared to 6.5 for Sub-Saharan Africa.

Outcomes and Lessons

More than 2,000 smallholders participate in the sunflower pilot. Several lessons have become apparent since the first

harvest was completed. The complex arrangement between farmers, buyers, banks, and retailers certainly allows farmers to obtain credit, reduces defaults, and increases trust. Yet the relationship remains extremely fragile. It is still susceptible to mistrust. Side-selling by farmers, scams from input retailers, buyers reneging on agreements, and hidden fees from the bank all erode trust and undermine the relationships. Such problems occur more often at the beginning of the process. As the partners come to understand each other's operations and develop trust, the problems should lessen. As noted, efficiency in service delivery is one way to mitigate some of these risks.

The partnership is also susceptible to problems arising from typical production risks such as droughts or floods. After the first year, when one region of sunflower growers was affected by a drought (McCormack 2009), the issue of loan repayment became contentious. Would Equity Bank allow an additional year to repay? Should DrumNet require a higher security deposit from farmers? Failure to reach agreement on such flashpoints before a partnership is implemented can unravel hard-won cooperation.

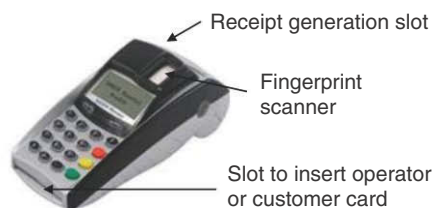
INNOVATIVE PRACTICE SUMMARY

A Common Platform Delivers Financial Services to Rural India

In India, Financial Inclusion Network and Operations (FINO), an Indian technology company, and ICICI Bank have used ICT to facilitate remote bank transactions and dramatically reduce the costs of serving rural areas. Using smartcards and point-of-sale devices connected to a centralized ICT platform, FINO has overcome the traditional problems of low volumes and values of transactions in rural areas.

ICT Application and Business Model

In partnership with IBM and i-Flex (now Oracle), FINO developed a remote transaction system that uses a small biometric point-of-sale device, in combination with a biometric smartcard, to authenticate users and conduct transactions (figure 7.10). Transaction data are sent over the Internet to a core banking system that houses the data and allows for analysis. Besides the obvious benefit of allowing remote transactions, the service provides the ability to uniquely identify customers and record their

FIGURE 7.10. Other Types of ICT Used by Financial Inclusion Network and Operations**Wireless point-of-sale device****Customer smartcard**

- Encrypted storage of account and customer information

Sources: FINO and author.

transactions over time. The transaction history for each customer can be used to provide credit bureau services to mainstream banks and allow them to lend to qualified borrowers in whom they have confidence (*Business Line* 2006).

An Extended Agent Network

FINO employs over 10,000 agents, 95 percent of whom are based in rural areas. The agents, called *bandhus* ("friends" in Hindi), form a network of human ATMs. Each agent is trained and equipped with the handheld biometric transaction device that allows clients with smartcards to access banking services. Balance transfers, deposits, and withdrawals can all be done through the smartcard system, even where the Internet is not accessible, since the smartcard retains the user's account information (India Knowledge@Wharton 2010). New transactions are stored on the transaction device until the Internet is available, at which point the data are synchronized with the core banking system.

Products and Services

Through its human and electronic network, FINO delivers microfinance transactions for various banks as well as its own banking services. Originally meant as a conduit for other financial institutions, FINO decided to offer its own financial services—savings, credit, insurance, and remittances—primarily because banks and businesses remained reluctant to pursue the rural market (India Knowledge@Wharton 2010).

FINO is also testing new initiatives. For instance, the company opened bank accounts for dairy farmers that supply milk to the National Dairy Development Board in Gujarat. Along with a savings bank account, farmers can receive bank

loans and cattle insurance combined in a single product (India Knowledge@Wharton 2010).

Profit Margin and Cost Structure

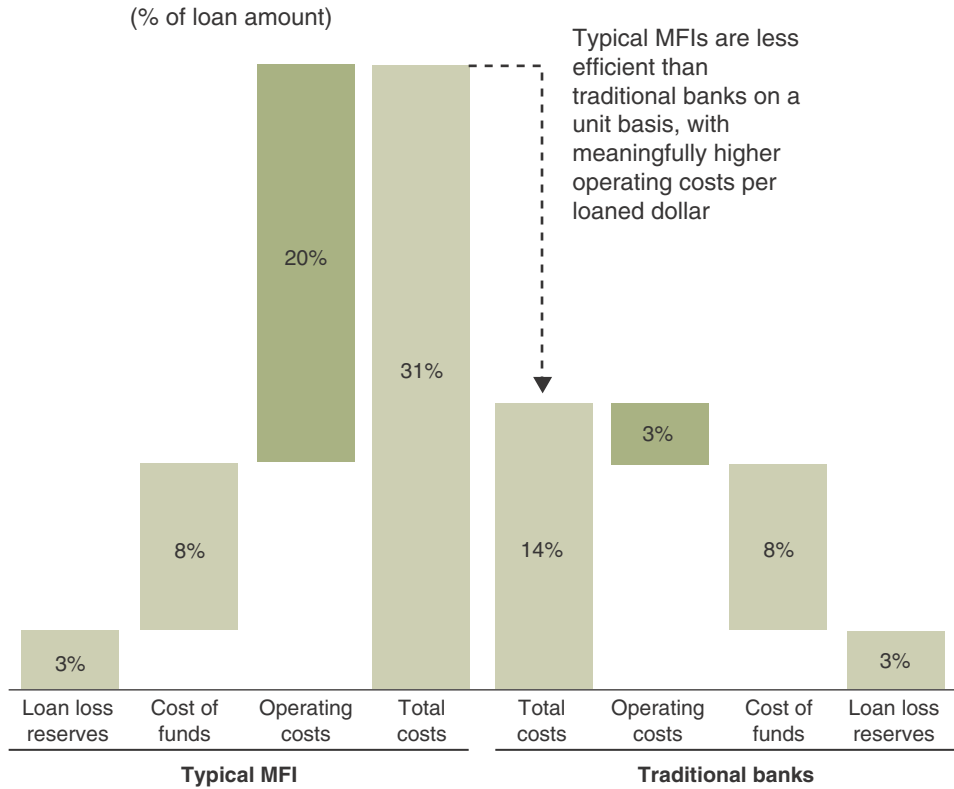
FINO earns approximately US\$0.10 for each transaction. A similar transaction costs US\$1.00 at a bank and about US\$0.40 cents at an ATM (Rotman 2010a). The company had turnover of US\$22.5 million in 2009–10 (India Knowledge@Wharton 2010). FINO aims to keep interest rates below 20 percent. The company has a cost structure similar to those of other microfinance institutions (figure 7.11), but it claims to have operational costs of 4–6 percent, nearly on par with traditional banks, because its rural agents cost less than urban agents, technology reduces administrative paperwork, and FINO shares the cost of maintaining the agent network with other banks that use FINO to conduct transactions (India Knowledge@Wharton 2010).

Scale and Sustainability

FINO has grown spectacularly since it was launched in July 2006. The company reached 2 million customers by 2008 (FINO 2008) and 5.5 million by 2009 (findBiometrics 2009), within an estimated market of 500 million rural people. By September 2010, "there were 21 million customers, 22 banks, 10 MFIs, 4 insurance companies and 12 government entities covering 22 states, 266 districts and 5,884 gram panchayats [village councils]." The ambitious goal was to reach 100 million customers by July 2011 and have revenue turnover of US\$52 million (India Knowledge@Wharton 2010).

The financial viability of the agent network is questionable, however. At about US\$23, the average monthly profit for

FIGURE 7.11. Cost Structure of Microfinance Institutions (MFIs) in India



Sources: CGAP and IBM.

a FINO agent is less than 20 percent of the profit made by an M-PESA agent in Kenya or an agent in Brazil, both of whom make around US\$130. FINO agents surely need additional income to supplement that from FINO, but being an agent for FINO takes up an enormous amount of time, leaving little time for another job unless there are synergies between the travel required for FINO and the other job (Rotman 2010a).

Key Enablers

An operation on such a large scale requires strong support from major institutions, policy initiatives, and infrastructure. FINO has benefited from all of these key enablers. A major advantage was that ICICI Bank, India’s largest private financial institution with assets of US\$81 billion, incubated FINO. It transferred critical technical and administrative capacity to the company in addition to financial support.

Early on, ICICI Bank recognized the challenge of reaching rural customers. The bank—founded in 1955 by the

Government of India, industry, and the World Bank—has consistently innovated in service delivery. In 2004, the bank launched the Kisan (“farmer”) Credit Card in Andhra Pradesh to facilitate delivery of cash loans and credit to tobacco farmers (ICICI Bank 2001). In the same year, ICICI unveiled biometric ATMs in peri-urban areas. The ATMs cost 5 percent of typical ATMs.

These steps led ICICI to envision a technology platform that could allow banking transactions in rural areas, and ICICI began incubating FINO to achieve this goal. The effort was guided by leaders of other companies that ICICI had incubated: Crisil, a ratings agency, and Ncdex, a commodities exchange (*Business Standard* 2006). FINO was spun off in 2006, with ICICI retaining a 19 percent stake. Intel Capital and the International Finance Corporation (IFC) each have a 15 percent stake, the Life Insurance Corporation of India has 8 percent, and various other public banks have the remaining 22 percent (figure 7.12) (India Knowledge@Wharton 2010).

Category	Sub-category	Percentage
International investors	IFC	15%
	Intel Capital	15%
	HAV 3 holdings (Mauritius)	10%
	ICICI Lombard	9%
Public sector	LIC	8%
	UBI, Indian Bank and Corporation Bank	22%
Private equity	ICICI Bank	19%
	IFMR trust	2%

Bagazonzya, H., Z. Safdar, A. K. M. Abdullah, C. T. Niang, and A. Rahman. 2010. *Linking Up and Reaching Out in Bangladesh: Information and Communications Technology for Microfinance*. Directions in Development 52863. Washington, DC: World Bank.

- Business Line*. 2006. "ICICI Bank Launches New Initiative in Micro-finance." *Business Line*, July 24. <http://www.thehindubusinessline.com/2006/07/14/stories/2006071404270600.htm>, accessed December.
- Business Standard*. 2006. "ICICI-FINO to Play Big Brother to MFIs." *Business Standard*, July 14. <http://www.business-standard.com/india/news/icici-fino-to-play-big-brother-to-mfis/250588/>, accessed December 2010.
- Campaigne, J., and T. Rausch. 2010. "Bundling Development Services with Agricultural Finance: The Experience of DrumNet." 2020 Vision for Food, Agriculture and Environment Series, Innovations in Rural and Agricultural Finance (Focus 18), International Food Policy Research Institute (IFPRI), Washington, DC.
- CGAP (Consultative Group to Assist the Poor) and IFAD (International Fund for Agricultural Development). 2006. "Emerging Lessons in Agricultural Microfinance." IFAD, Rome.
- CGAP (Consultative Group to Assist the Poor) and World Bank. 2010. "Financial Access 2010." CGAP and World Bank, Washington, DC.
- Cracknell, D. 2004. "Electronic Banking for the Poor: Panacea, Potential, and Pitfalls." *Small Enterprise Development* 15 (4): 8–24.
- CSR360 Global Partner Network. 2010. "mKRISHI—Connecting India's Rural Farmers." Interview with Arun Pande, June 4. <http://www.csr360gpn.org/magazine/feature/mkrishi-connecting-indias-rural-farmers/>, accessed September 2010.
- DrumNet. 2007. "Financing the Agricultural Value Chain." *Rural Finance.Org*, March 15. <http://bit.ly/fZ1N8Y>, accessed December 2010.
- . 2009. "Experience in Kenya's Sunflower Sector." *Pride Africa*. <http://bit.ly/iazdBk>, accessed December 2010.
- Dzawu, M. M. 2009. "Finding Ways to Improve Financial Literacy in Africa." *Business Times Magazine*, November. <http://bit.ly/ffJeci>, accessed January 2011.
- Economic Times*. 2009. "IFMR, HDFC Ergo Redefine Cattle Insurance Using RFID Technology." *Economic Times*, November 2. http://www.ifmrtrust.co.in/downloads/et_article_09.pdf, accessed December 2010.
- FAO (Food and Agriculture Organization). 2009. *The State of Food and Agriculture 2009*. Rome: FAO.
- findBiometrics. 2009. "India's FINO Provides Biometric Smart Card Services to 1200 Locations." *findBiometrics*. <http://www.findbiometrics.com/press-releases/f/7059/>, accessed January 2011.
- FINO (Financial Inclusion Network and Operations). 2008. "FINO Reaches Two-Million Unbanked Populations in India." *PRLog*, November 4. <http://bit.ly/fyW5vP>, accessed January 2011.
- Giné, X. 2010. "Biometric Technology in Rural Credit Markets: The Case of Malawi." 2020 Vision for Food, Agriculture, and Environment Series, Innovations in Rural and Agricultural Finance (Focus 18), International Food Policy Research Institute (IFPRI), Washington, DC.
- Gupta, A. 2010. "Cattle Insurance: Revisiting Assumptions." IFMR Blog, November 14. <http://ifmrblog.com/2010/11/14/cattle-insurance-revisiting-assumptions/>, accessed December 2010.
- IBM. 2007. "IBM and CARE Partner to Advance Microfinance in Africa." <http://www-03.ibm.com/press/us/en/pressrelease/22761.wss>, accessed November 2010.
- ICICI Bank. 2001. "Kisan Loan Card." http://www.icicibank.com/aboutus/pdf/Kisan_Loan_Card.pdf, accessed December 2010.
- IFMR Trust. 2008. "Redefining Cattle Insurance." http://www.ifmrtrust.co.in/announcements/cattle_ins.php, accessed December 2010.
- India Knowledge@Wharton. 2010. "FINO Shows a Low-Cost Way Out of India's Microfinance Mess." <http://knowledge.wharton.upenn.edu/india/article.cfm?articleid=4545>, accessed December.
- ITC. 2010. "ITC's E-Choupal Movement." http://www.itcportal.com/ruraldevp_philosophy/echoupal.htm, accessed September 2010.
- ITU (International Telecommunication Union). 2009. "ICTs and Food Security." ITU-T Technology Watch Report, ITU, Geneva. www.itu.int/dms_pub/itu-t/oth/23/.../T230100000B0001MSWE.doc, accessed April 2011.
- Jack, W., and T. Suri. 2009. "Mobile Money: The Economics of M-PESA." Stanford University, Nairobi. <http://bit.ly/hJZ0AT>, accessed October 2010.
- Kathpalia, G. 2010. "Government of India: Radio-Frequency Identification (RFID)." <http://www.mit.gov.in/content/radio-frequency-identification-rfid>, accessed December 2010.
- Kimani, M. 2008. "A Nank in Every African Pocket?" *African Renewal*, January. <http://www.un.org/ecosocdev/geninfo/afrec/vol21no4/214-cell-phone-banking.html>, accessed November 2010.
- Mas, I. 2010a. "M-KESHO in Kenya: A New Step for M-PESA and Mobile Banking." Financial Access Initiative, May. <http://financialaccess.org/node/2968>, accessed December 2010.
- . 2010b. "Everyone Needs a Safe Place to Save." *TedxSeattle* presentation, Seattle, April 16.
- McCormack, D. 2009. "Building a Supply Chain Transaction System for Smallholder Farmers in Kenya, Phase II Operations (2007–2009)." *YouTube Flooded Cellar Channel*, May 20. <http://www.youtube.com/watch?v=8hw4bWMQMBQ>, accessed December 2010.
- Nair, A., and A. Fissaha. 2010. "Rural Banking: The Case of Rural and Community Banks in Ghana." Agriculture and Rural Development Discussion Paper, World Bank, Washington, DC.
- Ogodo, O. 2010. "Kenyan Farmers Get Micro-insurance." *SciDevNet*, March 22. <http://www.scidev.net/en/news/kenyan-farmers-get-micro-insurance.html>, accessed September 2010.

- Pareti, S. 2010. "Out of the Tin, Into the Bank." Asian Development Bank. <http://www.adb.org/documents/feature-stories/2010/van-bank.asp>, accessed January 2011.
- Pickens, M., D. Porteous, and S. Rotman. 2009. "Banking the Poor via G2P Payments." Consultative Group for the Poor. <http://www.cgap.org/gm/document-1.9.41174/FN58.pdf>, accessed December 2010.
- Post and Parcel*. 2010. "Botswana Post and Bank Could Merge." *Post and Parcel*, March 22. <http://postandparcel.info/32367/companies/botswana-post-and-bank-could-merge/>, accessed January 2011.
- Pride Africa. n.d. "Experience in Kenya's Sunflower Sector." <http://www.prideafrica.com/assets/docs/DrumNet%20Sunflower%20Experience.pdf>, accessed July 2011.
- RFID Journal*. 2010. "RFID FAQs." <http://www.rfidjournal.com/faq#16>, accessed December 2010.
- Rotman, S. 2010a. "India's Doorstep Banking: FINO Starts Something New." *CGAP Technology Blog*, May 5. <http://technology.cgap.org/2010/05/05/indias-doorstep-banking-fino-starts-something-new/>, accessed December 2010.
- . 2010b. "The Forced Marriage between Social Protection and Financial Inclusion . . . or a Match Made in Heaven?" *CGAP Technology Blog*, November 29. <http://technology.cgap.org/2010/11/29/the-forced-marriage-between-social-protection-and-financial-inclusion%E2%80%A6or-a-match-made-in-heaven/>, accessed December 2010.
- Sevak Solutions. 2008. "Extending Financial Networks." Sevak Solutions. <http://www.sevaksolutions.org/prototypes/finideas.html>, accessed January 2011.
- Trivelli, C., and H. Venero. 2007. "Agricultural Development Banking: Lessons from Latin America?" FAO Rural Finance Learning Center. <http://bit.ly/dMmeFK>, accessed October 2010.

Module 8 **FARMER ORGANIZATIONS WORK BETTER WITH ICT**

WORLALI SENYO (consultant) and BENJAMIN KWASI ADDOM (CTA)

IN THIS MODULE

Farmer organizations can function more efficiently by using information and communication technology (ICT) to attract and retain a wider membership, generate more funds, and provide better services to their members. Documented benefits of ICT include improved connections for members, better accounting and administration, the provision of value-added service (VAS) to members, and stronger collective voice. Given the lack of basic infrastructure in much of the developing world, the most successful types of ICT are robust and relatively simple. Governments, donors, and nongovernmental organizations (NGOs) generally initiate the development and testing of ICT solutions for farmer organizations, but in many instances partnerships with the private sector are essential. Three key challenges are to scale up existing applications, ensure sustainability over the long term, and ensure inclusiveness.

Topic Note 8.1: Finding Better Marketing Options and Sharing Technical Information Using ICT. Mobile phone systems appear to be the most flexible technology for improving connections within farmer organizations and providing a wider range of services. Mobile phones help to tackle supply chain inefficiencies, poor logistics, and weak infrastructure in rural areas, all of which cause agricultural produce and other resources to be wasted after the harvest. Technologies that do not depend on literacy (digital photography and video clips) are extremely effective for sharing information within and between farmer organizations.

- **Zambia's National Farmer Organization Develops a Text-Based Service**
- **The SOUNONG Search Engine for Farmer Organizations in China**
- **Field Data Collection Tool for Certified Farmer Groups in Sustainable Agriculture**

Topic Note 8.2: Dairy Cooperatives Lead the Way with Computerized Systems to Improve Accounting, Administration, and Governance. While farmer organizations do benefit from third-party service providers, the use of innovative types of ICT can add value by strengthening the human and institutional capacity of farmer organizations to provide better commercial services to members. Computerized recordkeeping has transformed efficiency in farmer cooperatives; approaches include both commercial systems and systems using open source software. Supportive government policy and willingness on the part of government organizations to join partnerships are important enablers.

- **IT Tools for India's Dairy Industry**
- **CoopWorks Dairy and Coffee, Open Source Software Launched in Kenya**
- **ICT Improves Marketing and Governance for a Malian Cooperative**

Topic Note 8.3: Giving Farmers a Voice and Sharing Information. Farmers' collective voice is stronger and reaches wider audiences with the help of radio and television. Interactivity is possible and even more promising through phone-in programs and text messaging. Radio and television are also effective tools for agricultural extension. Interactivity through websites is becoming more crucial for farmer organizations, but less so for individual smallholders. Surging use of social media tools such as Facebook, LinkedIn, Twitter, and Dgroups is enabling farmers and farmer organizations to participate more intensively in policy dialogues and discussions.

- **Community Listeners' Clubs in Rural Niger**
- **Through Social Media, a Women's Producer Network in Caribbean Small Island States Improves Its Communication Capacity, Outreach, and Knowledge Management**
- **The Case of the Pan-African Farmers' Organization**

The authors of the original Module 8 were Julie Harrod (consultant) and Pekka Jämsén (AgriCord). The reviewer of the current Module 8 is Pekka Jämsén of AgroBIG.

OVERVIEW

Smallholder farmers can generate more income in a number of ways. They can use better cultivation techniques and improved seeds, follow practices to reduce postharvest losses, and find ways to improve their access to markets. Even so, as individual entrepreneurs they may lack the knowledge or capital to change the way they operate. Farmers are able to seize new economic opportunities to improve their livelihoods and food security when they have access to natural resources, productive assets and markets, information and knowledge, and the opportunity to participate in policy making.

One strategy for men and women farmers to access productive assets and expand their capacities is to collaboratively, voluntarily organize to pursue a shared goal and, through innovative institutional arrangements, build useful links with public and private actors, benefit from economic opportunities, and participate in policy making. Evidence shows that by virtue of the fact that they are organized rather than acting alone, smallholder farmers who form groups, especially groups resembling cooperatives, are more viable market actors because they have more access to information, better power to negotiate, and in general are better placed to seize market opportunities.

Farmer organizations therefore play an important role in tackling the systemic causes of poverty, because they legitimize the voices of farmers—men and women—in shaping pro-poor rural policies. By articulating farmers' interests to public and private institutions, farmer organizations encourage those institutions to tailor their strategies, products, and services to farmers' needs (Zimba 2013). Farmer organizations encourage democratic decision-making processes, leadership development, and education. Given their values and the principles inherent in their structure, they are also well designed to be vehicles for inclusion, especially of women farmers and youths.

Farmer organizations provide services to members by forging institutional links and giving farmers a collective voice. The collective strength of an organization can help individual members become more efficient, if the organization's services match its members' needs. To fulfill this commercial function, as seen in agricultural cooperatives and producer groups, farmer organizations need to begin acting as business organizations, by adopting viable business models and developing the flexibility to adapt to changing circumstances.

Despite the important role that farmer organizations play in the lives of their members, farmers still have several

challenges, which when solved will go a long way to improve their lives and livelihoods. Access to timely and relevant information in villages, many of which are remote and inaccessible, can empower rural citizens. Increasing awareness and knowledge through information on government schemes and welfare measures can improve the quality of life in rural areas, as most rural dwellers have difficulty accessing the resources that the government has put in place to safeguard their welfare. Farmer organizations have been striving to address these issues but often through conventional means. The use of ICT to help farmers, however, is a sure way to complement, and in many situations surpass, the effectiveness of conventional means. ICT is integral to fulfilling both the lobbying and the service functions of farmer organizations, speaking both for and to the farmer. Commercial activities become more efficient and transparent when supported by ICT.

"ICT" is a catchall term for an increasing number of technologies, each offering corresponding opportunities for innovation. This module looks at a range of technologies, from the well-established and familiar, like radio and mobile phones, to the more specialized, such as computerized recordkeeping and farm management systems, global positioning systems (GPS), and remote sensing technologies that facilitate access to timely and accurate information for agricultural development. The discussion emphasizes technologies that can (or that have the potential to) reach large numbers of beneficiaries and perform reliably in the challenging context of the developing world. Different technologies offer different benefits, achieve different objectives, and have different limitations, so each is considered on its own terms.

Benefits Offered through ICT

When considering the value of ICT to farmer organizations and cooperatives, it is worth bearing in mind that in remote rural areas of many developing countries, particularly in Africa, these organizations often are the only ones operating and providing peer support. Local government offices may be found in district headquarters and may offer some level of support, usually limited by inadequate budgets, from front-line extension officers and schools. In this context, farmer organizations—as hubs for business information, transportation, storage, and credit support, as well as a place where people share new systems and processes—have enormous potential, which should not be underestimated, for networking and bringing people together with the help of ICT.

Broadly, ICT appears to offer three categories of benefits to farmer organizations. Practical examples might cut across

these categories, and particular technologies may bring unexpected benefits:

- **Enhanced connections to members.** Through the organization, farmers share market information and technical know-how, and they remain informed about the organization's activities. For instance, topics discussed and decisions made at board or executive committee meetings can be shared with members who, for reasons of distance or cost (direct and opportunity) cannot attend. Decision-making processes become more transparent, increasing trust between members, the board, and executive managers, and the overall functioning of the organization is improved.
- **Improved accounting and administration.** Farmer organizations are often responsible for handling very large amounts of money that may represent the cash income of thousands of farm families. Efficient recordkeeping allows an organization to better serve its members, and the transparency offered by computerization and other technologies enhances trust. Cooperatives that have invested in modern management and member information systems can improve their image to attract high-quality staff and gain members' confidence.
- **Stronger collective voice, including improved political voice.** "Interactivity," as understood in developed countries with good infrastructure, is still rare in many parts of the world. But individual farmers nevertheless "have their say" through types of participatory engagement that were not possible before, such as crowdsourcing views and experiences using text, voice, and video technologies. Farmers now learn and give feedback through services offered by their farmer organization, local government, and private sector actors.

The application of ICT in these areas has facilitated greater involvement of farmer organizations and cooperatives in policy processes and agricultural value chain development. However, these propositions all reinforce the conventional roles of cooperatives as consumers or end users of products within the agricultural innovation system. The innovative use of ICT can add value and help farmer organizations go beyond these conventional roles by strengthening their organizational capacities—institutional and human—to provide commercial services to their members. By providing relevant services to their members, organizations improve members' ownership and access to technological and knowledge resources and enhance their economic power for value chain development, especially in terms of production and marketing.

Despite the potential benefits of ICT tools, farmer organizations are rarely the first to adopt them, given that they usually work in difficult environments with low margins to generate income for their members. Neither managers nor members are preoccupied with the latest smartphone or tablet technology. Where particular ICT solutions are available and necessary to guarantee better performance and benefits to members, farmer organizations can be expected to be late adopters of such technology without external support.

Generally, it is governments, donors, and NGOs that have the funds to develop and test ICT solutions that may benefit farmer organizations. Most if not all of the cases illustrated in this module are public-private initiatives to "include the excluded" by promoting ICT in remote rural areas. Successful cases provide good examples for scaling up and replicating in other countries and regions.

Promising Approaches

Table 8.1 summarizes the types of ICT covered in this module, arranged by topic note. All of them have proved useful in addressing one or more challenges faced by farmer organizations.

It is worth knowing that ICT applications—whether mobile phones, computers, smart mobile applications, or radio broadcasts—are not ends in themselves; they are simply the means by which information can be captured, recorded, summarized, displayed, and passed on more quickly. It is the information itself that is important. Since information (on market intelligence and agricultural techniques, for instance) changes, the task of collecting it and choosing the most relevant sources is critical. Farmer organizations might have to be helped to create partnerships that will provide information that is of most use and relevance to members and management. Any intervention dealing with ICT must therefore consider this point.

Key Challenges and Enablers

With regard to farmer organizations, ICT applications currently offer guaranteed improvements in enhanced connections to members and improved accounting and administration. Already, working examples offer lessons for future development of ICT interventions. The third topic discussed in this module—stronger collective voice—has fewer working examples, but it may benefit more from ICT interventions in the future.

Farmer organizations can function more efficiently by using ICT to attract a wider membership and thus generate more funds and provide better services in a virtuous spiral

TABLE 8.1. Specific Types of ICT Discussed in This Module

TYPE OF ICT APPLICATION		CHALLENGE FACED BY FARMERS AND THEIR ORGANIZATIONS				
		LACK OF MARKET INFORMATION—PRICES, POTENTIAL BUYERS, AND SO ON	LENGTHY MANUAL BUREAUCRATIC PROCEDURES, POOR TRANSPARENCY, INCLUDING WITH THE FO	LACK OF KNOWLEDGE OF MARKET STANDARDS BY FARMER, OR LACK OF CONSUMER CONFIDENCE	LACK OF ACCESS TO EXTENSION SERVICES AND LATEST RESEARCH, AND INABILITY TO SHAPE RESEARCH	EXAMPLES IN THIS MODULE
Enhanced connections to members	Mobile phones (voice or text messaging systems) to access price information, purchasing options, and other market intelligence; also to access information in broader sense.	Fairer relationship between farmer and trader	If GPS an option, can make it easier to verify the source of crops—for example, for organic or other certification	Informed farmer can sort and offer produce according to required standards	Voice and text increasingly used to contact interactive radio broadcasts to solve problems	<ul style="list-style-type: none"> • ZNFU (Zambia) • Coopeumo (Chile) • FrontlineSMS • SOUNONG (China) • mergdata (Ghana) • IFFCO Kisan (India)
	Digital multimedia (cameras, video recorders, computerized presentation) to share new techniques and effective practices; ICT-based information on grades and standards.			Can demonstrate standards in effective, visual way. Can help in reaching export market	FO can document best practice and share from farmer to farmer; pictures are more effective than words	<ul style="list-style-type: none"> • Song-taabaYalgré Association (Burkina Faso) • Coprokazan (Mali)
	GPS technology for plotting source of produce.		Speeds recording Process	Consumers know source of produce and trust claims about organic status and similar characteristics		<ul style="list-style-type: none"> • Song-taabaYalgré Association (Burkina Faso) • AuditAide (Côte d'Ivoire and Ghana)
	Mobile applications	Fairer relationship between farmer and trader	FO can share information for better transparency	Information available	Information available, interactivity possible	<ul style="list-style-type: none"> • IFFCO Kisan (India) • e-Granary
Improved accounting and administration	Member transaction systems; software for financial management.		Reduces need for clerks, speeds transactions, improves transparency	Graphic presentation of financial information makes statistics easier for coop members to understand		<ul style="list-style-type: none"> • Dairy and coffee cooperatives (India, Kenya) • Coprokazan (Mali)
	Automated milk measurement systems.	Fairer relationship between farmer and coop	Reduces waiting time for farmers and amount of milk spoiled; farmers trust the automated system			<ul style="list-style-type: none"> • Dairy and coffee cooperatives (India, Kenya)
Stronger collective voice	Local radio stations providing market and technical information and phone-in virtual markets. Could also share information about FO.	Farmers better informed about prices and possible markets	Together with mobile phones, can increase connections with FO members and increase transparency	Farmers better informed on standards	Possible to broadcast information on latest techniques; phone-in programs allow farmers to discuss problems	<ul style="list-style-type: none"> • Farm Radio International • RIU (Zambia) • Listeners' clubs (Niger, Zambia)
	TV programs are specially tailored to share farming information—technical, market, problem solving, and other.	Market information broadcast	As above for radio	As above for radio	Interactive problem solving seminars on agricultural issues; picture more effective than words	<ul style="list-style-type: none"> • Doordarshan Broadcasting Co. (India)
	Websites set up by FO and producer groups; online discussion forums	Can reach wider markets	FO could put financial and other information online to increase transparency	Inform members of standards required	Information can be accessed online	<ul style="list-style-type: none"> • Several

Source: Authors.

Note: BAAC = Bank for Agriculture and Agricultural Cooperatives (Thailand); FEPPASI = Fédération Provinciale des Professionnels Agricoles de la Sissili; FO = farmer organization; RIU = Research Into Use; ZNFU = Zambia National Farmers Union.

of development. Many examples in this module are relatively small-scale interventions that succeeded in changing the way farmer organizations operate. To speed the uptake of ICT, it may be appropriate for public agencies to provide funds that can overcome the inertia typical of organizations struggling on a shoestring budget. Supporting a pilot project to demonstrate benefits can be effective; but now, after decades of piloting, the fundamental challenge is for international development partners and donors to join hands with the private sector to scale up some of these cases.

A second fundamental challenge is to sustain the use of ICT after the period of support. Costs are associated with change, not only equipment costs but also the costs of maintenance, training, and continuous development. New technology must either generate enough extra income for an organization to cover ongoing costs, or individual users must be able to envision enough tangible benefits to choose to pay for the technology. In the developing world, and particularly in agriculture, subject as it is to the external shocks of unpredictable weather and global market forces, the benefits of ICT must be very firmly established for farmer organizations to sustain their costs.

A third challenge is that viable business models for providing services are still lacking. Most start-ups focusing on ICT for agriculture are not very business-minded. Little consideration is given to how ICT services expect to generate revenue; whether (and how much) beneficiaries will be prepared to pay for information; the opportunities for external contributions; and how to control costs in line with potential revenue—yet all of these questions must be addressed, both for government- and donor-led projects.

One way of looking at the sustainability issue is to regard well-functioning farmer organizations as a public good that merits support from public funds, at least initially. Given the vital role of such organizations in helping impoverished farmers improve their living standards in areas that may be poorly reached by other interventions, this argument is powerful.

Public-private partnerships are also important, as developments in ICT come largely from the private sector. Dealing with such partnerships will be a critical issue. Private companies need to make a profit for their goods and services, but safeguards need to be built into partnership arrangements so that the farmer organizations (and ultimately their members) see long-term benefits.

A key issue for ensuring sustainability is the ownership of the information service after donor support ends. Most initiatives to use ICT for agriculture have been led by donors, the private sector, or the public sector, with farmers and their organizations often at the receiving end. Now it is time for financial partners to recognize farmer organizations as strategic partners in the design and provision of services, and to strengthen organizations' capacities to own the service and carry it forward after outside support ends.

Where support is offered to farmer organizations that have not yet reached a level of financial maturity that would allow them to adopt ICT independently, it is important to design interventions that give due consideration to the issue of gender. Women need to be involved at the planning stage as well as in the management of a project to ensure their proper representation (box 8.1 lists obstacles to increasing women's use of ICT). Somewhat paradoxically, women, despite having

BOX 8.1. Factors That Can Hamper Women's Uptake of ICT

- Cultural attitudes discriminate against women's access to technology and technology education: What would a woman farmer want with a computer?
- Compared to men, rural women are less likely to own communication assets, such as a radio or mobile phone.
- Rural women are less likely to allocate their income to use in public communications facilities, except when they need to communicate with family or to arrange for income transfers.
- Rural women are often reluctant to visit cyber cafés or public Internet centers, which are often owned by men and visited by men. The café culture often excludes girls and women.
- Rural women's multiple roles and heavy domestic responsibilities limit the time they can allocate to learning and using ICT applications, until and unless they realize the potential information benefits (and time-saving elements) of using these technologies.

Source: World Bank 2008.

lower social visibility and literacy than men, have more to gain from ICT. Women may not be able to free themselves from their traditional time-consuming commitments to household and children, but armed with only a cheap mobile phone they can find the best prices for their crops without abandoning their domestic tasks. Women who might already be involved in the accounting function of a farmer cooperative should have the opportunity to learn computer skills when these functions become computerized. Such skills will become more valuable as computerization becomes more common, giving women more employment choices.

Consideration should also be given to age asymmetries in access to ICT, which younger people tend to adopt more readily. This asymmetry has the potential to cause friction in traditional societies where elders are respected and turned to for guidance. On the other hand, young people's readiness to adopt new technology can be turned to advantage and used as a learning tool within communities.

Of course, there are also the persistent challenges common to developing countries: poor infrastructure, poverty, illiteracy, and the draw exerted by urban centers. Mains electricity is rare outside major towns (although solar recharging devices and kiosks are starting to appear). Mobile phones are widely used in some rural areas, but others still lack network coverage. Maintaining computer systems can be a challenge in remote rural areas. Technical staff trained to use computers tend to migrate to towns, where salaries are higher. Farmers themselves may not see the importance of spending money on ICT (bringing Internet connectivity, say) when a reliable water supply would bring more immediate and tangible benefits.

A more subtle challenge is the danger of widening the digital divide, because better-educated groups are more likely to accept and use new technology, which further distances them from poorer organizations. The cooperatives that are likely to be successful are the ones that already have competent, educated managers and already function well as businesses (see the discussion in Topic Note 8.2). Smaller, less-well-organized groups will always present more of a challenge; they require more intensive training and support services over a longer period. They might also need a significant period to become aware of the benefits of technology before any intervention is possible.

Given these challenges, it is not surprising that the most effective technologies are relatively cheap and simple. Mobile phone ownership is increasing rapidly. Far more people own phones than have computers. Market information in the form of text messages can therefore reach large numbers of farmers and give them a stronger negotiating position

with traders. Phones that connect users directly to the Web unleash an even wider range of possibilities. A recent survey of eight emerging and developing countries found that about 9 of every 10 persons owned a mobile phone and that people in Sub-Saharan African nations—including Nigeria, Senegal, and Ghana—used mobile phones for texting and taking photos and videos at the same rate as people in other emerging and developing regions (Pew Research Center 2015b). Mobile money is another e-service that is rapidly gathering momentum; it enables individuals to make and receive payments via mobile phone and has become commonplace in Kenya, Uganda, and Tanzania (Pew Research Center 2015a).

Using text messages or the Web requires a certain level of literacy, and not everyone owns a phone, so radio broadcasts have proved even more effective than newer technologies, especially when the content and timing of broadcasts are carefully considered. Popular and informative programs transmitted at appropriate times of day—such as early evening, when outdoor chores have been completed and women can listen, too—can bring about real improvements over a wide geographical area.

It is also worth noting that ICT can be beneficial in indirect ways. Farmers who are not online or familiar with using any new technology may still be reached through farmer-to-farmer information sharing, at which farmer organizations have already proved adept. Some have used digital multimedia equipment to produce teaching materials showing better farming or production practices. Slide shows, animations, and video footage of real farmers demonstrating new methods, particularly if the farmers are from the local area, appear to be much more effective in getting a message across than dry information presented by an “expert” from outside. In such cases, even though the actual users of technology are few, the benefits are enjoyed by a much wider group.

The same can be said when community radio is combined with text or voice contributions via mobile phone, where the audience as a whole is much larger than the number of participants. Regular, facilitated programs covering local issues, agricultural extension messages, and specific problems raised by farmers that can be answered by experts command a wide and receptive audience. The approach is inclusive as well, and with the interactivity made possible by texts and phone calls, the audience can influence program content.

Taking the idea a step further, the workings of farmer organizations could be made more transparent with regular programs covering recent activities and financial information. Leaders of farmer organizations could take questions from listeners and viewers, improving both awareness and trust.

A final point is that even proven technology can take time to be adopted fully, and adoption rates will differ according to complex factors in the underlying development and business environment. The rate of adoption also depends on the route chosen, and so far it is not possible to say which will be more successful in the longer term. For instance, dairy cooperatives in India are already benefiting from computerization based on commercial software systems, whereas similar cooperatives in Kenya are at an earlier stage, pursuing a different approach with open source software developed specially for that context.

Topic Note 8.1 discusses how farmer organizations have used ICT to help their members find better markets and share technical information, using examples from Zambia, China, and other countries.

Topic Note 8.2 looks at new approaches in which farmer organizations themselves are using ICT to provide value-adding

agricultural services for members and to offer more efficient, transparent accounting of transactions. The topic note also highlights the unexpected benefits of ICT, using examples from India and East Africa.

Topic Note 8.3 examines how ICT can give farmer organizations and their members a stronger voice. The lack of infrastructure—for electricity, mobile signals, and Internet connectivity—in rural areas has severely limited the means by which farmer organizations can receive communications from their members, but many organizations now have websites and use email and online discussion forums to interact with similar organizations and the wider world. Other alternatives to communicate farmers' views, locally and nationally, are rural radio and telecenters. Farmer organizations can also pursue their advocacy role by confederating, linked by ICT. The note provides examples of how farmer groups have used all of these strategies and innovative practice summaries from the Caribbean Small Island States and Africa.

Topic Note 8.1: FINDING BETTER MARKETS AND SHARING TECHNICAL INFORMATION

TRENDS AND ISSUES

The concept of farmer organizations is based on the notion of strength in numbers, of giving small-scale farmers the chance to punch above their weight and become entrepreneurs in their own right. The challenge, though, is to reach isolated farmers with the information they need to sell their produce at the best price and to grow more and better crops. Although an organization's headquarters can offer a business hub for members, many members live too far away to make frequent visits. Others are effectively barred from using the facilities because they speak a minority language or cannot read or write.

New communication technologies are vital for overcoming these barriers. They include technologies that help farmer organizations to maintain and expand ties with grassroots members, mobile phone technology to provide services, and ICT to facilitate certification and access to international markets. A persistent issue is how farmers and farmer organizations will pay for obtaining and providing technical and market information.

TECHNOLOGY TO MAINTAIN CLOSE TIES WITH GRASSROOTS MEMBERS

Smallholder farmers are some of the poorest people in the world, and they cannot afford to join a group that does not offer tangible benefits. Creating better links between farmer

organizations and their members is crucial if the organizations themselves are to flourish. Reliable flows of information between headquarters and the grassroots should boost trust and membership.

The challenge of improving links between farmer organizations and their grassroots members can be tackled using ICT, but in the poorest areas of developing countries where infrastructure is lacking and many farmers are illiterate, the technology must be simple and cheap. Most farmer organizations cannot afford to introduce new technologies, even when they can see the potential benefits, so they rely on partnerships with public and private sector institutions.

Despite the digital poverty in rural areas, evidence suggests that farmers, both men and women, are well able to learn to use relevant technology if they are taught in the local language and can see clear benefits from new ways of doing things. For instance, some of the nearly 2,000 women who work with a shea butter association in Burkina Faso have become financially independent by learning to use ICT applications, including GPS and the Internet, to reach a developed-country market for certified organic shea butter. Another promising idea is for a farmer organization to communicate with members to create a database on crops and productivity. Backed by reliable historic production figures and sound projections of possible

future yields, the organization would be in a better position to access credit for its members—a valuable service.

Many small-scale producers struggle to access up-to-date technical information, but experience in Burkina Faso and elsewhere shows that farmer organizations can use new types of ICT to provide advice and services tailored to members' needs. For example, box 8.2 describes a project in Uganda designed to test a satellite-based information service for farmers that farmer organization themselves will ultimately own and manage. Using local languages and photos or moving images are effective ways of reaching poorly educated farmers. ICT has revolutionized the means of disseminating information to such an audience, although a facilitator is often needed as part of the process.

MOBILE PHONE TECHNOLOGY DELIVERS MARKET INFORMATION AND OTHER SERVICES TO MEMBERS

A major service provided by farmer organizations is to improve members' access to market information, and the advent of mobile phones, short messaging service (SMS), text messaging, interactive voice response (IVR), and apps has exponentially increased their capacity to do so (see the description of the Agricultural Commodity Exchange, ACE, for Africa in box 8.3). Module 9, which focuses on the use of ICT in marketing, discusses many aspects of these issues; this topic note concentrates on how farmer organizations have used ICT to gain an advantage in marketing and information sharing.

BOX 8.2. The Market-Led, User-Owned ICT4Ag-Enabled Information Service (MUIIS), Uganda

Market-Led, User-Owned ICT4Ag-Enabled Service (MUIIS) is an innovative project that harnesses the power of satellite data to support extension and advisory services for Ugandan farmers. The project is being implemented by the Technical Centre for Agricultural and Rural Cooperation (CTA) in partnership with the Alliance for a Green Revolution in Africa (AGRA), aWhere Inc., the East Africa Farmers' Federation (EAFF), Environmental Analysis and Remote Sensing (EARS) Earth Environment Monitoring (EARS-E2M), the eLEAF Competence Center (eLEAF), and Mercy Corps, Uganda.

The MUIIS project runs from September 2015 to August 2018 with support from the Dutch Ministry of Foreign Affairs (MFA) through the Geodata for Agriculture and Water (G4AW) Facility of the Netherlands Space Office (NSO). A critical component of the project is to build capacity in the participating farmer organizations to own the information service and provide services to their members. When support from the project ends, MUIIS is to be owned by EAFF and its national partners—the Uganda National Farmers Federation (UNFFE) and the Uganda Cooperative Alliance (UCA)—with revenue-sharing agreements with other cooperation partners.

The MUIIS project is designed to provide timely, accurate, and actionable information regarding crop management and climate risks so that participants can meet the production and postharvest demands of selected value chains in Uganda. The project also has a proof-of-concept function, seeking to demonstrate that satellite data-enabled extension and advisory services can increase farmers' productivity by about 40 percent. MUIIS was inspired in part by the globally acclaimed success of a farmer cooperative in India that provides "ICT4Ag" (ICT services for agriculture); it was also inspired by the fact that several mobile platforms have been taken to market in Uganda and attracted users who are willing to pay for agricultural and financial information services.

The information service consists of three bundled information products related to (1) weather forecasting and alerts, (2) crop management and agronomic tips, and (3) financial services (including index-based insurance). The service is expected to reach over 350,000 maize, soybean, and sesame farmers in central, eastern, northern, and western Uganda. The main distribution channel for the three information products is Ensibuuko's Mobile Banking and Information Software (MOBIS), operating in collaboration with Mercy Corps. The information service eventually will be complemented with the e-Granary platform (box 8.7) being developed and managed by EAFF in Kenya. The platforms will be supported by about 200 ground agents (farmer leaders) equipped with smartphones loaded with content. Revenue streams will include subscriptions by groups (via farmer organizations), third-party international development partners, and individual farmers; farmer profiling; sales of data products; surveys and data collection; advertisement; quantity discount; premium finance; and index-based insurance.

Source: CTA, <http://www.cta.int/en/news/muiis-project.html>.

BOX 8.3. Using ICT to Access Market Information: Agricultural Commodity Exchange for Africa (ACE), Malawi

The electronic ACE Platform consist of five independent services that are interlinked and interact with each other. The platform provides farmers, traders, food processors, and other stakeholders with access to real-time market information, collateral financing, structured trade, and formal markets. The five systems are:

1. The trading system, which allows buyers or sellers to submit bids and offers, respectively, and sends notifications instantly through texts and email. A buyer or a seller can accept the bid/offer to generate a formal contract on the system. The contract can then be tracked online until its settlement.
2. The Bid Volume Only (BVO), which is a reverse auction that provides a commodity price discovery tool for big buyers such as the World Food Programme. The buyer needs only to specify the details on the commodity and volume they would like to purchase without indicating the price. Sellers compete on the price until the auction closes. Users can access the BVO in real time through the ACE Android App or the Internet.
3. The Warehouse Receipt System, which is a collateral management and financing tool. Storage Operators manage the commodity deposited into an ACE-certified warehouse and issue an electronic Warehouse Receipt (WHR) through the ACE Android App or the Internet. The WHR can then be used as collateral to get financing from a bank. The system keeps track of storage costs, loans, and any other lien against the WHR.
4. The ACE network of rural trade agents, who collect market prices from the major rural markets across Malawi on a weekly basis. This information is uploaded to the Market Information System using the ACE Android App and sent to subscribers in the form of text messages. Users can subscribe to receive prices by selecting their preferred commodities and markets.
5. The Market Information System, which is to become an open-interface, nationwide farmer database. This database will give the government and other stakeholders—such as development partners, farmer unions, and NGOs—a chance to track accurate farmer statistics, including data on crops grown, household demographics, commodities stored and traded, and national market price information. The database will also help track from which interventions farmers and other target groups have benefited, when multiple actors work in the same area (such as agricultural NGOs, extension services, and ACE).

Sources: Peter Pemba; <http://www.aceafrica.org>.

Among farmer organizations, text messaging systems, voice/IVR systems, and smart apps are proving their worth by enabling farmers to compare prices in different markets and to take a stronger negotiating position when selling their produce. Some farmer organizations have opted to use platforms such as Esoko and Farmerline (box 8.4 describes how Farmerline uses voice messaging to overcome literacy barriers in sharing agronomic and marketing information). Other farmer organizations have set up their own services. Some large organizations, such as the Zambia National Farmers Union (ZNFU) and Indian Farmers Fertilizer Cooperative Limited (IFFCO), have developed message systems using commercial routes (see box 8.5 and the Innovative Practice Summary, Zambia's National Farmer Organization Develops Text-Based Service"). Smaller farmer groups have used free open source software such as Mobile Information Platform (box 8.6 describes the efforts of a very small cooperative in Chile) or FrontlineSMS,

which provide options for sending bulk messages. (For more detail, see Module 3.) Another example is the e-Granary system, developed by the East African Farmer's Federation (EAFF), which helps aggregate farm produce and in the process helps link farmers to buyers (see box 8.7).

FrontlineSMS (Banks 2009) is software that effectively turns a computer and mobile phone into a two-way, group text messaging hub that does not need Internet connectivity. Devised to enable information to flow to election monitors, news agencies, and humanitarian NGOs, the system is proving adaptable to the needs of farmer groups.

In El Salvador, for instance, where farmers in general have no access to computer-based information services but where there are more than 50 mobile phones for every 100 inhabitants, the Agricultural Technology Innovation

BOX 8.4. Farmerline's Voice Messaging Service Empowers Female Smallholders in Northern Ghana

The Greater Rural Opportunities for Women (GROW) project, funded by Mennonite Economic Development Associates (MEDA), seeks to assist at least 20,000 women to increase their soybean production and forge better market links to increase their income. Since 2014, Farmerline, a technology and content provider, has been helping farmers to receive location-specific weather alerts along with information on good agricultural practices, financial literacy, and market prices. Farmerline uses an innovative mobile communication and data collection platform to provide this relevant, timely, location-specific information in local languages to eight Village Savings and Loan (VSL) groups based in the communities of Piina/Nandom, Tumu, Vamboi, Tarsor, Naabugubelle, Dorimon, Poyentanga, and Ga in Ghana's of the Upper West Region.

Literacy in English and other local languages is a big challenge in these communities. Farmerline's innovation is that its platform (mergdata) supports voice messaging to deliver information. In this way, farmers have obtained valuable help to improve production and market their produces at better prices. To ensure that these women continue to benefit from the service, each farmer can subscribe directly to the platform and pay for a bundle of information services using mobile money.

Source: Farmerline (www.farmerline.org).

BOX 8.5. India's IKSL: Potential to Reach a Vast Farmer Base with Interactive Agro-Advisory Services

The Indian Farmers Fertilizer Cooperative Limited (IFFCO) has a membership exceeding 40,000 cooperative societies and an estimated base of 50 million farmers. These farmers are not only consumers of the fertilizers produced by IFFCO's various plants; they are also the owners of IFFCO through the share contribution system of their respective societies. Apart from distributing quality fertilizer to farmers through the cooperative societies, IFFCO organizes various promotional activities so that farmers can acquaint themselves with the latest technology in agriculture. IFFCO undertakes a large number of conventional agricultural extension activities to this end.

To more effectively leverage technology for the benefit of farmers, IFFCO launched a joint venture called IFFCO Kisan Sanchar Ltd (IKSL) in 2007 in association with Star Global Resources and Bharti Airtel. IKSL's mission is to empower Indian farmers by converting the ubiquitous mobile phone into a powerhouse of knowledge. IKSL uses mobile phone technology to provide timely, relevant agro-advisory services to farmers to improve their incomes, reduce cost, improve yield, reduce wastage, enhance quality, expand their markets, and educate them on issues such as health and the environment. Agricultural advice is provided as voice messages in local languages to ensure that even illiterate farmers can benefit.

The IKSL model is simple. It is based on the idea of engaging with farmers by showing them how to use their mobile phones in two new ways. The "push" approach ensures that farmers receive the latest updates and advice that are immediately relevant to their situation. The information is provided in the form of 1-minute voice messages in the pertinent local language or dialect. These voice messages are provided free of charge to IKSL Green Card subscribers. The "pull" approach provides an opportunity for farmers to call a helpline to request additional information about the data they have been provided with or seek solutions for their specific problems. The IKSL Green SIM Card is marketed mainly through farmer organizations, and the card's services have been offered through this model since 2007. This example shows how farmer organizations have managed to effectively use ICT to provide service to their members.

Source: IFFCO Kisan Sanchar Limited (IKSL), <http://www.iksl.in/>.

Foundation is promoting the use of mobile phones to encourage farmers to exchange information and strengthen market links. With 600 subscribers who pay only for the information they receive, the pilot project is currently supported by the cost of calls.

In Aceh, Indonesia, FrontlineSMS is used to send information to small-scale producers. A team gathers a range of information, and the data are entered into a computer running the program. The latest prices, input costs, and weather forecasts are sent to groups of producers and others in the agricultural sector.

BOX 8.6. Chile's Coopeumo and the Mobile Information Project

Coopeumo, a Chilean farming cooperative with fewer than 400 members, uses text messages to help small-scale farmers increase productivity. This area of Chile, south of Santiago, has good soils and climate, but smallholders are at a disadvantage compared to larger enterprises because it is not easy for them to access specific information on markets, technology, and weather that could boost production. The low population density and low incomes in the area make it difficult for private service providers to offer connectivity. This “digital poverty” has been noted in Chile, where the government is keen to promote social equity, and agricultural exports are an important part of the country's economy.

Through the Mobile Information Project (MIP), farmers now receive research findings and news (including market prices and weather forecasts) directly from the Internet on their mobile phones. Weather updates are particularly useful to farmers at critical points such as planting and harvest. The MIP software works on the cheap phones (US\$15–20) that farmers tend to use and is effective over slow networks.

Several organizations implement MIP:

- The Foundation for Agrarian Innovation (FIA, Fundación para la Innovación Agraria), is a Chilean governmental agency that works closely with agrarian communities to understand their information needs and to locate, edit, and/or create appropriate content to meet those needs (e.g., resulting in the creation of micro weather stations). FIA is therefore a key partner responsible for sending a content stream of locally relevant information.
- The United Nations Educational, Scientific, and Cultural Organization (UNESCO) is responsible for financial support and provides educational content.
- Coopeumo, a cooperative based in the town of Peumo, is responsible for local implementation of the project among cooperative members.
- Entel PCS, a Chilean telecommunications company, is helping support the project with the technological platform, telephony equipment, and competitive pricing for mass text messaging.
- The national Chilean newspapers *El Mostrador* and *El Mercurio* supply news feeds, among which users can choose preferred news streams.

Sources: Authors; Cagley 2010; Datadyne (<http://datadyne.org/programs/mip/>).

BOX 8.7. The e-Granary Platform of the Eastern Africa Farmers Federation

The Eastern Africa Farmers Federation (EAFF) has a new platform, e-Granary, that seeks to dramatically improve the way farmers do business in Uganda and Eastern Africa as a whole. EAFF members are being registered onto the system. The EAFF chief executive officer (CEO), Stephen Muchiri, has noted that the main idea behind e-Granary is to position farmers in the market for the purposes of obtaining better prices or bigger market shares using the mobile platform to help aggregate production from farmers.

The system is easy to use. Farmers interact with the platform, which has a registration component and can therefore identify a farmer by location, farmer group, gender, age, and commodity. The platform allows farmers to choose between commodities—about five—and they are able to key in information on planting and harvest.

The e-Granary system was developed as a result of two meetings organized by the Technical Centre for Agricultural and Rural Cooperation (CTA) in 2013 (Rwanda) and 2014 (the Netherlands). These meetings involved two farmer organizations—EAFF and the Indian Fertilizer Farmers' Co-operative (IFFCO). At the Rwanda meeting, IFFCO made a presentation on a very successful mobile and Web-based aggregation platform, which captured the interest of EAFF because it was already seeking a platform to help farmers aggregate produce and, in the process, link farmers and trade associations to national and regional buyers through the use of ICT.

Source: <http://www.eaffu.org/egranary>.

Farmers say they like to have a base price on which to start negotiations with buyers. They also report that as they learn the range of price fluctuations for each product, they are better able to choose which crops to grow.

An even more low-tech approach is used by the First Mile Project in Tanzania (IFAD n.d.). The project supports a group of “market spies” to gather market intelligence and share it with farmers (“Bahati Tweve: The Honest ‘Middleman’ Brokering Deals,” *New Agriculturalist* 2008). This intervention is based simply on phone conversations, text messages, face-to-face meetings, and village notice boards, but it has helped build market chains and put farmers in a stronger position when selling their produce. After support from project funding comes to an end, the spies aim to cover their costs by charging a commission to link buyers with producers. Other possible ways to generate revenue might be to charge a small fee for advertising on information boards and for storing produce.

Mobile market information has a number of benefits. At the very least, a smallholder armed with information on current prices has a better chance of negotiating a good deal for his or her produce with passing traders. Smallholders also value and use information on the price of inputs from different sources and on the whereabouts of the nearest buying center. Although household responsibilities keep many women close to home, if they can discover the best markets for their produce via a text messaging service, they can maximize their income.

Services for sending and receiving cash via mobile phone—such as M-PESA, which has 13.9 million active customers per day in Kenya (see Safaricom 2015)—make it easier for farmer organizations to provide other services, such as selling inputs and arranging more convenient payments for produce. For example, in 2015 Zambia launched a project¹ in which participating farmers register to receive prepaid mobile phone e-vouchers worth about US\$50 to purchase inputs from agro-dealers² (see Module 9). Farmer organizations may be able to develop similar arrangements with input suppliers.

Technology for International Certification and Markets

Farmer organizations are using ICT not only to provide local and national market information to members but also to increase their international reach. The lure of lucrative international markets, such as those for organic or Fair Trade products, can be a strong motivation for farmer organizations to master ICT in the first place. Anecdotal evidence from some organizations shows that they can reach this ambitious goal even if their members have little formal schooling (image 8.1).

Many women belonging to the Song-taabaYalgré Association, a shea butter trading group in Burkina Faso, never attended school but confidently use ICT tools and the Internet (Soré n.d.). The group has had a French-language website since 2004³ and handles 90 percent of its sales through the Internet, sending shea butter products to Europe, Canada, and the United States.

The website describes the background of the producer group and lists the various products formulated using shea butter as well as the chemical ingredients of these products. Largely through their website, the women have strengthened their position in the marketplace. As Noëlie Ndembe, the head of MIPROKA (the national shea information and promotion center), has said, “To be on the Net is to be seen everywhere in the world” (quoted by Soré 2008).

IMAGE 8.1. Women’s Cooperative Processing Shea Butter in Ghana



Source: Jonathan Ernst, World Bank.

1 ITWeb Africa, “Zambia: Govt Launches e-Voucher System for Farmers,” <http://www.itwebafrica.com/enterprise-solutions/692-zambia/235317-zambia-govt-launches-e-voucher-system-for-farmers>.

2 The scheme is a joint venture between the Zambian government and FAO, funded by various donors.

3 <http://www.songtaaba.org>.

A particular selling point for this shea butter (a sought-after ingredient for beauty products) is its certification under Bio-Ecocert and Bio-NOP, which guarantee that a product is 100 percent natural and has been manufactured under conditions that respect human and environmental health. GPS technology has been essential for recording the source of the shea fruit and thus assuring distant customers that the certification is genuine.

Website development and related training in the technology were done in partnership with MIPROKA. Two village telecenters were set up, each with several computers linked to the Internet, a scanner, a photocopier, and a telephone. Technical training had two elements: (1) how to produce shea butter to the exacting purity and cleanliness standards demanded of an export product; and (2) how to use ICT tools, including GPS and computers. Other facets of the training included better ways of marketing the product, as well as environmental and energy awareness.

Moré, the local language, has been used throughout, and the trade group produces an in-house bulletin that also appears in Moré. The bulletin gives information on the group's activities and on the production of organic shea butter.

Despite some literacy barriers, many women have learned to use GPS equipment to map their fields and record each tree from which they harvest shea fruit. A small group was initially taught by an expert from Europe, but they can now train other village women in the GPS and mapping skills that are vital for certification. As an incentive to capture all relevant GPS data each time, the women earn a small bonus if they do it without mistakes. Careful recordkeeping and good production techniques allow the women to sell their "bio" shea butter at more than twice the price of uncertified shea butter. Even the raw shea fruit is worth more if it is certified as coming from approved fields.

Lessons Learned

Although ICT can certainly improve connections between farmer organizations and their members, farmer organizations are unlikely to be early adopters of this technology. Organizations of small-scale producers in particular are likely to need support to try new systems and learn how to make them cost-effective. It is worth remembering that farmers can be reached by channels other than ICT; prices can be published in newspapers, broadcast on the radio, or simply chalked on boards in markets or farm supply shops.

Text messaging systems require a level of literacy that is often rare in remote rural areas, and the limit of 160 characters per

text message can make it a challenge to provide certain kinds of content. Newer versions of software such as FrontlineSMS, IKSL, and mergdata⁴ have become platforms for multimedia communication by incorporating audiovisual capabilities. Other software and hardware designers are also developing products that are more intuitive to use and employ audio and video. One benefit of using a common, open source platform like FrontlineSMS is that users can easily share experiences, which in turn should lead to improvements.

Studies of a range of agricultural market information systems in Sub-Saharan Africa suggest that disseminating information by mobile phone creates interactivity between the system and its users.⁵ Where users choose the information of interest to them, a wider range of information can be offered without inundating users with valueless data.

It is worth pointing out that mobile phone communication continues to be an effective way of sharing market prices. Several studies corroborate the view that mobile phone coverage can improve market efficiency (see Module 9).

The question of how information systems that rely on mobile phones can pay for themselves may be finding some innovative answers. Prospective solutions include pay-per-use and subscription models, leveraging the adoption of mobile money systems for payment. These models are still in the early stages of development, however, and the evidence of farmers' readiness or ability to pay for information services remains scant. In India, early results from research attempting to quantify the impact on farm profitability of a subscriber-based, local-language information service suggest that farmers cannot afford it.⁶ Farmers say they cannot pay, despite claiming to have negotiated better prices for their crops, spent less on inputs, and enjoyed overall better income. The package costs about US\$1.50 per month, for which the subscriber gets 75–100 texts. Each subscriber shared the information with about seven other people. Only about half of the subscribers planned to renew their package. Almost all of those who had not bought the service said that cost was the reason.

In Zambia, the ZNFU admits that although there is huge demand for its text-based market information system (see "Zambia's National Farmer Organization Develops Text-Based Service"), the system does not yet pay for itself and cannot yet be expanded. One possible revenue-raising mechanism

4 See <http://farmerline.org>.

5 Agricultural Market Information Systems in Africa: Renewal and Impact." Unpublished summary of workshop held March 29–31, 2010, Montpellier, CIRAD—UMR MOISA.

6 Grahame Dixie, World Bank, personal communication.

for ZNFU and similar schemes might involve transportation companies. Recognizing that after trucks make a delivery it is inefficient for them to return empty, truck owners might be willing to pay for information to find return loads. Other revenue-raising possibilities might include charging for arbitrage or brokerage services.

The experience in Chile (box 8.6) suggests that disseminating information via simple mobile phones is a good way to reach farmers in areas where Internet facilities are unlikely to be provided in the near future. Since the pilot project closed, Coopeumo has taken on the responsibility and costs of creating and sending the text messages. Farmers do not pay directly—the charges are included in the membership fees they pay to the cooperative. Refinements to the system should make it easier to provide relevant content to each individual. The goal is to tailor the content automatically (a human editor would slow the service).

A concluding lesson is that farmer organizations and their partners may find it challenging to use ICT in the absence of a supportive regulatory framework for the technology. Mobile phone networks are subject to varying degrees of bureaucracy, taxation, and government regulation in different

countries, and any proposal to set up a messaging service using mobile phones must comply with prevailing rules. When ZNFU was setting up its market information system, the fact that Zambia had not finalized its ICT policy was regarded as slowing development of the ICT industry.⁷

In many African countries, providers of new mobile services must use intermediaries to get a short code for customers to dial, and many governments see phone companies as sources of easy tax revenue. Competition and the development of new infrastructure are often limited by restricting licenses to new operators (see Module 3). Mobile communications are thus more expensive in Africa than they need to be.⁸

Kenya is a notable exception. Its good regulatory environment has led to competition and reduced the cost of mobile phone tariffs (World Bank 2010). See box 8.8 for additional considerations for designing effective ICT interventions for farmers' organizations.

7 Unpublished summary of the meeting of the Agricultural Thematic Group (part of the e-Brain Forum of Zambia), "e-Agricultural Marketing—What Are the Issues?" on October 27, 2006 in Lusaka.

8 *The Economist*, "Not Just Talk," <http://www.economist.com/node/18008202>.

BOX 8.8. A Checklist of Considerations for Designing an Effective, Sustainable, ICT-Based Project to Support Farmer Organizations

- What are the levels of literacy, mobile phone ownership, and willingness of farmer organization members to embrace new technology? Many smallholders cannot afford phones, do not know about texting or voicemail, or cannot punch a message into a phone keypad.
- How well can farmers understand market information and use it to their advantage?
- What is the role of smallholder farmers' organizations in this context? What capacity is required for them to be effective?
- How will the most vulnerable members of the organization be included? Some people might be too poor to pay for information or might live outside the range of mobile phone coverage. Women may be less likely to have access to a phone.
- What information is best disseminated using which media—text, interactive voice response (IVR) / Voice, video ICT-enhanced training workshops?
- Do different categories of farmers need different information? Large-scale farmers have different interests than smallholders, but both groups may belong to the same organization.
- Are there transportation links to the different markets? Information is of no use unless farmers can get their crops to the market of their choice.
- Can farmers store crops safely and without spoilage after harvest? Otherwise they are in no position to delay selling until prices are optimal. Market price information has little value here, so improved drying and storage facilities might need to go hand in hand with a market information system.

(continued)

BOX 8.8. continued

- What sources of information do farmers need? Sources are likely to include research bodies, government extension services, news media, the Internet itself, other farmers, other farmer organizations, and private seed or input supply companies.
- How should information be sorted to be most useful for the recipient? Text messages have a 160-character limit, so it is a challenge to prioritize messages.
- Who will be responsible for selecting and sorting information, and how can quality control be maintained?
- How will the costs of the service be covered?
- What is the level of cooperation offered by mobile phone companies? How well might rival companies work together?
- What is the appropriate software? Is free, open source software such as FrontlineSMS the way forward?

Source: Authors.

INNOVATIVE PRACTICE SUMMARY

Zambia's National Farmer Organization Develops a Text-Based Service

ZNFU's messaging system is an easy-to-use service that announces prices via text to mobile phones and the Web.⁹ ZNFU introduced the system with support from the main mobile phone network provider in Zambia, several other local organizations, many farming cooperatives, the agribusiness chamber, and buyers and sellers. The mobile phone network provider organized the bulk messaging process to deliver the information to as many mobile phones as possible, and it offered several hundred half-price mobile phones to farmers. The Smallholder Enterprise and Marketing Program gave additional funding and technical support.

Starting with details of just 6 commodities in 2006, the system now deals with 14 commodities and sends 1,000 messages each month. Pamela Mulozi, the market/trade information administrator at ZNFU's head office in Lusaka, reported "a significant change in how farmers and traders are dealing with each other" and observed that traders "are now taking the farmers much more seriously as trading partners" (Goudappel 2009).

More than 200 buyers use the system, giving farmers a wider set of options for selling their produce. Another measure of success is the fact that food-processing businesses, government ministries, and banks regularly use the system to provide broader support to the country's agricultural sector. Each commodity, trader, and district has a code. ZNFU supplies everyone using the system with a small information card

with instructions and relevant codes and trains them to use the system. Farmers wanting to know the price of a particular product simply type the code into a text message and send it to the specified number. The system sends back another text with the latest prices and the codes for the traders offering those prices. The farmer chooses a trader and sends the code in a second text to the system, which replies with the trader's full name, phone number, business address, and directions. The farmer can then contact the trader directly.

To make the information available to farmers without mobile phones and in areas lacking network coverage, ZNFU trains at least one farmer in every district to act as a contact farmer. Contact farmers, based in district offices, publish the commodity price and trader information that they get either via text (SMS) or from the website and give it to extension officers. Every week the extension officers display the prices and details of interested traders on posters in local information centers.

So far the system seems successful and popular with farmers. For instance, Grace, a farmer involved with the scheme, said, "The SMS system makes everything so much easier. You can check the market on your phone to find the 10 best prices in the district or even in another district if that works out better for the transport cost" (Goudappel 2009). Farmers coordinate their delivery times and organize a single location for traders to pick up goods in bulk, saving many individual farmers from traveling to the Lusaka market.

This arrangement saves money and gives farmers more time to work on the farm. Grace said, "Although we still pay for the costs of the SMS messages, we end up spending only 5,000 kwacha" (just over US\$1), adding, "It's a big saving but it also reduces a lot of the risk involved with travelling to the city every time" (Goudappel 2009).

9 This summary is based on Goudappel (2009) and personal communication with Pamela Mulozi, market/trade information administrator, ZNFU.

Despite this initial success, which means that ZNFU would like to extend the trading system to more farmers, any immediate expansion is limited by the lack of funding. Hamusimbi Coillard of ZNFU observed, “We still have to work out how the system will pay for itself.... If we can use the SMS system to link up farmers and other small traders to the trucking companies, then both sides would benefit and we would gain more subscribers to the scheme” (Goudappel 2009). If another network operator, MTN, joins the scheme, coverage will reach more communities.

ZNFU E-extension is an addition to the existing ZNFU 4455 SMS price information system, which has been operating for over eight years. The ZNFU E-extension service provides farmers with up-to date market price information for 17 agricultural commodities. It is meant to tackle key information and extension constraints by making practical agricultural information available to the farmer. The service uses Unstructured Supplementary Service Data (USSD) and can be accessed via mobile phone by dialing a dedicated short code, *880#. It is the Union’s approach to embracing new types of ICT that will bring about new, catalytic, and cost-effective development of agribusiness based on the provision of information.

The E-extension system interacts with users by presenting menus from which the user selects an option to receive specific types of agricultural extension information and tips. In this way farmers can obtain agricultural information relevant to their location without having to travel or search for it. Farmers can also benefit from vital information about crop field practices and on identifying, preventing, or treating crop-specific diseases and pests. Tips on livestock production and information on livestock diseases that require particular vigilance may also be obtained from the extension platform.

The information menu does not end there. Farmers can also obtain weather data and alerts on disease outbreaks, theft, new legislation, and business opportunities. The ZNFU E-extension system also makes contact information available for government extension staff, ZNFU field staff, and others with an important role in the agricultural sector (such as agro-dealers and other input suppliers), allowing groups of small-scale farmers to locate and contact service providers in their area. With recent developments in the mobile phone industry in Zambia, cell phone use by small-scale farmers is continually expanding. The opportunity to use mobile phones as a platform to provide extension information to facilitate direct communication between extension service providers and farmers remains immense.

For additional information: www.znfu.org.zm; www.farmprices.co.zm.

INNOVATIVE PRACTICE SUMMARY

The Sounong Search Engine for Farmer Organizations in China

A good example of how ICT enhances farmer organizations’ access to knowledge comes from a project in China, where a priority is to make ICT accessible and useful for farmers. The project—Construction and Popularization of Agriculture Info-Service System—introduced in Anhui Province, has three main features: an Internet portal, information assistants, and information dissemination models. It targets specialized farmers’ cooperatives, a primary force for agricultural development in China. The project is funded by the World Bank and implemented by the Hefei Institute of Physical Sciences of the Chinese Academy of Sciences.¹⁰

The Institute of Intelligent Machines developed an Internet search engine called SOUNONG to aggregate information and provide it to farmers’ cooperatives in a meaningful manner (figure 8.1). SOUNONG coordinates with China’s governmental agricultural websites, which maintain high user rates and have more authority to promote information. This multilateral collaboration has helped raise the visibility of SOUNONG and its activities and to prevent overlap.

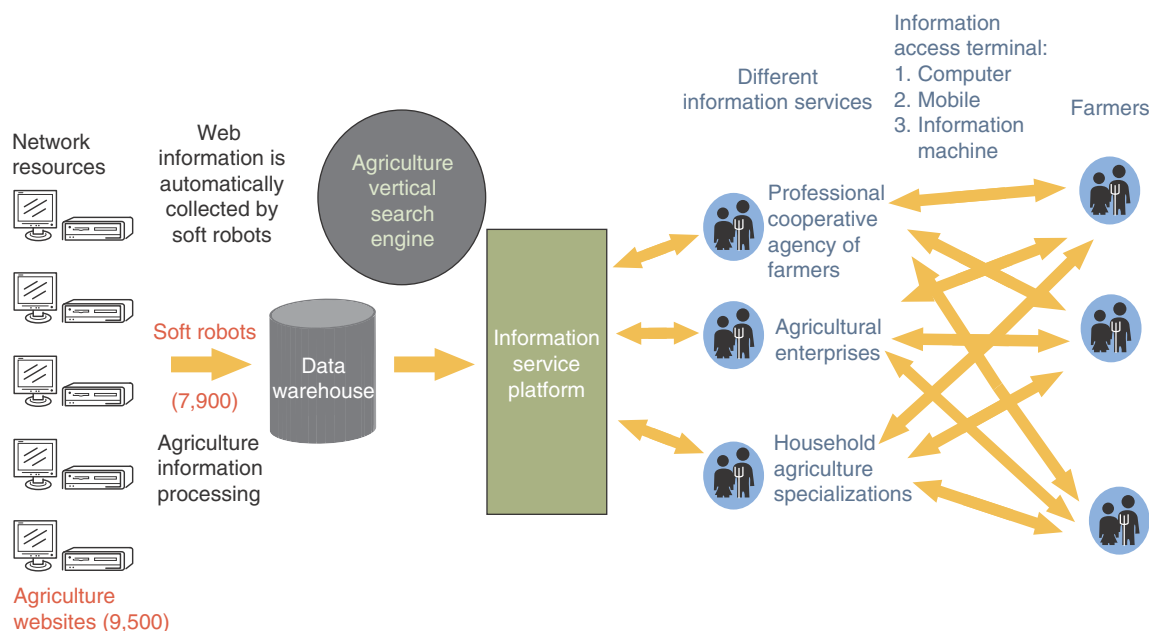
SOUNONG monitors over 7,000 websites per day, including nearly all of China’s agricultural data. These sites contain information on prices of wholesale farm products, prices in 9,000+ markets, and prices for 20,000 types of agricultural products. Information is also retrieved from a number of databases, including those on climate, crop species, and pest and disease diagnostics.

Electronically generating a short list of agricultural information from this array of websites reduces the time spent collecting it manually. In 2009, 1,276 households were using the site—and by 2010, that figure had almost doubled.

Once the website was launched, project leaders selected 38 farmer organizations to act as partners. The organizations were well established and had good management, which suggests that it may be critical for farmer groups to meet certain criteria to become involved in ICT for agricultural development.

A total of 76 information assistants, who are responsible for collecting and disseminating information, as well as 541 farmer households, were trained to use computers to search,

¹⁰ Information gathered from SOUNONG 2010, Institute of Intelligent Medicines.

FIGURE 8.1. Conceptual Technological Framework for the SOUNONG Search Engine

Source: Adapted from SOUNONG 2010, Institute of Intelligent Machines.

browse, download, and disseminate information through the Internet. As the project grew, over 1,000 members of cooperatives received ICT training (figure 8.1).

Members of farmer organizations can access information from the SOUNONG site through computers, mobile phones, personal digital assistants (PDAs), and PDAs plus mobile phones. Depending on network connections, regional characteristics, and farm conditions, farmers can select the appropriate option for their local network capacities and skill level. All of the options provide low-cost, easy access to the SOUNONG site. For members who may not have access to computers, mobile phones, or PDAs, cooperatives can also print information and recommended actions.

Surveys found the mobile phone option to be popular as a result of its timeliness and convenience. The mobile phone option is consumer friendly—farmers have both “push” and “pull” alternatives to obtain information. The computer option was also popular because users could browse and select specific information. Network coverage is not a problem in rural Anhui Province, but Internet service remains more expensive than mobile phones, and Internet users must become adept at identifying irrelevant or misleading information.

Success stories are common, including success in livestock disease identification and control (image 8.4). For instance, in 2010, farmers in TaihiJinqiao Cooperative recognized that a

IMAGE 8.2. ICT Programs Like SOUNONG Help Cooperatives Identify Livestock Disease

Source: Steve Harris, World Bank.

number of their pigs had high fevers. The information assistant released the information onto SOUNONG. Veterinary experts diagnosed fatal swine high-fever syndrome and provided control methods that prevented potential losses of 1,000,000 yuan (Y) for the farmer group.

TaihiJinqiao extended sales of their local chicken breeds to poultry markets like Nanchang and Wuhan by using the SOUNONG website. Smaller cooperatives producing pork have used SOUNONG to reach major markets like Shanghai.

SOUNONG attracted additional cooperatives, entrepreneurs, and farmer households and led to the development of more

specialized services for farmer organizations. Websites were developed to provide information for specific producer organizations; for example, the Agriculture Committee in Anhui Province formed an Anhui Farmers' Specified Cooperative website.¹¹ The Taihi County Government gave ¥ 24,000 to the Jinqiao Cooperative to generate an online platform enabling more discussion and real-time information sharing between members.

The Anhui Fengyuan Agriculture Science and Technology Co. Ltd. was selected to monitor and evaluate the project and its development over time. The company continuously examines the practicality, effectiveness, degree of user satisfaction, and public welfare (the four main indicators) of the Construction and Popularization of Agriculture Info-Service System. A key lesson is that farmers require training to use the information they access appropriately. Those involved in the project note the challenges associated with introducing ideas and technologies that have major learning curves for users.

INNOVATIVE PRACTICE SUMMARY **Field Data Collection Tool for Certified Farmer Groups in Sustainable Agriculture**

Tony's—a Dutch manufacturer producing certified Fairtrade Chocolonely chocolate bars—became popular in the Netherlands because of a successful television program about child and forced labor in cocoa production in West Africa. Through its “Crazy about chocolate, serious about people” mission, Tony's aims to achieve a 100 percent slave-free chocolate industry.

Because this goal is ambitious, and because Tony's had to be able to make accurate claims about its products, the company needed to monitor progress toward reaching its objective. The company recognized that the key to measuring improved conditions on cocoa farms and in cocoa farming communities was for farmer cooperatives to collect timely, accurate field data on a series of development and sustainability indicators. And the key to collecting those data was to strengthen and, where needed, implement the use of ICT tools by cocoa cooperatives.

In collaboration with the Max Havelaar foundation (Fairtrade Netherlands) and with support from the Dutch Postcode Lottery, Tony's initiated a project in 2014 to improve the use of ICT by the farmer cooperatives that produced and supplied the company with certified sustainably produced and

Fairtrade cocoa beans.¹² This project is part of a larger project with the primary goal of improving the well-being of children and young people from three Fairtrade-certified cooperatives in Côte d'Ivoire and Ghana. One of the project's desired outcomes is an improvement in the ICT systems used by the cooperatives.

Voluntary Certification Programs and Sustainable Agriculture

In recent years, sustainable cocoa has taken off in West Africa. Dozens of cooperatives have been certified as complying with Fairtrade or sustainability practices (such as UTZ Certified and Rainforest Alliance). These cooperatives are often federations of smaller organizations. They can have thousands of members, many living in very remote rural areas.

After more than a decade of programs and projects to implement sustainability standards, certain questions are being raised about their impact. What have they achieved? How did they improve the livelihoods of farmers and their families? What is the added value of these programs for farmers, who must spend more than five years becoming certified? One conclusion of these discussions was that improved collection and management of data on certified farmer cooperatives would help to meet the need for “big data” for assessing impact.

Pilots

Before rolling out the project to the entire group of cooperatives—comprising about 12,000 cocoa farmers—the project started with two pilot groups of 500–600 farmers, one in Côte d'Ivoire and one in Ghana. With the lessons learned from these two pilots, the project was to be extended to all farmers of both cooperatives in early 2016. It was expected that the project would reach almost 20,000 children in the cocoa-growing regions of both countries.

For this specific project, Tony's used AuditAide,¹³ a data collection and management solution specifically designed for producer organizations that engage in group certification of larger farmer groups. AuditAide includes data collection tools, data processing and analysis software, a custom-built management information system (MIS) for membership-based organizations, and training materials for farmers and field staff to learn the skills to scale up the IT capabilities of cooperatives in data collection and data management.

¹¹ <http://www.ahhzs.com>.

¹² www.tonyschocolonely.com.

¹³ www.audit-aide.com.

Benefits and Impact/Experience to Date

To date, the project has achieved some noteworthy results. An important achievement is that the pilot cooperatives, as part of their certification programs, improved their Internal Management Systems (IMS) by developing a well-considered data collection system and materials to train farmers to comply with Fairtrade, Rainforest Alliance, and UTZ Certified standards. The most important training tool was an Internal Standard combining the three different standards into one compact, easily understood standard. The Internal Standard also contained illustrations for each criterion to make sure that illiterate farmers were included. In the AuditAide methodology, each criterion in the Internal Standard refers to a question in the internal inspection form that helps to monitor compliance with standards. Each of the answers that can be chosen reflects a possible scenario in the field. The scenarios were determined jointly by the project partners.

A second important achievement was to implement Poimapper, a mobile data collection tool, and train field staff to use it.¹⁴ Poimapper was selected for several reasons. Its mobile client and online portal are easy to use. The mobile application provides several forms to collect accurate field data instantly. The project preferred a mobile application, because it was important to identify issues quickly on the ground, such as the use of child or forced labor or unapproved agro-chemicals. After the data are collected, the data in the portal are cleaned up and imported into AuditAide for further reporting at the IMS level. The Poimapper reporting module made it possible to analyze responses to the individual questions and monitor incoming data during the data collection phase itself. The training focused not only on how to use the Poimapper mobile client but also on the interpersonal and communication skills that field staff needed to collect reliable data (in fact, these skills appeared very useful and contributed to the reliability of the data).

A third achievement was that Poimapper made it possible to collect more accurate information. A common problem in collecting field data is to verify that staff actually make field visits and do not provide spurious information on the forms. Poimapper's GPS-tracking function made it possible to confirm that field staff were visiting the farms and communities where they were supposed to collect information. A considerable advantage of using the mobile data collection tool as opposed to paper data collection is that most questions in the mobile data collection forms are mandatory, and field staff had to provide an answer. With the paper forms, the level of non-response was high. Consequently, only a few

farmers were disqualified when the mobile app was used, whereas in previous years the percentage was much higher.

A fourth achievement is that AuditAide made it possible to automate the most time-consuming and crucial administrative processes within the certification programs. For example, the software contains a scoring and sanctioning module for automated assessments of internal inspection forms. Internal inspections are carried out annually because the cooperatives are externally audited once or twice a year to assess compliance with the respective standards. Internal Inspections assess farmers' performance based on the criteria in the Internal Standard. The software also automates the creation of corrective action letters to farmers, previously a time-consuming exercise. Another important feature of the software is the reporting module, which performs the specific data analyses and generates the reports required by the IMS of a certification program.

A fifth achievement was to train the office staff in the IT skills needed to execute and continue the project.

Finally, the MIS at the cooperative level was developed further. The MIS is important to manage all data, such as member data, sales, distribution of agro-chemicals, and inspection data. The cooperative in Côte d'Ivoire had an MIS that was not fully functional (it lacked some of the required data fields and reports for the project). The cooperative in Ghana had no MIS. Tony's decided to custom-design an MIS that they and the Ghana cooperative could use so they would not have to incur an additional cost. The Côte d'Ivoire cooperative received funding to further develop their MIS to make sure it would be fully functional.

Lessons Learned and Issues for Wider Application

The pilot projects proved successful. They collected, processed, and analyzed all of the required data, and all farmers and field staff were trained in the desired skills and knowledge. Lessons and issues to consider for the future include:

- Field staff were less familiar with smartphones than expected. It took the project nearly an additional week for field staff to become sufficiently familiar with the phones and the application to work with them. Most of these men did not use smartphones themselves, and the whole concept was new to them. Once they understood how to use the application, the inspection and other field data were collected without delay.
- Because there is no Internet connectivity in the communities, the field staff had to go to the nearest town, once a week, to upload the filled forms to the portal.

¹⁴ www.poimapper.com.

- Extra power banks had to be bought, because there was no electricity in many areas, and field staff could not always charge the phones.
- It was expensive to print the Internal Standards for each farmer. The project therefore added a poster

to the training materials, containing only the illustrations of the booklet. Each group of farmers would receive one printed Internal Standard, and each farmer received the poster to hang up at home or take with them to the farm.

Topic Note 8.2: DAIRY COOPERATIVES LEAD THE WAY WITH COMPUTERIZED SYSTEMS TO IMPROVE ACCOUNTING, ADMINISTRATION, AND GOVERNANCE

TRENDS AND ISSUES

Computer systems have the potential to vastly improve the efficiency, governance, and accountability of farmer organizations. Dairy cooperatives are considered the type of organization most likely to see clear benefits from computerized accounting systems, simply because of their numerous members and large volume of daily transactions. Even smaller cooperatives benefit from computerizing their accounts, which leads to greater efficiency and transparency. Having financial and membership information always at hand helps management make better decisions, and using software to present financial information in graphical or diagrammatic form can make the information easier to understand.

It is well known that small companies generally regard accounting as a “backroom” function, and consequently it attracts little management interest or company investment. Management counts the cash in the till and requires no other financial information. Accounting is done only because the government requires accounts for taxation. Yet when “other people’s money” is involved in a business (like a cooperative), accounting becomes the only means to explain what happened with the money, to prove that transactions with members and clients are straightforward, and to create the trust that enables a cooperative to function.

Farmer organizations and cooperatives in the developing world are turning to computerized management systems, despite their cost and the challenges posed by infrastructure, for some or all of the following reasons:

- Better accounting and management increase efficiency, save time, and reduce mistakes. The more logical approach demanded by computerization means that procedures have to be improved, which leads to better overall administration.

- Information for control and management decisions is available instantly. Inventory control improves, and information becomes available in real time.
- Relations between members and management can be improved. Better services to members flow from more efficient administration. New and improved services to members mean that they are prepared to invest more in the society.
- The cooperative has more options for communication and information sharing. There may be opportunities to communicate beyond the organization, using email, newsletters, websites, and information networks.
- Attention is paid to develop a sustainable business model that ensures co-creation and ownership of the services needed by farmers
- Data are available to guide policy decisions.

Capacity is built within the organization as staff members learn new skills. The general lessons from these efforts are discussed next, followed by three innovative practice summaries. Two summaries describe contrasting approaches to the development of computerized accounting systems for cooperatives in India (dairy) and Kenya (dairy and coffee). The third shows how computers brought in for other purposes improved administrative efficiency in a women’s shea butter cooperative in Mali.

LESSONS LEARNED

The evidence to date suggests that computer systems can be adopted successfully to improve accounting, administration, and governance, not only in cooperatives for staple commodities (such as milk) but also in cooperatives producing export commodities (such as coffee and shea butter), and in peri-urban as well as remote rural areas. People with very low levels of literacy can benefit from and learn to use the

IMAGE 8.3. Many Enablers Are Needed to Ensure Cooperatives Function



Source: Ray Wiltin, World Bank.

systems, if they are designed with care and deliver tangible benefits (image 8.3).

Even so, the danger of widening the digital divide persists. The best potential clients for computerization are successful and relatively rich organizations with business-minded management, situated near a big city. Poor cooperatives find it challenging to purchase computers, and distant ones do not have electricity.

Computerization has clear potential to make the governance of cooperatives more efficient, transparent, and fair. Even if they do not necessarily understand the technology, cooperative members can see that the new systems work well. In dairy cooperatives, for example, computerized systems facilitate timely payments to farmers for their milk, together with clear records of all transactions (milk supplied and inputs bought). Where there is an automated milk collection system, it is operated by personnel of the cooperative, who are generally also farmers and members of the society. Milk is always weighed and tested, with few errors, and the data are displayed clearly on the testing equipment. The operation is quick and transparent. Farmers no longer worry that figures might be adjusted by unscrupulous staff.

Benefits to the cooperative societies are many, largely because computerized accounting is faster and more reliable. Computerized accounts are much quicker to audit and may even be displayed online for greater transparency. Cooperatives need to employ fewer clerks, and daily accounts are available immediately at each milk collection center. Profit and loss

calculations are easily done, and the balance sheet is automatically updated. The various options for graphic display—using colored charts, for instance—make it easier for management and cooperative members to understand financial information.

In dairy systems, daily payment slips are printed for farmers and can be modified to include other pertinent information, such as reminders to inoculate cattle. When detailed milk records are kept for each farmer, patterns in production can be discerned. Seasonal variations in quantity and fat content can be predicted, which are useful for the dairy, veterinary services, and cattle feed companies alike.

The quality of infrastructure and the resources available to maintain it are challenging with all ICT tools. Computers need an electricity supply with backup generators and uninterrupted power supply equipment to cope with failures if they are common (generators will add to the overall cost of installing a computer system). Power can be provided by solar panels where the climate is suitable.

The choice of technology also depends on whether a range of computer and training experts can be found within a reasonable distance of the cooperative's offices and are able and willing to travel to the site. If a solar-powered computer system is set up in a remote area, for example, initial training and routine maintenance will almost certainly be done by staff from elsewhere. The cooperative's administrative personnel must be confident that any subsequent problems will be dealt with speedily. This kind of response is unlikely if support services are sparse or do not exist, or if the surrounding road network is poor.

Although there are real benefits for a farmer organization to have a simple computerized member and MIS, the organization can achieve far more if it also has Internet connectivity. Dial-up connections are possible where telephone land lines are available. Mobile phone coverage is expanding, and another alternative is to use a small, plug-in wireless adapter to connect to the Internet. Neither option is as fast as a broadband connection, and both are subject to lapses in service.

Supportive government policy and willingness on the part of government organizations to join partnerships are important enablers. For example, India's National Cooperative Development Corporation supports computer projects in the cooperative sector, including hardware, site preparation, system and application software, and training. It has encouraged cooperatives from the primary level to the state and national levels to install computers and evolve effective MISs. Lower-level (district and primary) cooperatives must have a threshold turnover of rupees (Rs) 1 crore (roughly US\$225,000) to qualify for assistance and must be financially

sound and viable. This stipulation raises the issue touched on before—that only the more organized cooperatives qualify for assistance, thereby widening the digital divide.

Indirect government support can come from the educational system, because skilled people are needed to develop and maintain computer systems. For example, among Kenya's roughly 30,000 university graduates in 2008, only about 5,000 were considered suitable for employment in the ICT industry (World Bank 2010). This situation makes it all the more important for Kenya's Cooperative College to move forward with plans to train students in the CoopWorks software.

The independent nature of open source software allows users to tailor it to their needs, and it can be a form of insurance against power issues—no single individual or group can control it, and users may be encouraged to cooperate. But this advantage is theoretical in the many cases where farmer organizations do not yet have the capacity to develop software themselves.

For long-term sustainability, the private sector probably should be involved in computerization projects. Success may thus depend to an extent on the willingness of entrepreneurs to risk capital. In India, the inventors of milk-testing equipment were prepared to lend it out for free so that dairy cooperatives could see the benefits. They also had the foresight to predict that illiterate farmers would accept the system and use it confidently. Success might also depend on creating a critical mass of users so that a business "ecosystem" can develop. This effort would include software development, support, marketing, and other network effects.

Finally, aside from modernizing their management information tools, cooperatives need to attract good management staff if they are to compete in the marketplace. A cooperative must decide how much it is prepared to spend on managerial capacity. Box 8.9 lists practical guidelines to help farmer organizations use computerized administration and management systems.

BOX 8.9. Considerations for Effectively, Sustainably Computerizing Farmer Organizations and Cooperatives

The organization's management and members will want a system that works, can be maintained, and is affordable. In small, cash-strapped cooperatives, it may be hard to persuade farmers that it is worth making the investment, because initial costs are high and benefits are not immediately apparent. It is broadly true that the bigger the institution, the more likely it is to afford the costs of computerization.

How willing are management and members to invest money and time and to take a long view? In the early stages, manual and computerized systems must operate in parallel to make sure that data are not lost, and this procedure increases costs in the short term.

Can cooperatives make independent investment decisions and buy a computer system from a local provider on a commercial basis? Management might lack the skill to do this, and it might be hard to get loans for the investment.

Which approach to software development—commercially licensed or free, open source software—is best? In practice, the cost of the software is likely to be only a small part of the overall cost of computerization, so this issue might be less important than others, such as technical support (see the next point).

Is backup technical support available? Aside from requiring initial installation of the software and training in its use, the contract should require fully functioning accounting output. All operations, not just the machinery, must work and be reliable for a long time.

Consider how the process will be funded and develop plans for sustainability.

Training is very important. Enough trained operators must be on hand locally. Local availability is a critical requirement, because individuals with computer skills tend to migrate to towns and work for companies at higher pay.

Training should not focus simply on narrow technical issues; it needs to provide an insight into the wide-ranging possibilities of a fully functioning computerized system. Without this overview, cooperatives may not use a system to its full capacity.

Consider the possibility of offering on-the-job training. Cooperatives that are already using computer systems might offer internships to staff from other cooperatives. Perhaps such internships could be linked with formal technical education at the tertiary level.

Source: Authors.

INNOVATIVE PRACTICE SUMMARY

IT Tools for India's Dairy Industry

With demand for milk in developing countries projected to double in the next 20 years, dairy cooperatives are crossing the digital divide. The need for computerized administrative systems is especially urgent in India, the world's largest milk producer.

Dairy cooperatives typically have thousands of members. The recording system at the collection point has to cope with the huge volume of members' daily transactions. Milk is highly perishable, especially in hot climates, and any delay in collection quickly leads to significant waste. Members often buy inputs on credit from the cooperative. These purchases have to be reconciled before members can be paid for their milk. Each member needs a statement at the time of each monthly or twice-monthly payment to show (correctly) how it has been calculated. Payments must be timely and regular, because cooperative members depend on receiving their money on time. In manual accounting systems, a mountain of paperwork is done before issuing each payment. Computer accounting can produce up-to-date payment calculations and member statements at the click of a mouse.

The most advanced examples of computerization are to be found in the Indian dairy industry, where cooperative societies have a long history. India has more than 10 million dairy farmers, most of whom run small, marginal operations (Sharma and Yadav 2003). Although milk yields had quadrupled in the 40 years ending in 2001, time-consuming manual recording systems had changed little. Producers waited for hours before they could deliver their milk, much of which soured in the heat.

EARLY INNOVATION

A significant change occurred in 1996, when a small private company (Akashganga—Shree Kamdhenu Electronics Private Ltd.) developed IT-based tools to automate milk collection at local dairy cooperatives and computerize the accounting system.¹⁵ The company introduced simple technology to weigh milk, check its quality (fat content), and pay producers promptly. The basic model was an electronic weighing system, a milk analyzer, a personal computer, and accounting and management software.¹⁶

15 This summary is based on information from the Akashganga website (<http://akashganga.in/WhatWeDo.htm> and <http://www.akashganga.in>), a presentation on the Amul Dairy Project by Vipul Vyas (<http://www.scribd.com/doc/16808474/Amul-Dairy-Project-by-Vipul-Vyas>), the UN-Habitat Best Practices Database (2006), and personal communication with Anil Epur.

16 Akashganga's current high-end system, selling for about US\$3,300, incorporates an electronic weighing system, a milk analyzer to test milk quality, a personal computer, and accounting and management software.

The new technology found a ready market, once initial mistrust was dispelled by active marketing by the company, which offered equipment to some cooperatives free of charge. The free installations showed neighboring cooperatives the utility of automated collection centers. Intensive training was provided, and IT systems were maintained by motorcycle-borne service engineers who could quickly attend to any faults. Only when the cooperative was convinced of the system's worth did it have to pay. The application, initially built around a microprocessor but now usually involving computers, took a decade to diffuse on a large scale, but many Indian dairy cooperatives have now adopted computerized systems.

Developers of the Akashganga system claim that there is a viable market for companies that can design products suited to the needs of cooperatives in developing countries. The design of the equipment was carefully considered, not only to ensure that it was easy to use but also to make the weighing equipment sufficiently robust to cope with the heat and dust of rural India. Price was an issue, as cooperatives have to justify expenditures to members. The equipment to measure fat content was developed in India for less than one-quarter the cost of European designs.

SUBSEQUENT INNOVATION

Village cooperatives have installed more than 3,000 computers to support automated milk collection.¹⁷ Distributors are keen to computerize their operations, too, and to get email connectivity for better communication with sales offices.

Currently, no standard ICT solution is used throughout the industry. Software may be tailored by local vendors to a particular enterprise (the Mulkanoor Women's Dairy Cooperative has taken this route), or dairies may choose to use packages developed by software companies such as Tata Consultancy Services.¹⁸ Member records can include not only information on milk delivered and inputs bought but also information on veterinary care (dates for vaccination or artificial insemination, for instance), so that farmers can be prompted to take action.

Some dairies are now upgrading to enterprise resource planning (ERP), which encompasses the range of activities from the farmer or collection point to consumer sales (box 8.10).¹⁹ One of these is the Gujarat Cooperative Milk Marketing Federation Ltd., whose brand name is Amul. The federation

17 See the presentation on the Amul Dairy Project by Vipul Vyas (<http://www.scribd.com/doc/16808474/Amul-Dairy-Project-by-Vipul-Vyas>).

18 Anil Epur, personal communication.

19 A widely used, comprehensive ICT solution (based on the Microsoft DYNAMIX ERP package) currently costs around Rs. 3.5 million. It can handle all activities for a daily throughput of up to 10,000 liters of milk (Anil Epur, personal communication).

BOX 8.10. What Is ERP?

A large company's "back office" makes use of many different systems, including planning, manufacturing, distribution, shipping, and accounting systems. Enterprise resource planning (ERP) integrates these functions into a single system designed to serve the needs of each department within the enterprise. ERP is more of a methodology than a piece of software, although it does incorporate several software applications under a single, integrated interface.

Source: Sererra (<http://www.sererra.com/ERP>).

collects over 10 million liters of milk every day and is co-owned by some 2.8 million milk producers. All zonal, regional, and member dairies are connected through very small aperture terminals (VSATs) to make information-sharing easier. Amul is in the process of Web-enabling the entire supply chain so it can capture key information at the source.

The experience in India suggests that the private sector plays an important role in bringing computers to rural communities and that such activities can profit private enterprise and benefit users. Complementary support from the public sector was also valuable, including support from the National Cooperative Development Corporation (discussed earlier) and the National Informatics Center. The National Informatics Center developed Lypsaa and openLypsaa software, a complete solution for dairy cooperative societies, used by more than 50 societies in Kerala. The center also developed a Linux-based portal for communication between the cooperative department and the cooperative societies.²⁰

The key lesson is that change does not come quickly, even where all factors are conducive to development. Despite aggressive marketing by the inventors, clear benefits to users, and a supportive policy environment, it has taken a decade to automate dairy cooperatives on a large scale.

INNOVATIVE PRACTICE SUMMARY **CoopWorks Dairy and Coffee, Open Source** **Software Launched in Kenya**

Kenya, one of the largest milk producers in Africa, sources more than 80 percent of its milk from roughly 800,000 small-scale dairy farmers (Seré 2010). These producers "represent an emerging market opportunity for local and international agribusiness alike" (Seré 2010).

Despite this potential, the process of computerizing agricultural cooperatives and producer organizations is at an earlier stage in Kenya than in India. The impetus for computerization in Kenya has come not from private enterprise with government support, as in India, but as a joint push from Food and Agriculture Organization (FAO) and donors (Kenya National Federation of Agricultural Producers 2008).²¹

Under a donor contract, the private sector developed a prototype management and member information system to improve the business efficiency and competitiveness of producer organizations and cooperatives in national, regional, and global markets. The system, known as CoopWorks, is open source software available free of charge from <http://sourceforge.net/projects/coopworks/>.²²

The software replicates all the accounting functions that would formerly have been done on paper, and it consists of a dozen or so modules (including member management, inventory, payroll, and others). It conforms to Kenyan government regulations and the stipulations of the International Systems Audit and Control Association, and the prototype was followed by improved versions (the latest being CoopWorks 5).

THE DAIRY EXPERIENCE

CoopWorks was first trialed at the Tulaga dairy cooperative in 2006. The system kept member records, including the amount of milk delivered and any purchases made by the member. Clerical officers found they could operate more efficiently, without duplicating work, and the task of preparing members' monthly payments was much easier. Fewer errors in this important task meant that members' confidence in the society improved.

At the start of the trial, Tulaga had 800 active members, which increased to 1,800. Daily milk intake more than tripled, from 3,000 to 10,000 kilograms, and the average price paid to members increased from K Sh 10 per kilogram to K Sh 17. Cooperative sales also tripled in eight months. The milk customer base increased from two processors to five after many private buyers emerged.

²⁰ See <http://www.kerala.nic.in/Brochures/opensource.pdf>; <http://informatics.nic.in/archive/july2007.pdf>.

²¹ Specifically, an FAO project funded by the Government of Finland in collaboration with Agriterra (the Netherlands) and Kenya National Federation of Agricultural Producers.

²² This summary is based on information from the Kenya National Federation of Agricultural Producers (2008); personal communication with Marcel Werner (Flametree Systems / Innovation Africa) in Kenya; the draft report of the AgriterraCoopWorks evaluation mission to Kenya (January 2011); "How Open Source Software Makes Money for Coffee Grower Cooperatives" (<http://www.selectstartcafe.com/2010/08/how-open-source-software-makes-mon-...>); and "Kenya Coffee Eyes a New Golden Era" (2011).

After various revisions, CoopWorks Dairy version 2 was tested at Ololaiser and Wamunyu dairies, where it was also well received. By 2010 at Tulaga, cooperative membership had reached 3,000, and milk production was 18,000 kilograms per day. Since the introduction of CoopWorks Dairy, Tulaga has used its own funds to increase the number of computers from 4 to 15 and uses all the capabilities (modules) of CoopWorks in its operations.

A group of donors and international organizations, together with the Cooperative College, the Cooperative Bank, and the Kenyan Ministry of Cooperatives, all see a need to computerize Kenya's dairy cooperatives on a larger scale and believe that it can be done. Electricity is available in most places, dairy cooperatives are big enough to need quick accounting methods, and investors are ready to help. CoopAfrica has a project to involve all stakeholders, including the Cooperative Bank (providing loans) and the Cooperative College (training local service providers).

THE COFFEE EXPERIENCE

Given the applicability of the software to other products as well as milk, a Finnish-funded AgriCord-Agritera project developed a version of CoopWorks for coffee (Kiplagat 2010). Smallholder coffee farmers were dissatisfied with the recordkeeping in coffee factories, where they suspected that unscrupulous clerks easily abused the paper-based system. The Kenya Coffee Producers Association (KCPA), which implements the project, was attracted by the lower cost of free, open source software.

The new system has two components, one to keep records within the society and one to provide information via a website and text messaging. The system tracks all the steps from coffee collection to processing to sales. A member management feature holds data on individual members, and the accounting module has cash book registers, ledgers, and a payroll system. Other features include asset registration, loan management, inventory for the cooperative store, and report publication.

With the old manual data entry system, the cooperatives did not know how much coffee the milling factory would produce from their beans and could not predict the financial return. The new system, however, can convert the weight of beans into an estimated value once it goes into the mill.

The software also monitors coffee deliveries based on each cooperative's tracking number. Once the coffee is sold, the payment is received into the system and credited to the appropriate cooperative's account. CoopWorks already produces a member statement of inputs bought on credit and the proceeds of deliveries sold to millers, which helps farmers

better understand their costs and profits. KCPA is delivering coffee and input prices to members on their mobile phones via text and will soon link to mobile banking as well. The association has also promoted CoopWorks Coffee throughout the country (covering about 600,000 producers).

A weighing scale may be added to the system, although this option is relatively expensive (€1,000). Farmers are said to value automated scales, as they believe there is less scope for dishonesty behind the scenes, but their high cost has prevented most cooperatives from adopting them.

PRELIMINARY CONCLUSIONS FROM THE OPEN SOURCE EXPERIENCE

The experience in Kenya suggests a different route to computerization. Free, open source software can be developed, customized, and upgraded, preventing the software provider from becoming too powerful within an organization.

Using free, open source software does not mean there are no costs to computerization, however. The software is available as a free download, but a cooperative still has to buy appropriate computing hardware and find resources to train staff to use the system.²³ The low costs and high adoptability of open source software are insufficient to create critical mass and network effects if other related costs are too high.

A survey in late 2009 of 27 agricultural cooperatives in Kenya suggested that many are aware of the potential benefits and would be keen to computerize if the process were less expensive (Flametree Systems Engineering Ltd. 2010). The two cooperatives involved in the pilot project certainly felt the system to be a success (Nissila, Puhakainen, and Tanhua 2009).

A recent review found differences in the extent to which cooperatives use CoopWorks' capabilities. Even when only some modules were used, the effects of computerization were considerable, not least in creating a stronger bond between the cooperative and its members. The main challenge is to make users aware of the true scope of the software and the significant benefits that will accrue on top of the improvements in efficiency and transparency already experienced. Good ICT support at the local level is vital. Trainers or advisers must be proactive in demonstrating the "big picture" of what CoopWorks can do, rather than

²³ Successful free, open source software (FOSS) initiatives are driven by large developer communities, including programmers, trainers, and advisers with commercial interests. The software will be free, but related services may not be.

dealing only with narrow technical instruction or responding to queries from cooperative staff.²⁴

Apart from highlighting capacity issues specific to CoopWorks, the experience has shown that further capacity building in modern information systems is required. To address this issue, Kenya's Cooperative College is adopting a proactive, innovative approach by planning to cover CoopWorks software in its curriculum. Even though the short timeframe of the pilot project was insufficient to develop capacity, it could be argued that without such support for development, dairy cooperatives in Kenya might be even slower to computerize.

INNOVATIVE PRACTICE SUMMARY

ICT Improves Marketing and Governance for a Malian Cooperative

In some cases, the decision to use computers is not driven by a perceived need for better governance and administration, but better governance may be a welcome by-product of the process. Women in southern Mali traditionally gather fruit from the shea tree (*Butyrospermum parkii*) to extract the seeds for processing into cooking oil and a "butter" that is an effective skin moisturizer. In 1999, by forming a cooperative society, Coprokazan,²⁵ producers were able to get better prices for their products. All management and accounting procedures were done manually, and the society had only a few hundred members.

The move toward computerization came from a desire to produce effective training materials for cooperative members, raise the profile of the society, and enable its products to reach a wider market (Laureys, Marcilly, and Zongo 2010). Working with the Malian Association for the Promotion of Youth and the International Institute for Communication and Development (IICD), Coprokazan assessed what sort of technology would be most useful. Zantiébougou, the town where the society was based, had no mains electricity, so all equipment had to be solar powered. This requirement limited the society to three computers, together with a printer, a projector, a small video camera, and some digital photo cameras.

With these, the cooperative planned to create visual training materials that would give clear information to all members, including those who could not read. Photographs showing the quality of nut suitable for processing would prevent

women from harvesting and transporting poor-quality produce to the collection point only to have it rejected. Filmed demonstrations of new, more efficient processing methods would improve the quality as well as the quantity of shea butter.

These benefits materialized, and Coprokazan now has its own website showcasing its products. An unplanned benefit of computerization was that it enabled Coprokazan to improve governance and administration. The cooperative's office personnel began using the computers for routine administration, and member records are now kept electronically. Staff members also learned to use PowerPoint to produce a visual overview of yearly accounts and activities to show at the Annual General Meeting, which has increased transparency and boosted members' confidence in the workings of the coop. This experience indicates the extent to which it can be challenging to neatly apportion the benefits of ICT.

In the first four years after ICT techniques were introduced, the cooperative almost tripled its shea butter production and income. With its improved administrative capacity, the cooperative can now deal with more members. From a base of fewer than 400 in 2006, the cooperative expected to have more than 1,100 members by the end of 2010. The cooperative plans to invest in GPS equipment as a step toward traceability and possible organic certification.

Among the more general lessons from Coprokazan's experience was the lesson that local languages make technology more accessible. Many poorer farmers, especially women, have poor reading and writing skills, even in their own language. It is unrealistic to expect them to master ICT in a foreign language. Computer keyboards were adapted to make it easier for Coprokazan women to type in the local language.

Multimedia tools, on the other hand, often do not require high literacy levels. Women who could barely read or write learned to use digital cameras and create image-oriented narratives that could be used for training cooperative members.

Another unforeseen effect of bringing solar-powered computer equipment to a small town without electricity was that the cooperative offices became a magnet for nonmembers. Some people reportedly traveled more than 30 kilometers to type, print, and copy documents. The training room was used by other organizations for training sessions, and local schoolchildren were attracted to the premises to do their homework, as the building is one of very few in the area to have electric light.

24 Draft report of AgriterraCoopWorks evaluation mission to Kenya, January 2011.

25 <http://www.coprokazan.org>. Coopérative des Productrices de beurre de Karité de Zantiébougou (Zantiébougou Shea Butter Producers' Cooperative).

Topic Note 8.3: GIVING FARMERS A VOICE AND SHARING INFORMATION

TRENDS AND ISSUES

In an increasingly interactive world, the idea of “having your say” is easier to put into practice. Internet-based discussion forums, blogs, and phone-in radio programs are part of the information exchange landscape. For farmers in the developing world, opportunities to be heard are few, but the situation is changing, largely as a result of the simple combination of local radio and mobile phones. (See Module 13 for more on citizen participation, exchange, and knowledge sharing.)

Farmer organizations have higher visibility than individual farmers. Many have a website and Internet connectivity to communicate with similar organizations or in regional forums. If farmers can raise issues with their local organizations, there is a chance that their concerns will be noted and passed to higher levels, which suggests an important role for ICT. Answers to technical problems raised by members need to reach farmers even in remote areas, which is currently best achieved by using broadcast media.

Given the lack of infrastructure typical of remote rural areas, it is a challenge for farmer groups to use ICT for interactive communication. Radio and, to a lesser extent, television broadcasts reach wide audiences and can be understood by all, even those who cannot read or write, so they are currently the best ways of transferring information to individual farmers. When the makers of radio and television programs base their output on real issues raised by farmers themselves, farmers readily act on the information to improve their production methods. Farmer organizations thus have a role in seeking the views of their members on which topics should be featured in the broadcast media.

The following sections highlight the effectiveness of radio and television in reaching a broad audience, including women. They show that the interactivity enabled by phone-in and SMS contributions brings true relevance and usefulness to farmers.

ICT MAKES RADIO PROGRAMMING LESS EXPENSIVE, MORE INCLUSIVE

Radio is a popular medium that can draw a wide audience and operate in local languages (image 8.6). Like mobile phones and other ICT applications, however, radio has issues related to access, such as who owns the radio, who chooses which programs to hear (men, women, elders), or whether programs are broadcast when listeners can actually listen. The innovation in radio is that programming is becoming more interactive, with phone-ins, live community forums, and radio diaries all finding

a place; and the radio is also becoming cheaper in the sense that the cost of setting up a radio station has fallen dramatically in recent years (AFRRI and FRI 2008). Recording equipment that only a decade ago would have cost thousands of dollars can now be bought for about US\$100 or less, and computers, the Internet, and mobile phones have brought down the cost of obtaining and storing information for broadcast. Research in 2008 reported that a microstation with a broadcast range of 2.5 kilometers had been set up in Mali for just US\$650.

The hope is that as radio becomes cheaper and more interactive, its programming can become much more locally relevant and inclusive. Efforts in this direction include Farm Radio International. This NGO partners with more than 350 radio broadcasters in almost 40 African countries to develop programming to help small-scale farmers improve their food security. Participatory Radio Campaigns, carefully planned broadcasts focusing on one farmer-selected issue at a time, feature farmers’ participation and appear to make measurable differences to farmers’ livelihoods (AFRRI and FRI 2009). (For more detail, see Module 6.) In Uganda, Her Farm Radio, an initiative of Farm Radio International since 2013, reaches more than 2 million women. Thirty episodes of a radio drama are aired in six languages by 10 radio stations to promote the consumption of orange-fleshed sweet potatoes. These episodes are vibrant and interactive, because widespread use of mobile phones enables listener polls, call-ins, and discussions. A current program, *Her Voice on Air*,²⁶ feature true stories of women farmers in Malawi, Tanzania, Uganda, and Ethiopia.

Local radio stations are particularly well placed to develop programming to suit their audiences. When radio operates as a source of reliable information that works at the local level, it gives farmers an alternative to limited public agricultural extension services. In Kenya, Radio Mbaitu FM prioritizes content on fruit farming and horticulture and uses the Kikamba language to reach the farmers in its listening area. Radio Coro FM, broadcasting in Kikuyu, covers dairy farming, which is widespread in central Kenya. Radio Salaam uses Kiswahili to broadcast information on fisheries and fruit farming to coastal farmers, while Kass FM, a Kalenjin station, focuses on dairy and maize production.

In Zambia, the *Research Into Use (RIU)* program uses community radio as a way of promoting conservation agriculture (*Research Into Use* 2011). Programs follow different

26 <http://www.farmradio.org/portfolio/her-voice-on-air/>.

IMAGE 8.4. Clara Moita, Broadcaster with Radio 5 in Arusha, Tanzania

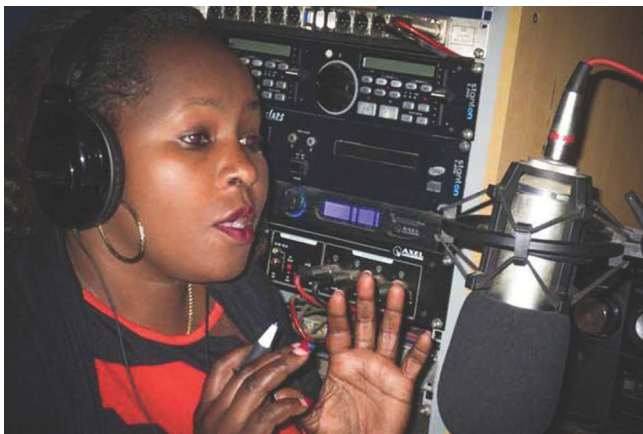


Photo: Facebook.
Source: Takepart.com.

formats—prerecorded factual programs, drama programs, and phone-in or interactive programs—and are broadcast in either English or the local language. Listeners particularly enjoy the vernacular, drama, and interactive output.

RIU Zambia has set up radio listeners' clubs that have trained over 1,000 people in recording skills and club coordination. Local farmers can now record their discussions, questions, and development concerns and send the recordings to their local radio station. A producer then edits the material and includes feedback from experts before the program is aired. These programs are also interactive at the point of broadcast; farmers phone in with further contributions.

Some of the radio stations are private, such as Sky FM in Monze District. The *RIU* program supports them to broadcast this content, and six radio dramas were sponsored by a local seed company. This suggests a route toward sustainability when *RIU* support comes to an end. Another possibility is shown by Namwianga Radio in Kalomo District, which is supported by the church. Community church services have apparently proved to be useful forums for smallholders to share experience with conservation agriculture.

TELEVISION SUPPORT FOR AGRICULTURAL EXTENSION IN INDIA

In 2005, the Doordarshan Broadcasting Corporation of India began a project to televise live, interactive, problem-solving crop seminars as well as to set up various other initiatives to spread agricultural information.²⁷ Agricultural seminars are set

up in a village, with farmers invited to bring diseased or pest-infested crop samples or other field problems to be discussed by a panel of experts. Possible solutions are then suggested.

Each seminar is filmed and broadcast live by Doordarshan through its provincial network (55 stations, using the appropriate local language) to share the information with farmers who live too far to attend in person. Daily bulletins on the latest market prices and weather forecasts also appear on television. The broadcaster also offers a weekly live phone-in program to give experts' "instant solutions" to farmers' problems. In some areas of India, this televised exchange occurs twice a week. Information about the programs is shared on the Internet—television producers upload program details onto the portal. The website also features contact details to facilitate interaction between farmers and appropriate subject matter specialists, as well as opportunities for farmers to give feedback and offer suggestions.

FARMERS "CLUSTER" IN THE CARIBBEAN

The Caribbean Farmers Network (CaFAN)²⁸ has found that farmers in the Caribbean region benefit from working in clusters that are created either geographically or thematically (Greene 2010). Farmers working in close proximity, or those who simply share an interest, set up a cluster to share technical information and experiences, plan for new market demands, and maximize their lobbying and bargaining power.

CaFAN encompasses 30 member organizations that together represent half a million farmers in 12 countries. Clusters cut across membership boundaries. Farmers use Skype, email, and the CaFAN website to keep in touch. Text messages are also widely used to communicate directly with farmers, and it is hoped that production information will soon be sent that way.

CaFAN claims that fostering connections, sharing information, and training farmers puts farmers in a stronger position to respond to the perennial problems of the agricultural sector. They say that collective action can give better access to important resources (agricultural inputs, credit, transportation, information) and can reduce financial risk. Pooling resources and collective marketing reduces the high transaction costs incurred by farmers acting alone: Operating as part of a group is simply more efficient.

THE ZNFU DISCUSSION FORUM

ZNFU reports more than 10,000 hits a month to its website.²⁹ New topics are introduced to its discussion forum as a means of encouraging farmers to participate and share their

27 "Mass Media Support to Agricultural Extension," ICT for Development.

28 <http://www.caribbeanfarmers.org/>.

29 <http://www.znfu.org.zm/>.

experience related to particular issues. Current threads include the state of feeder roads in rural areas, price expectations for the maize crop, and tariffs charged by Zesco (the national electricity supplier). Members are invited to make suggestions to be included in ZNFU's submission of proposals relevant to agriculture in the national budget. The "How Do I" section for technical questions is divided by subject and includes farm and land, equipment, livestock, and employment.

Despite its welcome and advanced features, this online forum still has low participation, because most farmers do not have computers, Internet access, typing skills, or great proficiency in English. There are only a few posts and comments on the forum—some discussion categories are empty, and several of the other posts are more than six months old. At this stage, the ZNFU website appears much more useful to large-scale farmers than to the smallholders who form the majority of those working in agriculture in Zambia.

LESSONS LEARNED

There is much to gain but also much to be done in giving farmers a voice. Rural areas lag behind towns and cities in the infrastructure needed for online connectivity and access to blogs or Internet discussion forums. Many farmer organizations are situated within reach of electricity and the Internet, however, so they are able to set up websites to raise their profile and market possibilities. Their online forums offer a space for those few farmers with Internet access to share information or raise concerns to be aired more widely.

Considering the current state of infrastructure in much of the developing world, it is realistic to expect the uptake of ICT to give farmers a stronger voice at the organizational level rather than individual level. Giving smallholder farmers a stronger political voice, for example, can be done by encouraging them to join an organization or cooperative. If individual farmers can reach their representative organizations better, these organizations can effectively represent farmers at the local, regional, national, and international levels. The best way for individual farmers to be heard at present is via local radio stations.

The visual nature of television makes it particularly valuable for practical demonstrations of good agricultural practice. Overall, though, radio seems more useful than television as a discussion forum, given the ubiquity of radio ownership and access. Radio producers are now skilled in presenting information in memorable ways, and radio programs are more interactive, owing to contributions made through mobile phones. Listeners' clubs in Zambia and Niger show that oral communication is very popular.

Technological developments can be seen simply as extensions of a very human need. These developments indicate that there is an argument for recommending that governments and donors should strengthen the capability of farmer organizations to contribute to radio programming. The credibility and transparency of farmer organizations would improve if problems and achievements were discussed openly on local radio, with members' comments being welcomed on air. Any issue related to the organization could be raised.

Independent community radio is relatively new in most African countries. About a decade ago, the only programs offered were from publicly funded state radio. A study of the effectiveness of the Participatory Radio Campaigns tentatively concluded that participatory farm radio by itself, without any other intervention, has a strong impact and is a highly cost-effective strategy for helping farmers learn about and adopt new approaches to farming (AFRRI and FRI 2009). However, a more recent study showed that farmer exposure to and participation in radio campaigns may increase awareness and knowledge but may not be sufficient to cause the farmer to adopt new technologies or innovations (Manda and Wozniak 2015).

A study into the economics of rural radio, a hitherto-unexplored subject, points out that the costs of programming depend on the level of interactivity of the program format, the accessibility of additional resources to produce specialized programs, and the type of station involved (AFRRI and FRI 2009). Community stations tended to invest more resources in interactive programming with community involvement and less on in-studio formats. The cost of a reporter in the field (a common format for agriculture reporting) was about US\$300 per program for a commercial station in Uganda and just over US\$100 per program for a community station in Malawi.

Educational farm radio must compete for airtime with less expensive and popular items such as music and evangelism, but interactive programs with farmers—phone-in shows, field interviews, listening groups, and talk shows with local experts—can be popular enough to compete. Among the radio stations examined, the average cost of rural production ranged from just over US\$100 for a phone-in show to US\$300 to record and air a village debate. An investment of US\$500 per week (US\$26,000 per year) would therefore finance the production and broadcast of 3–6 hours per week of interactive farm radio programming. Radio broadcasting requires an enabling policy framework under which local radio stations can flourish without excessive regulation. Many African countries lacked such a framework until recently, so commercial and community radio stations are

still relatively new. Many countries have issues related to freedom of expression. For instance, proposed amendments to the Zambian Constitution included scrapping an article on freedom of speech in favor of one providing penalties for false statements. This amendment is of major concern to the many privately sponsored and civil society–sponsored local radio stations. Another example is Ethiopia, where community radio (whether run by the private sector or civil society) is not fully liberalized.

Effective radio programs depended heavily on partnerships, both with radio broadcasters, individual farmers, and agriculture experts. For example, close cooperation with the Indian Department of Agriculture has been necessary to support the Doordarshan Broadcasting Corporation's live crop seminars. Villages are chosen in consultation with the department, and the experts who deal with the farmers' questions come from the agriculture department of the nearest university. Where possible, the Department of Agriculture sets up an exhibition in tandem with each broadcast to offer farmers additional information about crop varieties and new technology.

For farmer organizations wishing to set up a website, with or without a discussion forum, the question of design can be fraught with difficulties. Bandwidth—as a percentage of average annual income—is still expensive. International bandwidth increased 20-fold and the size of terrestrial networks doubled between 2009 and 2014, but to make the Internet accessible and affordable, more investment is needed in national backbones, cross-border connectivity, and last mile access (Nyirenda-Jere and Biru 2015). At the same time, traditional website design has been transformed: optimizing content for mobile devices is critical, given that

a large proportion of first-time Internet users access it via their mobile phones using Web 2.0 applications such as Facebook. Because the biggest factor in user satisfaction is the speed of response, it makes sense to design websites for prevailing conditions. See box 8.11 for additional considerations in designing and implementing ICT interventions to increase farmers' voice.

INNOVATIVE PRACTICE SUMMARY

Community Listeners' Clubs Empower Social Networks in Rural Niger

Since July 2009, 300 community listeners' clubs (200 all-women, 89 all-men, and 11 mixed clubs) have been established in villages of southern Niger.³⁰ Involving more than 6,000 women and men, together with nine community radio stations, the Listeners' Clubs Project breaks the isolation of rural populations, especially women. It does this by offering access to information and communication and by encouraging people to join discussions on development issues. The project is led by FAO, via the Dimitra Project, and cofinanced with UN agencies and the Canadian Development Corporation. It is implemented by an NGO.

The community listeners' clubs are groups of villagers who have been trained and organized through literacy training centers to identify and discuss their information needs and development priorities. Whenever a group finds a topic that they feel deserves attention, they contact a community radio to record club members' views on the subject. These views

³⁰ This section is based on information from FAO's *Dimitra Newsletter*, issues 17, 18, and 19, available at <http://www.fao.org/dimitra/dimitra-publications/newsletter/en/>.

BOX 8.11. Considerations for Effectively, Sustainably Enabling Farmers to Share Information and Gain a Greater Voice in the Agricultural Sector

- How many members of the farmer organization can realistically benefit, given local infrastructure? This question favors radio broadcasts over Internet discussion forums and similar technologies.
- What resources are available to the farmer organization, including basic infrastructure and financial and human resources?
- Will radio broadcasts be done in the form of “community” radio, or will they be part of a commercial local radio station?
- What is the best way to support the process to ensure that it can become self-sustaining? Consider whether radio broadcasts should be regarded as a significant public good that justifies long-term public support.
- When setting up a website, determine how complex it will be. The level of complexity will depend on its intended purpose. Is it simply intended to raise the profile of an organization and provide contact details, or does it need to be used interactively by buyers or those seeking information?

Source: Authors.

are then broadcast, prompting immediate responses, opinions, and suggestions sent by mobile phone from other listeners. The clubs have already discussed a wide range of topics, including food security, agricultural inputs, plant and animal health, and policy issues such as land access and decentralization. Debating and listening to radio programs gives the participants knowledge, allows them to share their experience, and reinforces self-confidence.

The project has also improved rural populations' knowledge of new technologies. At the outset, each club was given a solar-and-crank-powered radio and mobile phones fitted with solar chargers, but the project was so popular that clubs were soon given extra mobile phones. These phones were linked up in a network known as a "fleet," which enables cost-free communication at any time between the clubs and radio stations.

These mobile phones are now also used to pass wide-ranging information between villages—such as forthcoming social events or the price of agricultural produce and livestock—or to offer products for sale. The telephones in the fleet also serve as public telephones, allowing private calls to be made for a small charge. For women, the telephones have helped create a social network, enabling them to communicate with other women they have never met and to exchange information beyond the topics covered by the clubs.

The enthusiasm for the listeners' clubs has exceeded all expectations. Preliminary data indicate that women have gained self-confidence, good practices have been shared, and even sensitive subjects such as HIV/AIDS have been discussed. Club members have realized that their knowledge and opinions have a value and that their voices matter.

INNOVATIVE PRACTICE SUMMARY **Through Social Media, a Women's Producer** **Network in Caribbean Small Island States** **Improves Its Communication Capacity, Outreach,** **and Knowledge Management**

Established in 1999, the Caribbean Network of Rural Women Producers (CANROP) is an umbrella organization that collaborates with 12 national chapters of rural women's associations in the Caribbean.³¹ CANROP's mission is to empower rural women producers in the region to improve their livelihoods

through targeted interventions to reduce the level of inequality they experience and improve their socioeconomic position. The interventions include but are not limited to training, cultural exchanges, networking and promoting interregional and intraregional trade, access to specialized credit, creation of sustainable employment opportunities, and advocacy to sensitize society to the needs and contributions of women in agriculture.

From the beginning, CANROP has received regular support from the Inter-American Institute for Cooperation on Agriculture (IICA)³² and the Technical Centre for Agricultural and Rural Cooperation (CTA).³³ In 2014, CANROP initiated a series of activities to facilitate networking and communication among members and strengthen their knowledge management (KM) skills. A KM scan³⁴ developed by CTA and Co-Capacity³⁵ has helped the network to set new priorities for KM and communication and for finding new sources of support. The first priority was to improve the network's communication capacity and extend its reach to farmers, markets, governments, and external supporters. One of the results was a KM and Storytelling workshop held in Trinidad to create awareness among stakeholders, share experiences and lessons, and identify key issues and opportunities in using KM to drive entrepreneurship and improve food and nutrition security. Participants resolved to develop a common vision and values, create a database, decide how to use social media tools, and determine who should undertake specific tasks to have a more profound impact on policy.

For example, Faumuina Tafuna'i of Women in Business Development Incorporated³⁶ shared her experience in Samoa, where her organization has used a positive news approach to help elevate farming as an honorable, exciting, and innovative occupation.³⁷

Acting on recommendations from the workshop, CANROP began implementing activities to improve communication and knowledge skills among members, including:

- The establishment of a website, directly managed and maintained by CANROP members, to serve as the

31 This Innovative Practice Summary is adapted from *ICT Update Bulletin*, Issue 81. It was written by Gia Gaspard Taylor (nrwptt@gmail.com), president of the Network of Rural Women Producers Trinidad and Tobago (NRWPTT), and Isaura Lopes Ramos (lopes@cta.int), CTA.

32 <http://www.iica.int/en>.

33 <http://www.cta.int/en/>.

34 "Introduction to the Knowledge Management Scan," http://www.cta.int/images/documents/Introduction%20KMScan_V2Sept2013.pdf.

35 A knowledge management advisory firm based in Wageningen, the Netherlands.

36 <http://www.womeninbusiness.ws/>.

37 ICT Update, "Women at the Forefront of Knowledge Sharing," [http://ictupdate.cta.int/en/Feature-Articles/Women-at-the-forefront-of-knowledge-sharing/\(published\)/1455449487](http://ictupdate.cta.int/en/Feature-Articles/Women-at-the-forefront-of-knowledge-sharing/(published)/1455449487).

main showcase for sharing best practices, promoting products and events, and disseminating news and publications.

- The development and creation of a dynamic Facebook page and Twitter account to serve as the key tools for internal and external networking and informing stakeholders rapidly about the latest activities.
- Continuous ICT training to ensure that members can update the network's social media tools.
- Improving stakeholder connections through stakeholder analysis, strategic alliances at the leadership level, and becoming more aware of stakeholders' needs and demands.

Among other activities, CANROP marked International Women's Day in 2015 with a series of "image messages" in recognition of the work of Caribbean rural women producers. Since then, CANROP's work has put more emphasis on the importance of KM as a tool for members to share information and experiences. For example:

- Everyone can learn more about the women of CANROP on Facebook and follow their Twitter conversation with the hashtag #weareCANROP.
- CANROP chapters also use Facebook: <https://www.facebook.com/SLNRWP?pnref=lhc>; <https://www.facebook.com/BAHMROP>.
- Many CANROP members use Facebook personally and for their businesses: <https://www.facebook.com/pages/Good-Hope-Mushrooms/208423655856405?pnref=story>; <https://www.facebook.com/pages/Chiccharney-Farms/423924377632772?pnref=lhc>; <https://www.facebook.com/pages/Chiccharney-Caterers-Bahamian-Bread-and-Tang/217035645154282>.
- They also have a closed sharing group: <https://www.facebook.com/groups/798898080161785/>.

REAL CHANGE

Internal communication among and within the chapters has intensified and become easier at all levels. Many CANROP chapters depended entirely on IICA for communication with other chapters and their own members—with unavoidable delays and a lack of communication. The CANROP president notes that "now we are on Facebook and we keep in touch, connected, and we can access each other individually and share. You get instant response to emails. But further change is possible as some six or seven chapters still work mainly using (Internet) communication facilities of IICA."

New ways and tools for external communication have put the network and the women it represents on the radar of key national and regional policy makers. Chavara Roker of the Bahamas chapter was part of the CANROP delegation at the Caribbean Week of Agriculture (CWA) and felt that they had a strong presence: "A whole lot of people were talking about CANROP, and after the CWA, the Director National School for Science and Agriculture in the Bahamas invited us to do a presentation which enabled us to recruit new members and inspire young women."

DIVERSITY AND PROCESS

The approach of CTA, IICA, and the consultants they mobilized to accompany CANROP was to support the emergence of an organic process, in which the energy of diverse groups with different histories and interests could blend to generate positive action. For example, the dynamic of the group work in the first workshop acknowledged the diversity between long-standing network executives, the newer chapters, and the passionate supporters, and at the same time sought to bring their different ideas together. The KM scan smoothly aligned KM with the overall strategy and institutional capacities of the network. The KM scan "tree" has been developed, and its use by different actors in the network has been supported and encouraged.

TOOLS AND METHODOLOGIES

Storytelling has boosted the network internally and at the same time contributes to CANROP's external image. Facebook seems to be a tool that fits the target group, but it excludes women who have no easy Internet access, and using a mobile phone can be expensive. Yet using visual media (on and offline) is flagged as empowering for a target group that has generally low levels of education.

INNOVATIVE PRACTICE SUMMARY

The Case of the Pan-African Farmers' Organization (PAFO)

In 2010, five regional farmers' organizations created the PAFO³⁸: the Network of Farmers' and Agricultural Producers' Organizations of West Africa (ROPFA),³⁹ the Southern

38 This Innovative Practice Summary was adapted from *ICT Update Bulletin*, Issue 81. It was written by Chris Addison (addison@cta.int), a senior program coordinator of knowledge management at CTA, in collaboration with Fatma Ben Rejeb (ceo@pafo-africa.org), chief executive officer, PAFO.

39 <http://map.seedmap.org/solutions/food-sovereignty/people-farmer-led-movements/network-of-farmers-and-agricultural-producers-organisations-of-west-africa-ropfa/>.

African Confederation of Agricultural Unions (SACAU),⁴⁰ the Organisations Paysannes d'Afrique Centrale (PROPAC)⁴¹ in Central Africa; the Maghrebian and North African Farmers Union (UMAGRI),⁴² and the EAFF.⁴³ PAFO aims to organize farmers and agricultural producers, to effectively engage members in advocacy, and promote participation in the formulation and implementation of Africa-wide development policies that affect agriculture and rural development. PAFO recognized the value of KM from the outset, making it a key pillar of its formative strategy and creating a knowledge manager position almost immediately.

Since 2012, CTA has worked with PAFO to support information exchange and KM with an ICT platform that enables policy discussions among board members and by building a website for the organization. Prior to the first PAFO Continental Briefing, which took place in Yaoundé, Cameroon, in December 2013, ideas resulting from e-discussion held earlier on the website's group space were presented to help formulate policy on themes such as land acquisition, links between climate change and agriculture, and rural youth in agriculture. The strong achievements of the e-discussion led the KM and communications officers to hold a half-day session during the conference to present those achievements and challenges for farmer organizations in KM.

As part of the development of PAFO's knowledge platform, the regional farmer organizations were supported in developing their websites to ensure that content would be available across the network as a whole. Most recently, the PAFO KM team was at the forefront of a massive Twitter campaign called #includeagriCOP21⁴⁴ at the third PAFO Continental Briefing, in the context of the Africa edition of the Global Forum for Innovations in Agriculture (GFIA). The Twitter campaign was launched to advocate the inclusion of agriculture in the text of the Paris Climate Conference agreement (COP21).⁴⁵

Although the results vary with the different regional farmer organizations, the achievements are encouraging.⁴⁶ Strengthening farmer organizations' KM skills through initiatives such as the PAFO knowledge platform is an effective

way of disseminating relevant information and creating space for dialogue. Even more important, it helps to create PAFO's human network and build the skills to capture information and foster communication.

REFERENCES AND FURTHER READING

For general information on the use of ICT in development, see: Information and Communications for Development (IC4D), <http://go.worldbank.org/DMY979SNP0>. Three publications by the Royal Tropical Institute (KIT), Amsterdam, and International Institute of Rural Reconstruction (IIRR), Nairobi, are particularly recommended:

- KIT and IIRR. 2005. "Chain Empowerment: Supporting African Farmers to Develop Markets."
- KIT and IIRR. 2008. "Trading Up: Building Cooperation between Farmers and Traders in Africa."
- KIT and IIRR. 2010. "Value Chain Finance: Beyond Microfinance for Rural Entrepreneurs."

AFRRI and FRI (African Farm Radio Research Initiative and Farm Radio International). 2008. *The Economics of Rural Radio in Africa*. Ottawa: AFRRI and FRI. <http://www.farmradio.org/english/partners/afri/info.asp>.

———. 2009. "The Effects of Participatory Radio Campaigns on Agricultural Improvement Uptake." Ottawa: AFRRI and FRI. <http://www.farmradio.org/english/partners/afri/info.asp>.

AgriCord. 2010. "Farmers Fighting Poverty: Strengthening Farmers' Organisations in Developing Countries." September, Leuven.

Banks, K. 2009. "A Program to Reach Many Farmers." *ICT Update*. <http://ictupdate.cta.int/en/Feature-Articles/A-program-to-reachmany-farmers>.

Bossio, J. F. 2007. "Sostenibilidad de Proyectos de Desarrollo con Nuevas Tecnologías: El Caso de la Organización de Regantes y Su Sistema de Información en Huaral." *Community Informatics* 3 (3). <http://www.ci-journal.net/index.php/ciej/article/view/394>.

Cagley, M. 2010. "From the Web to the Phone." *ICT Update*. <http://ictupdate.cta.int/en/Feature-Articles/From-the-web-to-thephone>.

de Silva, H., and A. Zainudeen. 2007. "Teleuse on a Shoestring: Poverty Reduction through Telecom Access at the 'Bottom of the Pyramid.'" Paper presented at the Center for Poverty Analysis Annual Symposium on Poverty Research in Sri Lanka, December 6–7.

Economist, The. 2010. "The Next Billion Geeks: How the Mobile Internet will Transform the BRIC Countries." September 2. <http://www.economist.com/node/16944020>.

———. 2011. "Not Just Talk: Clever Services on Cheap Mobile Phones Make a Powerful Combination—Especially in Poor Countries." January 27. <http://www.economist.com/node/18008202>.

FAO (Food and Agriculture Organization). 2004. *Computerizing Agricultural Cooperatives: A Practical Guide*. Rome: Economic and Social Development Department. <http://www.fao.org/docrep/007/y5471e/y5471e00.htm>.

Ferris, S., P. Engoru, and E. Kaganzi. 2008. "Making Market Information Services Work Better for the Poor in Uganda."

40 <http://www.sacau.org/>.

41 <http://infopropac.org/>.

42 <http://pafo-africa/umagri.org>.

43 <http://eaffu.org/>.

44 <https://twitter.com/hashtag/includeagricop21>.

45 www.cop21paris.org.

46 See the PAFO evaluation video: https://www.youtube.com/watch?v=ceJoYvyidEs&index=3&list=PLUtvla4Yp5ynhqVxDwj1_EfBlxQrT0xTh.

- CAPRI Working Paper 77, CGIAR Systemwide Program on Collective Action and Property Rights (CAPRI), Washington, DC.
- Fin24. 2011. "Kenya Coffee Eyes a New Golden Era." Agence France-Presse, updated March 6, MSN, <http://www.fin24.com/Markets/Commodities/Kenya-coffee-eyes-new-golden-era-20110306-2>.
- Flametree Systems Engineering Ltd. 2010. *Baseline Survey Report ICT in Farmers Societies*. (Annex 3 of 10 June 2010 Progress Report).
- Goudappel, P. 2009. "Sending the Right Message." *ICT Update*. <http://ictupdate.cta.int/en/Feature-Articles/Sending-the-rightmessage>.
- Government of Uganda. 2010. "Programme Implementation Manual for the Agricultural Technology and Agribusiness Advisory Services (ATAAS) Programme." Final Draft.
- Greene, J. 2010. "The Bridge between Farm and Market." *ICT Update*. <http://ictupdate.cta.int/en/Regulars/Perspectives/The-bridgebetween-farm-and-market>.
- IFAD (International Fund for Agricultural Development). n.d. "The First Mile Project." Rome: IFAD. http://www.ifad.org/rural/firstmile/FM_2.pdf.
- IICD (International Institute for Communication and Development). 2010. "Augmenter la production agricole à travers les TIC: Leçons apprises d'une fédération paysanne Burkinabè." Learning Brief, IICD project website, The Hague. <http://www.iicd.org/projects/burkina-feppasi/?searchterm=increasing%20agricultural%20production%20through%20ict>.
- ITWeb Africa. 2015. "Zambia: Govt Launches E-Voucher System for Farmers." October 13. <http://www.itwebafrica.com/enterprise-solutions/692-zambia/235317-zambia-govt-launches-e-voucher-system-for-farmers>.
- Kenya National Federation of Agricultural Producers. 2008. "CoopWorks: Computerising Agricultural Co-operatives and Producer Organisations." *Farmer's Voice* 1 (11). http://www.coopworks.org/index2.php?option=com_docman&task=doc_view&gid=24&Itemid=66.
- King, R. P., and I. G. Shuker. 1991. "Information System Adoption and Use in Local Cooperatives." Journal Article 18,559 of the Minnesota Agricultural Experiment Station. <http://ageconsearch.umn.edu/bitstream/46260/2/Vol%206%201991%20Article%205.pdf>.
- Kiplagat, R. 2010. "A Program to Build Trust." *ICT Update*. <http://ictupdate.cta.int/en/Feature-Articles/A-program-to-build-trust>.
- Laureys, F., B. P. Marcilly, and O. Zongo. 2010. "The Market Spread." *ICT Update*. <http://ictupdate.cta.int/en/Feature-ArticlesThe-market-spread>.
- Lenoir, M. 2009. "Farmers Teaching Farmers." *ICT Update*. <http://ictupdate.cta.int/en/Feature-Articles/Farmers-teaching-farmers>.
- Manda, L. Z., and J. Wozniak. 2015. "Farmer Participation in Radio Campaigns for Technology Adoption: Lessons from AFFRI's [sic] Hybrid Maize Campaign in Mangochi, Malawi." *Journal of Development and Communication Studies* 4 (1): 2–17. <http://dx.doi.org/10.4314/jdcs.v4i1.1>.
- Mbogo, S. 2008. "Found in Translation: Farm Radio Goes Local." *New Agriculturalist*. <http://www.new-ag.info/en/focus/focusItem.php?a=484>.
- Nabwowe, A. 2010. "Uganda: Farmers On-Line." *Spore*. http://spore.cta.int/population/en/HS4_09report_ouganda.html.
- New Agriculturist*. 2008. "Bahati Tweve: The Honest 'Middleman' Brokering Deals." *New Agriculturist*, July. <http://www.new-ag.info/focus/focusItem.php?a=477>.
- Nissila J., J. Puhakainen, and I. Tanhua. 2009. "CoopWorks: A Case Study on an Information System Meant to Enhance the Capacities of Agricultural Cooperatives." In Proceedings of the 10th International Conference on Social Implications of Computers in Developing Countries, Dubai, May (accessed May 2011), http://www.ifip.dsg.ae/Docs/FinalPDF/Full%20Papers/ifip_25_nissila,%20tanhua,%20puhakainen.pdf.
- Nyirenda-Jere, T., and T. Biru. 2015. "Internet Development and Internet Governance in Africa." Internet Society, Geneva. <http://www.internetsociety.org/sites/default/files/Internet%20development%20and%20Internet%20governance%20in%20Africa.pdf>.
- Pew Research Center. 2015a. "Cell Phones in Africa: Communication Lifeline." April 15. <http://www.pewglobal.org/2015/04/15/cell-phones-in-africa-communication-lifeline/>.
- . 2015b. "Internet Seen as Positive Influence on Education but Negative on Morality in Emerging and Developing Nations." March 19. <http://www.pewglobal.org/2015/03/19/internet-seen-as-positive-influence-on-education-but-negative-influence-on-morality-in-emerging-and-developing-nations/>.
- Research Into Use*. 2011. "Zambia Turns on the Media," January 31, 2011 (accessed May 2011), <http://www.researchintouse.com/news/110131media.html>.
- Safaricom. 2015. *Annual Report 2015*. http://www.safaricom.co.ke/images/Downloads/Resources_Downloads/annual_report_2015.pdf.
- Séré, C. 2010. "Backing Smallholder Farmers Today Could Avert Food Crises Tomorrow." *The Guardian, Poverty Matters* (blog), October 14, 2010. <http://www.guardian.co.uk/global-development/poverty-matters/2010/oct/14/smallholder-farmers-agribusinessinvestment>.
- Sharma, A., and A. Yadav. 2003. "What Works: Akashganga's IT Tools for the Indian Dairy Industry." What Works Case Study, World Resources Institute. <http://www.bdsknowledge.org/dyn/bds/docs/293/Akashganga%20-%20India.pdf>.
- Sibanda, N. 2010. "Zambia Scales Up Agriculture e-Voucher Scheme." SciDevNet, November 30 (accessed May 2011), <http://www.scidev.net/en/news/zambia-scales-up-agriculture-e-voucher-scheme.html>.
- Soré, R. n.d. "Agriculture and ICT—From Traditional to Modern Harvest: Upgrading of Skills of Rural Women in Burkina Faso." i4d, <http://www.i4donline.net/articles/current-article.asp?articleid=774&typ=Features>.
- . 2008. "Burkina Faso Shea Butter Producers Go High Tech." *PCWorld*, May 15. http://www.pcworld.com/businesscenter/article/145954/burkina_faso_shea_butter_producers_go_high_tech.html.
- SOUNONG. 2010. Institute of Intelligent Machines, Chinese Academy of Sciences, Hefei, China.
- Souter D., N. Scott, C. Garforth, R. Jain, O. Mascarenhas, and K. McKemey. 2005. "The Economic Impact of Telecommunications

- on Rural Livelihoods and Poverty Reduction: A Study of Rural Communities in India (Gujarat), Mozambique, and Tanzania." Commonwealth Telecommunications Organisation for UK Department for International Development. <http://www.telafrica.org/R8347/files/pdfs/FinalReport.pdf>.
- UN Habitat Best Practices Database on Improving the Living Environment. 2006. "Akashganga—Using Simple and Appropriate ICTs to Facilitate Timely Collection of Milk and thereby Generating Higher Revenues to Rural Milk Producing Farmers in India." <http://www.unhabitat.org/bestpractices/2006/mainview.asp?BPID=357>.
- USAID (United States Agency for International Development). 2010. "Using ICT to Provide Agriculture Market Price Information in Africa." Briefing Paper, USAID, Washington, DC. <https://communities.usaidallnet.gov/ictforag/node/11>.
- Veeraraghavan, R., N. Yasodhar, and K. Toyama. 2009. "Warana Unwired: Replacing PCs with Mobile Phones in a Rural Sugarcane Cooperative." *Information Technologies and International Development* 5 (1): 81–95. <http://itidjournal.org/itid/article/view/327>.
- Ward, D. 2010. *Manual for Participatory Radio Campaigns: Revised Manual for the Programming Stages of AFRRI Participatory Radio Campaign Number Two*. Ottawa: African Farm Radio Research Initiative.
- World Bank. 2008. *Gender in Agriculture Sourcebook*. Washington, DC: World Bank. <http://go.worldbank.org/5Z9QPCC7L0>.
- . 2010. "Kenya at the Tipping Point? With a Special Focus on the ICT Revolution and Mobile Money." Kenya Economic Update, December, Nairobi. http://siteresources.worldbank.org/KENYAEXTN/Resources/KEU-Dec_2010_with_cover_e-version.pdf.
- Zimba, J. 2013. "Role of Farmers' Organizations for Inclusive Business in Africa." Paper presented at International Green Week, Berlin, January 16–22. <http://www.wfo-oma.com/documents/role-of-farmers-organizations-for-inclusive-business-in-africa.html>.

SECTION 3

Assessing Markets and Value Chains

Module 9 **STRENGTHENING AGRICULTURAL MARKET ACCESS WITH ICT**

SHANE HAMILL (consultant, the World Bank)

IN THIS MODULE

A growing body of evidence suggests that market information services, especially those based on mobile phones and tablets, can enhance farmers' ability to access markets and match consumers' demands through improving the flow of information between traders and producers, reducing transaction costs, and enabling farmers to purchase required inputs. As new programs and applications are developed, and as the speed of information increases, the potential of information and communication technology (ICT) is still being discovered.

Mobile Phones for Market Intelligence

Farmers use mobile phones to build a network of contacts and draw on this wider expertise to obtain critical information more rapidly. Essentially the mobile phone, its special applications, and the Internet are becoming management tools for farmers, especially in relation to market intelligence. Greater access to information has proven to help farmers make better decisions about transportation and logistics, price and location, supply and demand, diversification of their product base, and access to inputs.

ICT also facilitates market research, increasingly using live information. This market information strengthens farmers' position in their day-to-day trading. Over time, market intelligence enables them to focus on satisfying consumers' and buyers' demands and on developing relationships with stakeholders in the next stage of the value chain. The key development challenge lies in assembling and disseminating this information in a timely manner, not just to traders or larger-scale farmers but also to smallholders.

Case studies:

- ***Esoko in Ghana: Market Information Tool Increases Price and Builds Inter-Village Networks***
- ***mFarming in Tanzania: Mobile Phone Service Increases Smallholder Access to Market Information***

Improving Logistics and Access to Inputs

By improving supply chain management (SCM), ICT tools enhance logistics and reduce transaction costs. They reduce costs of coordination and transportation, increase transparency in decision making between partners, disseminate market and weather information, and ensure traceability. In doing so, ICT fosters smallholders' inclusion in supply chains (see "Smallholder Inclusion in Commercial Supply Chains" section).

ICT increases access to inputs by enabling farmers to make more informed decisions about which inputs are most suitable or offer the best value for money, when and where to obtain them, and how to use them. ICT can also ensure that subsidized inputs are correctly sold to the intended beneficiaries.

(continued)

The authors of the original module 9 were Grahame Dixie (World Bank), Vikas Choudhary (World Bank), Nithya Jayaraman (consultant), and Soham Sen (World Bank); the authors of the original module 10 were Soham Sen (World Bank) and Vikas Choudhary (World Bank). The reviewers of the current Module 9 were Vikas Choudhary (World Bank) and Judith Payne (USAID).

Case studies:

- ***TruTrade in Uganda: Paying Smallholders a Fairer Share of Their Produce Value***
- ***E-Wallet Scheme in Nigeria: Using Mobile Phones to Increase Access to Subsidized Inputs***
- ***E-Krishok and Zero Cost In Bangladesh: Providing Extension and Advisory Services through Mobile Phones***

Smallholder Inclusion in Commercial Supply Chains

Smallholders can raise their incomes by participating in commercial supply chains, but including small farmers entails significant challenges for both the agribusinesses and smallholders. For agribusinesses, interacting with a large group of smallholders implies high transaction and monitoring costs to ensure quality, safety, and timely delivery. For smallholders, participation can be risky, requiring access to inputs and training to satisfy stringent quality requirements.

ICT can address this by facilitating exchanges and flows of information between parties all along the supply chain and can be used to manage transactions and arrange logistics. ICT-supported SCM software stores information on suppliers, enables customers to transmit orders to farmers in an efficient manner, monitors production, and tracks the movement of inputs and end products along the supply chain.

ICT-supported SCM software also has an important role to play in eliminating unnecessary intermediaries from transactions and assisting farmers in their management of traceability schemes, quality assurance programs, and certification schemes such as Fairtrade, Rainforest Alliance, and others.

Case studies:

- ***Farmforce in Guatemala: SCM Tool Facilitates Sustainability Certification for Smallholders***
- ***Farmbook in Africa: Enabling Smallholders to Develop Business Plans and Locate Buyers More Effectively***
- ***Digital Green in Africa and Asia: Transforming Agricultural Extension Systems and Creating Routes to Market***

OVERVIEW

As data collection and the dissemination of easily digested market data for agriculture become more feasible and widespread, it has become increasingly clear that information is power. Driven by the view that greater price transparency better empowers farmers to turn a profit, a number of initiatives aim to provide market price services.

Both public and private sector organizations are leveraging ICT solutions to build market intelligence, improve logistics, and integrate smallholders into commercial supply chains. The primary role of government in promoting ICT for the immediate acquisition of the most updated information is to focus on the overarching importance of maximizing mobile phone coverage while improving access to the technology for the rural poor. An equally important role for government is to support producers in using the technology to become more commercially astute and better attuned to changing markets for agricultural products.

The overall aim is to strengthen farmers' position in their day-to-day trading and, over time, enable them to focus

production on satisfying consumers' and buyers' demands and to develop skills in market servicing (the capacity to develop relationships with stakeholders in the next stage of the value chain).

The Technology Is Changing

Government-run market information services have been criticized in the past for providing information that is neither accurate nor timely and that has yielded little immediate economic impact. Public market information systems collect, analyze, and disseminate information, but their weakness lies in price gathering, as public organizations have fewer incentives for accuracy than private organizations. The major criticism has been that public sector information does not reach farmers on time, if at all.

Mobile phone applications are overcoming this problem. Agricultural applications support logistics with graphical presentations of available supplies and methods for traders to upload price and supply information directly. They facilitate marketing by linking buyers and sellers.

Private companies increasingly sell subscription-based information services and use price information as a means of promoting other products to farmers—most notably, to sell mobile phone services or agricultural inputs, such as fertilizer. These services generally rely on local-language text messages to farmers' phones. This information has been well received by farming clients, with positive reports on its quality, accuracy, and timeliness and positive evaluations of its impact.

Generally, content consists of technical, marketing, weather, costing, pest, and disease alerts as well as information on government schemes. Short messaging service (SMS)–based services are likely to cost considerably less than sending out mobile extension officers to visit farmers, and text-based services are also likely to be more accessible than Internet-based services.

SMS will increasingly enable the two-way flow of information. The emergence of open source software is facilitating the dissemination of targeted SMS messages on a large scale. Agricultural initiatives are using this technology to better control and improve their agricultural information dissemination. In particular, this new technology can help eliminate the recognized weaknesses in dissemination by government-run market information services.

Farmers' Information Needs Are Evolving

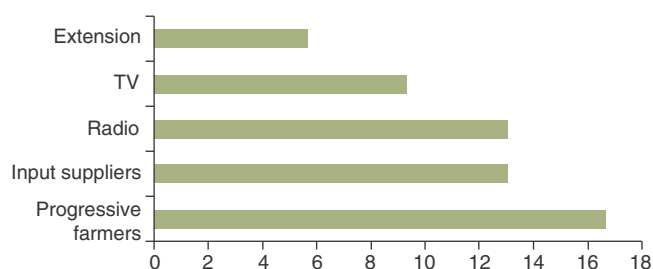
Farmers' information sources outside their immediate network have not always been reliable, but with ICT this

situation is changing. Very often, farmers' primary source of information continues to be progressive farmers (figure 9.1 presents an example from India).

Farmers' information priorities include accurate local weather forecasts, technical information sequenced according to the stage in the crop cycle, data on the costs of production, and market supply and price information. Toward the start of the harvest, these priorities shift toward market information. When a subscription-based agricultural information service has been rolled out, farmers claim that the market news service was the most valuable.

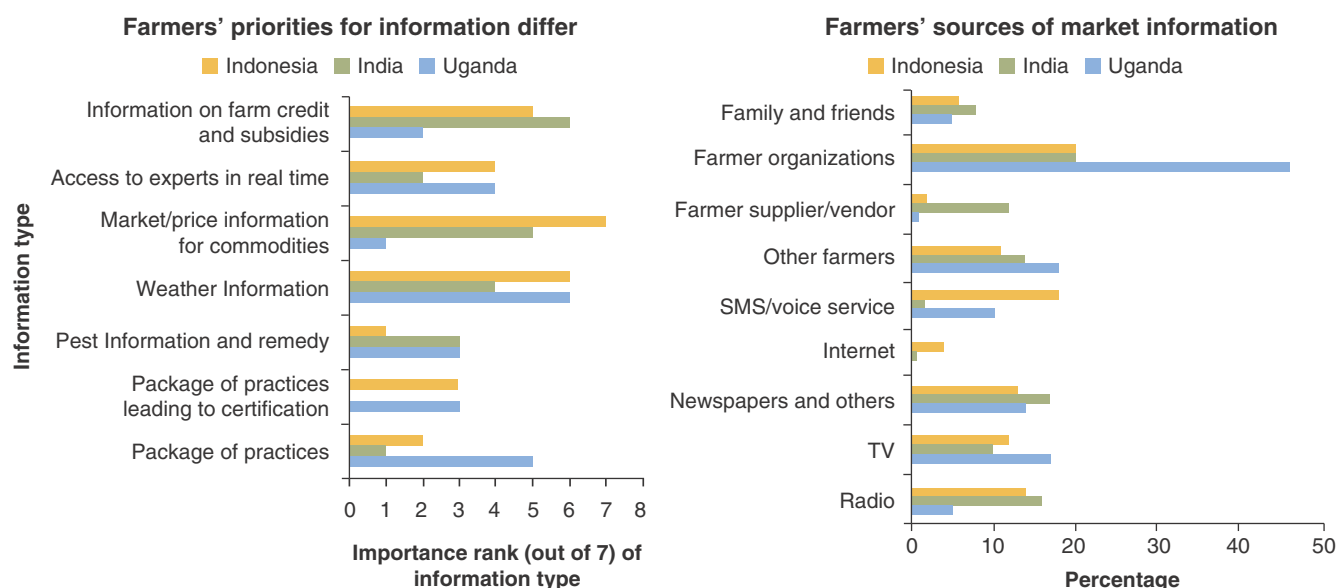
Through examples from India, Indonesia, and Uganda, figure 9.2 illustrates how farmers' information priorities and sources of information can differ. For market information, these farmers rely less on the Internet but turn

FIGURE 9.1. Percentage of Farmers in India Relying on a Given Information Source



Source: Mittal, Gandhi, and Tripat 2010.

FIGURE 9.2. Farmers' Differing Information Priorities and Sources of Market Information in Indonesia, India, and Uganda



Source: Kumar, n.d.

to multiple other sources, including farmer organizations, other farmers, newspapers, radio, TV, and SMS and voice services.

Overall however, according to studies, technical advice is the most popular agricultural information service (provided via phone-in hotlines), followed by SMS-based technical and weather advice, with SMS-based market price services coming third.

THE IMPACT OF ICT ON FARMERS

Quantitative evidence is increasingly available on how market information affects prices paid to farmers (table 9.1). The results are generally positive in terms of farmers' income and prices. Although some evidence indicates that consumer

prices can be lowered, it is also clear that traders who have access to ICT and mobile phones can raise their margins.

Effects on Prices

Price is disseminated in many ways—chalked on notice boards, broadcast by local radio stations, published in newspapers, texted on mobile phones, and (more recently) posted on websites and circulated via smartphones. The scale of the effect on farmers' prices appears to depend on a number of factors, including:

- **The effectiveness** of the informal market information networks that already exist.
- **The stability** of the price structure (for example, whether the government controls prices for a staple crop or whether fixed-contract pricing is widely used).

TABLE 9.1. Summary of ICT's Impact on Farmers' Prices and Incomes, Traders' Margins, and Prices to Consumers

LOCATION, PRODUCT, MEDIUM (STUDY AUTHORS)	FARMER	TRADER	CONSUMER	COMMENTS
Uganda, maize, radio (Svensson and Yanagizawa 2009)	+ 15%			Increase in price paid to farmers considered to be due to farmers' improved bargaining power
Peru, range of enterprises, public phones (Chong, Galdo, and Torero 2005)	+ 13%			Increases in farm income, but higher for nonfarm enterprises
India (West Bengal), potatoes, SMS (M. Torero, IFPRI, pers. comm.)	+ 19%			Yet to be published, but showed information to be important both in the form of SMS and as a price ticker board in markets
Philippines, range of crops, mobile phones (Labonne and Chase 2009)	+ 11–17%			Effect on income among commercial as opposed to subsistence farmers, plus perceived increase in producers' trust of traders
India (Madhya Pradesh), soybeans, Web-based e-Choupal (Gayal 2008)	+ 1–5% (average: 1.6%)			Transfer of margin from traders to farmers, effect seen shortly after e-Choupal established
Sri Lanka, vegetables, SMS (Lokanathan and de Silva, pers. comm.)	+ 23.4%			Appreciable price advantage over control over time, plus benefits such as increased interaction with traders and exploring alternative crop options
India (Maharashtra), range of products, SMS (Fafchamps and Minten n.d)	No significant effect			In this one-year study, quantitative analysis did not show any overall price benefit, but this finding is thought to be due to sales in state by auction; price benefits of 9% were observed with farm-gate sales and younger farmers
Morocco, range of crops, mobile phone (Ilahiane 2007)	+ 21%			Small sample showed usual behavioral changes; higher-value enterprises took a more proactive approach to marketing via mobile phones
India (Kerala), fisheries, mobile phones (Jensen 2007)	+ 8%		–4%	Outlier in the sense that fish catches are highly variable and fishermen have their own boat transportation
Uganda, range of crops, SMS and radio (Ferris, Engoru, and Kagaozi 2008)	Bananas + 36% Beans + 16.5% Maize + 17% Coffee + 19%			Awareness of market conditions and prices offers more active farmers opportunities for economic gain
Niger, grains, mobile phones (Aker 2008)		+ 29%	–3 to –4.5%	Traders increased margin by securing higher prices through greater capacity to search out better opportunities
Ghana, traders, mobile phones (Egyir, Al-Hassan, and Abakah 2010)		+ 36%		Traders using mobile phones tended to sell at higher prices but also tended to be larger-scale traders than nonusers
Kenya wholesale traders, mobile phones (Okello 2010)		+ 57%		Improved trader margin though combination of cheaper buying prices and higher sales prices

Source: Authors.

TABLE 9.2. Current and Future Roles of ICT in Agricultural Marketing

FUNCTION DELIVERED BY ICT	ENABLING OR DELIBERATE?	TECHNOLOGY	FUTURE
Real-time market research	Enabling infrastructure	Fixed-line and mobile phones	Extending range of mobile phones and ICT, facilitated by infrastructure investment and policies
Coordination of logistics	Enabling infrastructure	Fixed-line and mobile phones	Specialist applications, training/producer organizations
Market information (price and supply)	Deliberate: Public and private sector	Web-based and SMS	Applications and public–private sector partnership, plus training and organization
Market intelligence	Deliberate	Web-based	Applications and development of market intelligence services, plus training and organizations
Inputs	Enabling infrastructure	Fixed-line and mobile phones	Targets SMS messaged by private sector, e-vouchers for subsidies

Source: Authors.

- **How the product is sold.** ICT may have a greater effect where negotiation is part of the sales process and a lesser effect when sales are by auction.
- **The type of product being marketed.** Circumstantial evidence suggests that market information systems have a greater effect on prices of higher-value, less perishable products—such as onions, potatoes, and beans—and a lesser effect on prices of extremely perishable products, such as leaf salad.

Delivery to Rural Areas

In many countries, profits generated by mobile phone use in urban areas are set aside specifically for extending the mobile phone network further into rural areas. In occasional instances, technologies such as mobile phone amplifiers and transmitters, focused on marketplaces, can extend the distance over which wireless signals travel and can encourage additional agricultural trade to emerge.

Sharing the Benefits

Although ICT appears to reduce transaction costs, in the past most of these cost savings accrued to traders who invested in mobile phones. Little analytical work has been done to provide empirical evidence of these effects. These kinds of studies are likely to be important for informing better investment decisions on infrastructure, particularly at the nexus between investments in roads, markets, and communication technology.

Given accelerating urbanization and the increasing emphasis on food security, the development sector needs a better understanding of how to ensure that the reductions in transaction costs that are possible along the agricultural supply chain especially benefit those at both ends—the rural producers and urban consumers.

It can be argued that if the situation were left to resolve itself, the bulk of the benefits generated by these new market opportunities would go to the larger-scale and better-off farmers and to the trading sector. To redress this imbalance, there may be a role for extension to alert farmers to new market opportunities, provide training on changing market conditions (especially experiential training), and transmit important market intelligence, especially through the Internet.

Input supply companies can use text messages to promote their products and provide technical advice to farmers. Electronic voucher schemes offer potential for implementing subsidy programs that include the private sector and enable more precise targeting of input supply programs to the poor.

Table 9.2 summarizes the role of ICT in agricultural marketing, based on whether the ICT consists of enabling infrastructure such as telephones or deliberate applications.

FUTURE TRENDS

The use of ICT tools in ensuring market access for small-holder farmers has grown and evolved rapidly over recent years, and this trend is forecast to continue. Future trends in ICT will center on improving existing services and developing new capabilities focused on Internet access, smartphones, social media, and data collection and integration for the user by Internet of Things (IoT)-type services.

Internet Access

Approximately two-thirds of the world's population is offline. Access to high-speed Internet service can be limited in many cities around the world, while access in rural areas can simply

be nonexistent. Internet access will expand over the coming years, including through innovative services such as Google's Project Loon and Facebook's Free Basics (formerly internet.org).

Project Loon is a research and development project aimed at providing Internet access to rural and remote areas through the use of high-latitude balloons. By partnering with telecommunications companies to share the cellular spectrum, Google has enabled people to connect to the balloon network directly from their phones (Google 2016).

Since launching the project in June 2013, Google has conducted a number of comprehensive tests in the Northern and Southern hemispheres. In May 2014, the project's latest long-term evolution high-speed wireless communication (LTE) radio technology was tested at Linoca Gayoso, a rural school in Brazil that had never before enjoyed Internet access. Challenges remain over the length of time the balloons can stay afloat, but Google is committed to launching 300–400 balloons over the coming years (Google 2016). In the medium term, farmers in Sri Lanka will be able to access this Google service. Google signed an agreement with the national ICT Agency in July 2015, and in February 2016 the Government of Sri Lanka announced that it will take a 25 percent stake in a joint venture with Project Loon to provide high-speed Internet service across the country (*Guardian* 2016).

Facebook's Free Basics service also aims to provide high-speed Internet service to areas that until recently have remained difficult to reach. By partnering with the world's leading telecommunications companies, Facebook aims to make Internet access more affordable. Simple, quick-to-load websites are available on the platform via smartphones for free without data charges. Launched in August 2013, it is now available in 36 countries and has reached 19 million people who otherwise would not have had access to the Internet (Facebook 2016b). In 2015 and early 2016, this initiative came under strong opposition, particularly in India, from some groups over Net neutrality issues. As reported by *Forbes* and other media outlets, this may have implications for how Free Basics is rolled out in other countries and regions in the future (*Forbes* 2016).

As an extension of its Free Basics program, Facebook has awarded a number of Innovation Challenge Awards to projects in India that have played a role in connecting and providing added value to communities through ICT. Farming has been identified as a key category, and in October 2015, US\$250,000 was awarded to eKutir, an Internet program accessible by computer or smartphone. eKutir provides farmers with tools and resources to support all aspects of

farming, including the sales process through market connections (Facebook 2016a).

An underlying challenge of the Internet's expansion will be overcoming the digital divide, which carries the risk of marginalizing groups that may not have equal access to services. Internet access is not universal, and as long as restrictions on Internet service remain in place, investments in rural infrastructure and addressing farmers' constraints will require incentives offered by public stakeholders and will be addressed by both public and private actors.

Smartphones

By complementing existing text messaging and phone call services with Internet access, smartphones have the potential to be a truly disruptive technology in increasing market access for smallholder farmers. Estimates of smartphone use around the world vary widely, however, and can be more difficult to obtain for rural areas than for urban areas.

Forecasts of smartphone use can be equally problematic. According to eMarketer, Latin America is home to 155.9 million smartphone users, and this number is forecast to grow to 245.6 million users by 2019. In 2015 an estimated 84 percent of these users came from just six countries; Argentina, Brazil, Chile, Colombia, Mexico, and Peru (eMarketer 2015). In Bangladesh, smartphones accounted for 6 percent of total handset shipments in 2013. However, the mobile Internet reached 20 percent penetration through 2G networks. The 3G Internet is expected to outpace 2G by 2020 (GSMA Intelligence 2014).

In North Africa and Sub-Saharan Africa, smartphone penetration reached approximately 20 percent of the population by 2013, according to the United States Agency for International Development (USAID). By 2017, it is expected to exceed 50 percent in South Africa, 29 percent in Nigeria, and 28 percent in Kenya (USAID 2013).

Smartphones can drive further innovation in market access through real-time information but also through application interfaces driven by video and sound. Smartphones turn a surface into a screen, and over time farmers will increasingly absorb content through video. This trend is illustrated by the growth of Access Agriculture and Digital Green, two nonprofit organizations that host videos on a digital platform to improve the lives of farmers across South America, South Asia, and Sub-Saharan Africa.

Launched in 2008, Digital Green enables extension agents and peer farmers to upload videos online to share knowledge on

improved agricultural practices, livelihoods and market trends. As of March 2016, in India the organization had reached over 1 million individuals across over 12,000 villages through 4,360 videos, which showcase and demonstrate best practices (Digital Green 2016a). According to a controlled evaluation by Digital Green, this approach led to an uptake of new practices that was 7 times higher compared to traditional extension services and 10 times more cost-effective (Digital Green 2016b). Digital Green is addressed in more detail in the “Smallholder Inclusion in Commercial Supply Chains” section.

Social Media

The power of social media is still being discovered with every new global event, news cycle, and digital start-up. Ultimately, through platforms such as Facebook, Twitter, WhatsApp, and LinkedIn, social media empowers individuals to connect to one another, collaborate, and share. For smallholder farmers, it can facilitate new connections, strengthen networks, and disseminate information on markets, inputs, logistics, and supply chain stakeholders. All of these factors create a grassroots enabling environment for smallholders to negotiate better prices for their produce, find new customers, and make informed decisions.

USAID highlights a case in Maharashtra State in west-central India, where farmers used Facebook to discuss prices and plan a joint market strategy. In 2012, these turmeric farmers had overproduced their crop and turmeric prices were crashing. Farmers contacted one another across the country through Facebook Messenger to plan a reduction in supply over a number of days (USAID 2013). Initially, 35 farmers agreed to boycott the local auction in Sangli District. Within days, thousands of farmers withheld their produce. Their protest—which would traditionally have taken months to organize—was finalized within 10 days. When farmers returned to the auctions, turmeric prices had doubled, from Rs 4 to Rs 8 per kilogram (*Economic Times* 2012). As the Internet becomes more accessible, these trends will continue to grow in rural areas, particularly among younger users.

Data Collection and Integration by IoTs

With increased integration of devices such as smartphones, computers, and tablets, access to information will become even easier. This cross-screen trend has implications for content delivery, advertising, and analytics. Increasingly, the network upon which the information lies becomes more relevant than the device being used. The integration of printers and scales with mobile devices is also streamlining the business of smallholder farming. Recent development of a range of

data collection methods by sensors and crowdsourcing, combined with processing platforms called IoTs, are transforming agriculture.¹ Today, farmers in developed countries use IoTs to remotely monitor sensors that can detect soil moisture and follow the growth of their crops. They can also remotely manage and control crop management and irrigation equipment, and utilize artificial intelligence to make sense of the data to guide their management actions on the farm and in the market.² Adoption and development of IoT applications in international agriculture are also emerging and expanding. Some examples include connected micro-weather stations for localized weather data and provision of crop insurance (Kenya); low-cost, mobile-controlled micro irrigation pumps (India); soil-monitoring sensors to improve tea production (Sri Lanka, Rwanda); and radio-frequency identification (RFID)-based food supply testing and tracking systems (India) and RFID-based livestock tracking, theft prevention, and vaccination records (Botswana, Senegal, and Namibia) (ITU and CISCO 2016).

KEY MESSAGES

Farmers use mobile phones to build a network of contacts and draw on this wider expertise to obtain critical information more rapidly. Essentially, the mobile phone, its special applications, and the Internet are becoming management tools for farmers, especially in relation to market intelligence. Greater access to information has proven to help farmers make better decisions about transportation and logistics, price and location, supply and demand, diversification of their product base, and access to inputs. ICT also facilitates market research, increasingly using live information.

By improving SCM, ICT improves logistics and reduce transaction costs. ICT can foster smallholders’ inclusion through these logistical improvements by reducing costs of coordination, increasing transparency in decision making between partners, reducing transaction costs, disseminating market and weather information, and ensuring traceability. ICT also facilitates exchanges and flows of information between parties all along the supply chain and can be used to manage transactions, arrange logistics, and ensure that quality specifications are clearly understood. The IoT is fast finding its way to support agriculture, from field monitoring to processing and marketing, and is a trend to follow and adopt where feasible.

1 For an overview of the IoT in agriculture, visit <http://www.link-labs.com/iot-agriculture/>.

2 <https://www.thingworx.com/platforms//>

With the development of Internet access in rural areas, ICT will continue to evolve to incorporate smartphone interfaces and social media. However, with this advancement, ICT providers will need to overcome the challenges of any potential digital divide. ICT programs will no longer be restricted to text messaging, phone lines, or websites but will be integrated across all platforms, reaching all smallholders any-time, anywhere.

No single digital platform for market access has yet to outperform all others, so no single model can be used going forward. Many different organizations across the world are developing programs to assist farmers, with varying objectives and results. Diversity in these programs is likely to continue to yield positive outcomes under each specific scenario. It is important to emphasize, however, that ICT applications are tools and not solutions. All stakeholders along the value chain, both public and private, have a role to play in maximizing the potential for ICT to disseminate knowledge and empower smallholders.

By all indications, the mobile phone is the most powerful marketing tool available to farmers and traders. The studies reviewed throughout this module indicate the phone's potential for reducing asymmetries of information between traders and producers, lowering transaction costs, and enhancing farmers' ability to fine-tune their production strategies to match the accelerating rates of change in consumer demand and marketing channels. The phone's potential is still being discovered, and the scale of its impact is still being understood.

MOBILE PHONES FOR MARKET INTELLIGENCE

Trends and Issues

Multiple and complex dynamics operate around market demand. Consumer demand fluctuates constantly as marketing channels continuously evolve, to name just two such dynamics. To become adept at pairing production with opportunities, farmers and others along the value chain need to become better at both acquiring market information that is immediately useful and obtaining longer-term knowledge related to markets.

The Need for Market Information

Immediate market information is needed to gain a better understanding of short-term fluctuations in pricing and demand, thus enabling the sale of existing crop and livestock products in ways that maximize their profitability. Most often, short-term information helps in price negotiation, but it can also influence the timing of sales and selection of the

market. As this kind of information tends to change rapidly, its timeliness and accuracy are of great importance.

Longer-term market information changes slowly and informs decisions such as which product to produce, which marketing channel to use, and other strategic decisions aimed at maximizing profits. To be made well, these kinds of decisions require an understanding of a wide range of factors, such as competing suppliers, product specifications, market trends, and other issues for specific products. Generally these decisions also build on the aggregate knowledge created through the acquisition of short-term market information over a period of time.

The key development challenge lies in assembling and disseminating this information in a timely manner, not just to traders or larger-scale farmers but also to smallholders so that they can make more sensible management decisions and increase their opportunities.

The type of product-based information that farming stakeholders generally require includes:

- **A general overview of the market.** What is the market's size, value, and growth rate? What are the divisions between sectors? Who are the competing suppliers?
- **Product specifications.** What are the prevailing grading and packing standards and consumer and market preferences (taste, color, size)?
- **Marketing issues.** What are the typical prices and seasonal price patterns, quality premiums, and marketing channels? What is the prognosis for future prices and changes occurring in the supply chains for the market?
- **Key contacts.** What are the names, addresses, and telephone numbers of key contacts, particularly buyers, agribusinesses, and traders but also specialist input suppliers and transportation operators?

Challenges Faced by Smallholders

Although the situation differs by product, in most situations market information for smallholders has proven to be fragmented, anecdotal, outdated, inconsistent, and incomplete. For example, markets for staple cereals, which are often subject to price controls, move relatively slowly. Information about these markets is more widely known. For products that are more perishable or for which consumer demand is shifting, the market situation is far more opaque.

In terms of balance of power in negotiations, smallholder farmers are mainly at a considerable disadvantage in the

day-to-day marketing of their products. Often, market information will come from a neighboring farmer who may have visited a market on the previous day. A trader's core skill is to read the market, assess supply and demand, and compute how these factors might affect price. Increasingly, traders will triangulate their information with information from others. Given the opportunity, traders may exploit farmers' relative ignorance to buy low and, ideally, sell high. Case studies have shown that the power balance in these negotiations is altogether different when the trader senses that the farmer-interlocutor also appreciates the real market situation and can access different markets, buyers, and outlets.

Figure 9.3 provides a sense of the package of information that farmers need with respect to immediate information and long-term market intelligence and displays the likely sources of that information.

Role of ICT

A growing body of knowledge indicates that phones, tablets, TV and radio, mobile phones, and increasingly smartphones have a positive impact on agricultural income. This technology gives users the ability to tap into a wider range of knowledge and information than they could access previously. Research is emerging on just how much farmers are starting to use mobile phones to assist in marketing their production. Work in Bangladesh, China, India, and Vietnam showed that about 80 percent of farmers now own mobile phones (Minten, Reardon, and Chen n.d.). Mobile phones are used to speak to multiple traders to establish prices and market demand, and more than half of smallholder farmers concluded selling arrangements and prices on the phone.

Greater access to information and buyers steadily adds to farmers' market knowledge and gives them greater confidence to diversify products. The additional knowledge translates into a more accurate understanding of demand and an enhanced ability to control production and manage supply chains.

Farmer Networks. Farmers build up a network of contacts and draw on this wider experience and expertise to obtain critical information more rapidly. With phones, farmers deal directly with wholesalers or larger-scale intermediaries rather than small-scale intermediaries. Farmers who own mobile phones have also proven able to develop a broader network of contacts than their peers who do not own them.

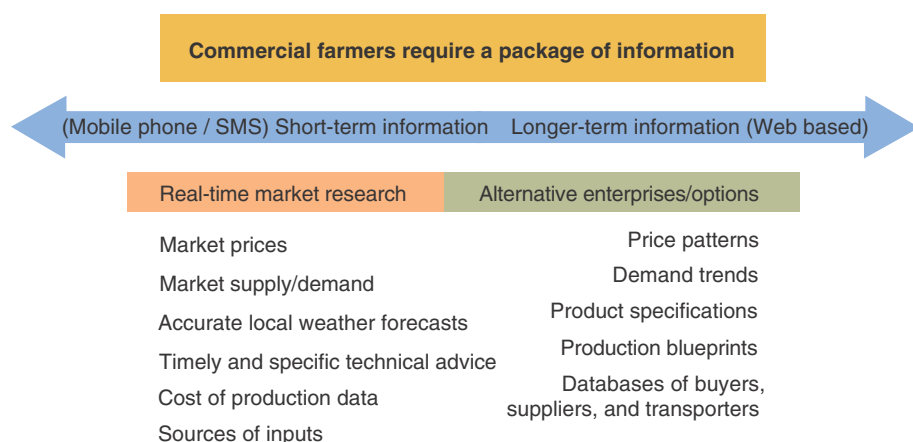
Studies have shown that in Malaysia, for example, mobile phone use was linked to increased profits among younger owner/managers of farms and smaller agribusinesses. A survey of 134 younger agricultural-based entrepreneurs asked for their perceptions of the impact of mobile phones on their businesses. The two overarching benefits they reported were that they could draw upon a wider network of people for information (a "wisdom of crowds" effect), and they could obtain information at a greatly increased speed (Shaffril et al. 2009). Other benefits—such as market information, time savings, and technology—were of a lower order. The overall impact was an increase in profits from their businesses, especially after the entrepreneurs had used their mobile phones for more than two years.

Price and Location. An ability to compare prices increases farmers' power to negotiate with traders (as discussed below). It also enhances farmers' ability to change the time and place of marketing to capture a better price. Figure 9.4 shows how market information can significantly affect farming profits.

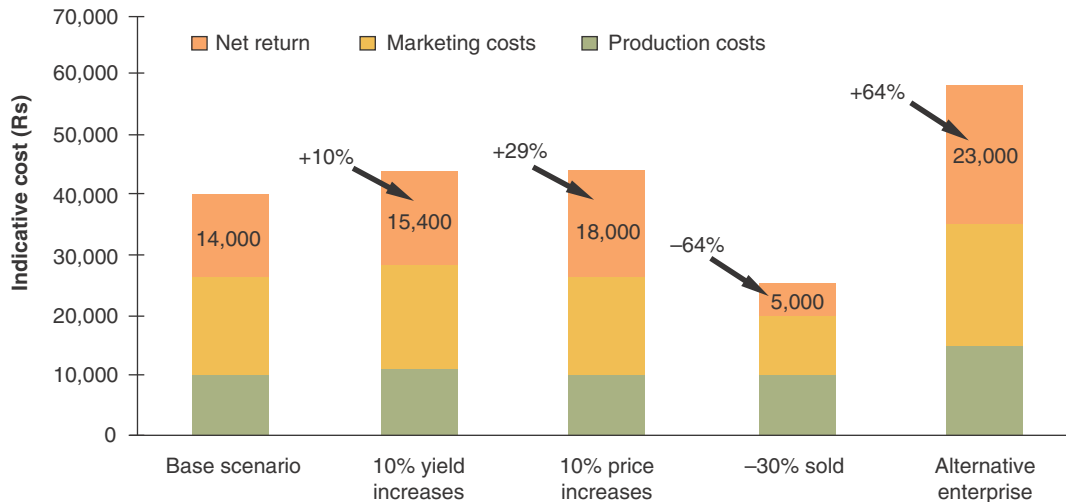
Profitability is highly affected by prices, largely because any change in price has little or no effect on costs, so the effects are directly on the bottom line. An inability to find buyers for products naturally has a profound effect on profits. By accumulating market knowledge, however, producers gain an opportunity to identify and diversify into alternative and more profitable products.

The main goal of increasing access to market information is to empower farmers to take greater

FIGURE 9.3. Commercial Farmers' Information Needs and Sources



Source: Authors.

FIGURE 9.4. Market Information Affects Farmers' Profits

Source: Authors.

control of marketing their produce and orienting their production to identified market opportunities. In essence, the ability to conduct market research—to gather both short- and long-term information—will increasingly become part of the mix of farming skills.

One of the most influential studies of the impact of mobile phones was carried out by Jensen (2007), who tracked effects on the fisheries subsector as mobile phone coverage was extended along the coast of Kerala, South India. The results were dramatic. Because farmers could identify the best markets for selling their catch, price volatility was reduced, wastage was significantly lower, fishermen achieved higher average prices, and consumer prices fell.

Studies in Niger have found that mobile phones bring better price integration, improve profits for traders, and reduce consumer prices. Aker (2008) found that mobile phones reduced search costs by 50 percent compared with personal travel. Traders' profits increased by 29 percent—not because they traded more products but because they obtained better prices through real-time market research conducted via mobile phone. Mobile phones were also associated with a 3.5 percent reduction in average consumer grain prices.

A survey of a small sample of farmers in Morocco found that mobile phone use resulted in a 21 percent increase in income (Ilahiane 2007). An even more relevant finding was that the technology changed farmers' behavior; increasingly, they spoke directly with wholesalers or larger-scale intermediaries rather than smaller intermediaries. Farmers switched

markets to capture better prices coordinated with local truckers to improve product transportation. A particularly important change was that they used their new knowledge to become more market oriented in their production, moved away from producing low-value crops, and diversified into higher-value enterprises. The knowledge gained from using the mobile phone reduced the perceived levels of risk and helped them target their production to specific, identified market opportunities.

Svensson and Yanagizawa (2009) assessed how prices paid to farmers were influenced by market information collected by the Market Information Service Project and disseminated through local FM radio. The information was broadcast through daily bulletins of 2–4 minutes and a longer weekly program that provided district market prices.

Having access to a radio was associated with a 15 percent higher farm-gate price. Where market information was not disseminated through the radio, there was no effect. The results suggest that reducing the information asymmetries between farmers and other intermediaries increased farmers' bargaining power.

One of India's leading private companies, ITC, has annual revenues of US\$7 billion and 29,000 employees. It is active in fast-moving consumer goods, hotels, paper and packaging, agribusiness, and information technology. Through its e-Choupal program, it has established Internet access kiosks across rural India to both enable farmers to retrieve market information and to serve as a sales channel for its products.

Launched in 2000, the kiosks operate in 40,000 Indian villages and reach approximately 4 million farmers. These kiosks are hubs where farmers can obtain price information, seek options for selling their produce, buy inputs, and obtain advice on farming practices related to input use. This service is free of charge; ITC earns revenues through commodity transactions at the kiosks and through advertising other goods via the kiosks such as agricultural inputs. Ultimately, ITC expects half of its revenue to come from input sales through its Web-enabled e-Choupal network.

In addition to the kiosks, ITC also offers information services to farmers via mobile phone, thus deepening its relationship with the farmer and enabling them to make more informed decisions (Kumar n.d.). Table 9.3 demonstrates the impact of the e-Choupal service on farmers' yields and costs.

Negotiations. Research on negotiation approaches indicates that it is important to obtain as much information as possible prior to a potential transaction. This information should include the trading patterns, goals, and preferences of those that one is negotiating with. Groups provided with more information in advance achieved more effective and efficient outcomes as well as higher levels of satisfaction with the negotiation.

Farmers reported feeling increased trust in their trading partners after they had gained access to mobile phones.

Research on tomato farmers' negotiations with rural traders in Ethiopia showed that, on average, farmers' initial asking price was about three times higher than the final price they obtained from buyers (Jaleta and Gardebroek 2007). Yet when farmers had market price information—typically obtained by a mobile phone call to acquaintances close to the central market—the difference between their initial asking price and the final price was reduced by 16.5 percent. In other words, market information increased farmers' bargaining power by one-sixth.

Goyal (2008) compared farmer prices in the regulated market (*mandi*) for soybeans in two areas of Madhya Pradesh, India. In some areas, 1,600 e-Choupals Internet kiosks operated by the aforementioned agribusiness company ITC disseminated price information, whereas the other areas relied only on the *mandi* for such information. Goyal found that farmers obtained better prices when they had access to a wider range of market information. Farmers' price increases ranged from 1 percent to 5 percent, with an average of 1.6 percent. The additional farm income from soybeans in Madhya Pradesh

TABLE 9.3. Agricultural Interventions Made through e-Choupal Kiosks and Their Effects

TYPE OF AGRICULTURAL TECHNOLOGY OR PRACTICE	BEFORE E-CHOUPAL: 2000	E-CHOUPAL INTERVENTION	EFFECTS
Seed use per unit area	For soybeans, farmers used a high planting density (45–50 kg seeds/acre)	Farmers advised to use a lower planting density (30–35 kg seeds/acre)	Savings: 10 kg seeds/acre (Rs 200 / acre)
Seed of verified quality	Farmers' limited awareness of benefits of certified and foundation seeds led to limited use of such seeds	The e-Choupal demonstrated the benefits of foundation and certified seeds through its agricultural extension program (Choupal Pradarshan Khet)	Yield increase and self-sufficiency in seeds (for self-fertilizing, nonhybrid crops)
Seed treatment	Low awareness of benefits of seed treatment	The e-Choupal spread awareness about benefits of seed treatment and provided treated seeds to some farmers	Germination percentage and yields increased significantly
New varieties and improved timing of planting	Farmers used varieties inappropriate for local conditions (climate, pest, and disease incidence and timing of rainfall)	The e-Choupal suggested new varieties suitable for adverse conditions and advised farmers how to better align planting with rainfall	Most suitable variety planted on time, leading to higher yields
Weed and other pest management	Farmers controlled weeds by hand; for pest control, they were largely guided by local input dealers	The e-Choupal suggested use of herbicides and/or pesticides in specific circumstances	Effective weed and pest control leading to low loss of yield
Soil testing	No awareness of soil testing and consequent benefits	The e-Choupal propagated the practice of replenishing soil nutrients based on soil testing reports	Reduced fertilizer costs and more appropriate nutrients applied
Storage practices and market linkages	Low awareness of hygienic practices for stored crops; limited opportunities to sell products	The e-Choupal advised storage of grain based on moisture content to avoid loss and contamination; it offered farmers alternate opportunities to sell their products	Reduced losses from poor storage practices as well as better earnings from the sale of output

Source: ITC Ltd 2010.

was estimated at about US\$10–20 million per year. This income was almost certainly a transfer from traders to producers as a result of producers' greater market knowledge and improved strength in negotiation.

Increasingly, ICT is being used to integrate markets and bring in more transparency and opportunities. This provides many opportunities for empowering the negotiation position of smallholder farmers. The Government of Karnataka (India), for example, has been implementing electronic markets (e-mandi) for the past many years. This has been found to improve marketing efficiency through competitive and transparent bidding mechanisms and by minimizing manipulations in trading practices (Athawale 2014). Now this approach is being scaled at national level by the Government of India, which plans to integrate 585 wholesale markets through a common electronic platform (*The Hindu* 2015).

Supply and Demand. Farmers gain greater control over their production and product sales by finding new sources of demand, improving their ability to adjust supply and quality to market conditions, and learning about quality, grades, and product presentation.

Over the longer term, a better understanding of market demand and consumer trends helps farmers diversify into higher-value crops and capture greater value. Farmers can also make more informed decisions about which inputs are better or cheaper to buy and when and where to best obtain them.

Transportation and Logistics. Farmers can organize and coordinate among themselves and (larger-scale) truckers to consolidate volume and leverage economies of scale. Greater coordination also occurs around the timing of aggregation, collection, and volumes. Larger volumes lower costs and enable farmers to realize higher prices.

Increased Uptake of ICT

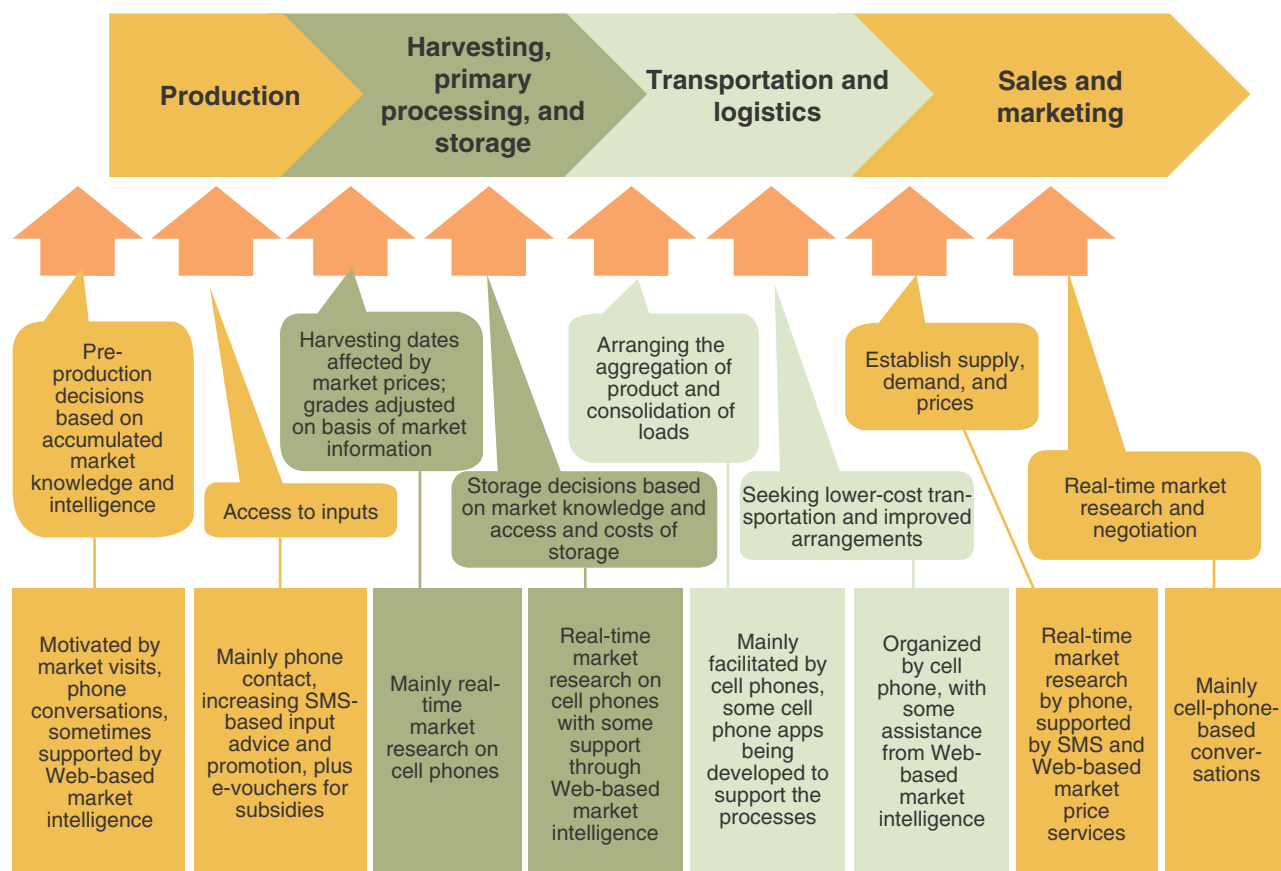
Evidence indicates that farmers increasingly use mobile phones for real-time market research. In Bangladesh, for example, about 80 percent of farmers now have mobile phones; of these, two-thirds have owned mobile phones for three to five years (Minten, Reardon, and Chen n.d.). About 70 percent of rice growers and 30 percent of potato growers contact multiple traders by phone to explore selling opportunities and prices, and about 60 percent will agree on the details of the trading deal over the phone. In parallel with mobile phone growth, smartphone penetration is also growing in Bangladesh and other regions (as discussed in the overview).

Figure 9.5 illustrates where the effects of ICTs on agricultural marketing occur along the links in value chains, thus indicating the information required and the technology involved. The figure has two key messages. First, ICT potentially has an impact on the management of every step in the production marketing chain, from planning to sales. Second, almost all of these functions are likely to be carried out by mobile phone. Other potential services (for example, market price information, market intelligence, and specific phone-based applications) largely perform support and secondary functions that make farmers' mobile phones more useful.

Lessons Learned

Experience in using ICT devices to improve access to market information reveals that they contribute to:

- **Broader and deeper networks.** Farmers communicate by phone with traders and farmers outside of their immediate geography, as opposed to making a physical trip. The ability to communicate more easily and to triangulate information creates deeper trust in key trading relationships.
- **More sophisticated marketing plans based on price information.** Farmers can modify the date of marketing, product permitting, or switch to alternate markets, transportation and regulation permitting. Producers also use market information to decide when to harvest produce or, if possible, where to store it until they can sell it at higher prices.
- **Improved negotiation power.** Farmers increase their power to negotiate, particularly with traders, based on their ability to understand pricing in multiple markets, to cut out intermediaries, and to sell directly to larger-scale buyers.
- **Informed use of inputs.** Farmers improve their capacity to raise yields through better use of inputs and/or use of better inputs. They can identify sources of inputs, obtain them more cheaply, and are better able to buy and apply them at the optimal times.
- **Future production and marketing choices.** Aside from increasing their profits and competitiveness through immediately useful information related to prices, markets, and logistics, farmers also require information about market changes that may influence their production and marketing choices over the longer term.
- **Reduced logistics and transportation costs.** Farmers obtain the latest information with a phone call instead of making a long trip to a market.

FIGURE 9.5. ICT Input for Marketing along the Agricultural Value Chain

Source: Authors.

They can coordinate with other local farmers to use one large truck rather than several smaller ones to deliver their products.

- **Innovative partnerships.** Partnerships are facilitated and built among groups of producers, or by virtue of direct communication with corporations and traders, or through the ability to supply product based on just-in-time and/or quality needs.
- **Improved farm business management.** Farmers can become better managers through better information about which inputs to use, new knowledge about grades and standards for produce, and increased interaction with corporations, traders, and other farmers.

Debate among practitioners centers on the relevance of the public and private sectors' roles in market information services and how public-private partnerships can offer the best way forward. Some take the view that if telephone infrastructure is provided, stakeholders will find a way to use ICT

for gathering the price and market information that they need. As ICT services improve, resources become available, infrastructure expands, and technological learning becomes more widespread. In the future, smartphones might make Internet-based dissemination more effective, especially for interventions that seek to expand market intelligence.

The private companies that have emerged in recent years to deliver market information take a proactive approach to understanding potential customers' information needs, and they build feedback loops to learn how their services can be better attuned to demand and more responsive to complaints. They use their own enumerators, whose employment depends on the accuracy of their price reporting. Generally, their customers—mostly younger, more literate, and larger-scale farmers—have reacted positively.

Principles and Guidelines for Potential Interventions

Based on the accumulating evidence, experience, and lessons learned, a number of principles and guidelines are

important to consider when using ICT to develop market intelligence:

- **Market intelligence is one of the building blocks for stronger knowledge of the changing landscape of agricultural production.**
- **Market information on prices, supplies, and demand can positively affect prices paid to farmers, but only if it is done well.** Farmers need a package of information that evolves as their priorities change throughout the agricultural season. This information package can encompass weather forecasts, technical advice, market prices, pest and disease alerts, and messages about schemes and support from the appropriate line departments. Market information on its own is not enough to make farmers both more productive and more profitable, however. An integrated approach to information generation and delivery is required.
- **Both the government and private sector are having difficulty in delivering ICT-based information in a sustainable, effective way. Public-private partnerships offer a way forward.** New open source technology is making it possible for government institutions to provide far more targeted information, primarily by sending local-language SMS messages or voice messages directly to farmers' phones and by allowing feedback from the field. The technology helps overcome the major criticism that government information systems do not reach their clients.

Open source systems can become the foundation of an ICT-mediated extension service that alerts clients to pest and disease problems, other information vital for production, and opportunities to participate in new government schemes. The potential for generating income to cover operating costs would be significantly increased if the government would use its resources to build an accurate and useful database of its farming clients, with their mobile phone numbers and farming characteristics, and leverage a very substantial reduction in the cost of SMS messages.

The extension service will have the very real possibility of selling SMS broadcasting services to clients supporting the farming sector, such as banking institutions (to send messages, technical and price information, and loan repayment reminders to borrowers) or input suppliers (to promote products, remind farmers to buy inputs, and respond to pest, disease, and plant/animal nutrition issues). Sales of such services, along with the collection of price data, may best be done by the private sector or suitably incentivized individuals.

- **Lower the cost of SMS.** Clearly, there are important opportunities for enhancing the range, scale, and impact of information dissemination by working with the regulator to reduce prices for bulk messaging to producers. Development institutions need to be able to benchmark costs to strengthen negotiations when proposing the development of public good, SMS-based information services.
- **Invest in farmer education and extension training.** Helping smallholders to understand needs for grading, organization, coordination, and market opportunities is critical to success. Marketing education, especially experiential marketing training, can be an important element in leveraging the benefits that ICT can bring to farmers' prices and returns.

Case Study: Esoko in Ghana—Market Information Tool Increases Price and Builds Inter-Village Networks

Esoko, a private company founded in Ghana in 2004, provides information and communication services for agricultural markets in Africa. Now operating in 8 countries and employing over 200 people, it has played a role in the explosive growth of cellular services across the continent. It has grown to be the leading initiative in delivering market information to farmers across Africa, and it is an example of how Ghanaian software developers can build world-class technology that is used throughout the continent (Esoko 2015).

Esoko uses a simple text messaging system and website to bridge the information gap being faced by smallholder farmers. This platform provides three services: current local market prices; a matchmaking platform that connects buyers and sellers; and information including weather forecasts, news, and tips for farmers. These services enable farmers to make informed decisions that can increase their income.

By driving this social and economic impact in rural communities through the use of mobile phone technology, Esoko has succeeded in increasing farmers' incomes by about 10 percent per year. Now, 6,000 farmers in 16 countries in Africa use the platform (Hildebrandt et al. 2015). According to a 2015 study by New York University (NYU) on the impact of market information tools, farmers in Ghana using Esoko were able to increase their income by 9 percent per year (Hildebrandt et al. 2015).

For this 2015 study, researchers conducted a randomized field experiment to examine how market price information shared via text messages to mobile phones affected smallholder farmers. As in other parts of Sub-Saharan Africa, a majority

of Ghanaian farmers are smallholders who depend on traders to market their production. In each agricultural season, the typical farmer in this study sells, on average, to three to five different traders. About half of these traders are individuals with whom farmers have a long-standing relationship.

It is common in the region for transactions between farmers and traders to take place at the farm gate or in the local area, to be conducted in an informal manner, and to involve bargaining between the parties. As described earlier in this module, farmers often complain of unfair practice by traders, and this is also the case in Ghana; smallholders believe traders cheat them by citing prices that are lower than the actual urban prices. Farmers cannot verify this and are at a disadvantage in negotiations (Hildebrandt et al. 2015).

As mentioned above, this NYU study found that by simply having access to market information, farmers were able to increase their income by 9 percent. For a typical yam farmer in Ghana, the resulting increase in annual household income was approximately US\$170. The direct return on investment for this service was in excess of 200 percent (Hildebrandt et al. 2015).

Researchers also found a spillover effect, in which nearby farmers without direct access to Esoko information also

experienced higher prices. This spillover probably is the result of two factors. First, farmers tend to share market prices with one another, demonstrating the importance of farmer networks built up locally and via mobile phone. Second, traders apparently did not know which farmers had access to market information and which did not, therefore shifting the power balance in negotiations. Many traders began offering the higher price once they encountered farmers who had access to that information (Hildebrandt et al. 2015); see image 9.1.

Case Study: mFarming in Tanzania—Mobile Phone Service Increases Smallholder Access to Market Information

Poor transportation and communication infrastructure means that smallholder farmers in Tanzania, a large and fairly sparsely populated country, struggle to access vital agricultural market information and training. Finnish mobile-service company Sibesonke was established in 2009 and aims to offer a cost-effective and scalable mobile service to address these challenges.

Sibesonke launched its mFarming Service to empower farmers to receive real-time weather forecasts and crop and livestock management tips, including advice on topics such as pests and disease treatment. This information presents smallholder farmers in Tanzania with an unprecedented opportunity to increase their yields and improve farming practices.

In March 2013 Sibesonke announced a partnership with the Tanzanian Ministry of Agriculture, Food Security, and Cooperatives, and the Ministry of Livestock and Fisheries Development to empower both ministries to better reach the 33 million Tanzanian farmers with relevant, up-to-date farming content on mobile phones (Finnpartnership 2013).

The mFarming service allows farmers to buy and sell crops and livestock, receive crop and livestock management tips, and obtain weather forecasts. Farmers on the network Vodacom can access the mFarming service by dialing *149*50# on their mobile phones.

IMAGE 9.1. Market Information Tools Used by Smallholder Farmers

a. Mobile and computer screen views of Esoko



b. Close-up of data fields for a commodity



By 2013 over 600 smallholder farmers benefited from this initiative. The mFarming website has an interesting monitoring tool for their customer activity on a given day, which indicates rapid uptake of the service across the country with most customers in the North (<http://mfarming.sibesonke.com/>).

IMPROVING LOGISTICS AND ACCESS TO INPUTS

Trends and Issues

Field observations show that in many places ICT devices, particularly mobile phones, are transforming how rural logistics function. The resulting improvement in logistics can be seen through lower transaction costs and less wastage. Mobile phones enable market agents to better coordinate product supply and demand, strengthen existing trade networks, facilitate the assembly of products to reach a critical mass, and enable products to be delivered cost-effectively to new markets.

Logistics

Despite these positive effects, other factors can still limit increased supply chain efficiency, such as geographic position, limited access to transportation and credit, and poor access to inputs. An ICT-enabled logistics system can help in:

- **Collection**, by setting out well-organized collection routes.
- **Aggregation**, by assembling markets with sufficient critical mass to attract large-scale traders. Traders use the quantity and variety of products and the mobile phone network to conduct real-time research and identify arbitrage and market opportunities for the products they buy directly in rural areas.
- **Delivery**, by coordinating directly with other farmers or truckers to organize times, dates, volumes, and so forth. The literature on ICT's impact on rural logistics largely focuses on data obtained from user surveys and case studies. Less research has been done to assess the direct impact of mobile phones on reducing transaction costs related to agriculture. Perhaps the reason is because logistics are regarded as an infrastructural issue, so its synergies with ICT are not often considered.

For example, mobile phones proved very effective for the Nyabyumba Farmers' Group in Uganda, which reached an agreement in 2007 to supply Nandos, a multinational fast-food restaurant in Kampala, with graded ware potatoes at a fixed price throughout the year. Supplying these outlets offered

farmers higher incomes and more stable demand but required farmers to make significant improvements in product quality, quantity, and business management (Kaganzi et al. 2008).

To ensure direct communication between all stakeholders under this agreement, the chairman of the Nyabyumba Farmers' Group purchased a mobile phone to maintain regular contact with Nandos as well as other members of the cooperative. The phone facilitated collection, delivery, and the fine-tuning of harvesting and dispatch to match demand in Kampala.

To meet these conditions and engage with this higher-value market over the long term, farmers needed to become more organized and strengthen their partnerships with service providers. The key challenges were to ensure that farmers could consistently produce potatoes to these standards and communicate directly with their client. Farmers' lack of grading knowledge and initial inability to produce potatoes that met Nandos' quality standards caused 80 percent of their production to be rejected. Training reduced the rejection level to less than 10 percent in less than a year.

Access to Inputs

Farmers' yields may not approach the highest potential yields for a variety of reasons; poor climate or weather may play a part, along with other factors such as socioeconomic status, physical infrastructure, institutional and government policies, or poor access to farming technology or finance. If farmers narrow the gap between their yields and potential yields, they can improve productivity and profits; but to do so, they require accurate information on agricultural inputs, technology, working capital, and how to obtain them. Much of the yield gap is related to problems in accessing inputs. For example, farmers can be unsure when inputs are available, particularly when the government distributes subsidized inputs.

Questions remain about how ICT can help to facilitate access, although some answers may be emerging from efforts such as the e-Choupal kiosks mentioned in this module. In a study in India, farmers' search for inputs—particularly seeds, fertilizer, and plant protection chemicals—was listed high among their reasons for using mobile phones. Farmers highlighted difficulties in sourcing inputs such as fertilizer, seeds, and agrochemicals for plant protection twice as frequently as their next key problem, lack of irrigation. They especially wanted information to distinguish genuine products from counterfeits.

Even if they know where to buy inputs, farmers cannot always buy them at the right time due to high costs and other barriers.

myAgro is a service in Senegal and Mali that helps smallholders purchase agricultural inputs on an incremental payments basis via a mobile phone platform and a network of local village vendors. By topping up their myAgro accounts, farmers easily save and then digitally pay for inputs over time.

Farmer Behavior

Even if they know where to buy inputs, farmers still do not always buy them at the right time. Duflo, Kremer, and Robinson (2009) argue that a tendency to procrastinate may explain why so few African farmers use fertilizer, despite knowing that it raises yields and profits. Only 9 percent of farmers interviewed believed that fertilizer would not increase their profits, yet only 29 percent had used any fertilizer in either of the two preceding seasons. When asked why, almost four-fifths of the respondents said that they did not have enough money to buy fertilizer, although fertilizer was readily available. However, even poor farmers earned enough to buy fertilizer for a portion of their fields. Better intentions made little difference. Virtually all farmers said they planned to use fertilizer the following season, but only 37 percent actually did so.

The question is whether ICT, with targeted messages, could be effective for helping farmers to become more rational and better-organized buyers of inputs. In other circumstances, having access to such information through ICT seems to provide clear benefits (table 9.4):

- In India, farmers with access to ICT services reported 10–40 percent yield increases, primarily through gaining better access to hybrid seeds and being encouraged to introduce new farming practices (Vodafone India 2009). All farmers claimed that their mobile phones had led to increased yields, with some also citing price and revenue improvement. These increases are a result of better information flows

through the use of mobile phones and other ICT services such as e-Choupal kiosks.

- A national survey of Indian farmers in 2005 found that only 40 percent of farm households accessed information about modern agricultural techniques and inputs. The survey also found that almost all small-scale farmers reported some increase in convenience and cost savings from using their mobile phones to seek information such as input availability.
- RML (formerly Reuters Market Light) was launched in India in 2007 to provide market information and intelligence to farmers and agribusinesses. In a survey of farmers who received the RML service, 50 percent said they reduced expenditures on agricultural inputs because of SMS information services. The service is also changing farmers' behavior; 44 percent said that it changed their fertilizer applications and 43 percent said that it changed the timing of spraying.

A reason commonly cited for the difficulty in obtaining inputs is that the government will often distribute subsidized inputs, often through schemes that last only a few years. These policies restrict the potential for the private sector to supply inputs; and when government programs end, no company can sustainably deliver inputs to the farming community.

Lessons Learned

Findings on how mobile telephony enhances marketing by improving logistics include:

- **More efficient use** of existing storage, packaging, transportation, and processing facilities.
- **Increased monitoring and coordination** of freight transportation operations, including product collection, delivery, and security.

TABLE 9.4. Information Priorities of Farmers Using Mobile Phone in India

NSS 59TH ROUND OF PHONE USAGE	INFORMATION PROVIDED VIA: VODAPHONE	REUTERS MARKET LIGHT
Seeds	Seeds	Accurate local weather forecasts
Fertilizer application	Prices	Technical information
Plant protection	Plant protection	Input sources and/or production costs
Harvesting and marketing	Fertilizer application	Market information
Farm machinery	Harvesting and marketing	
	Farm machinery	

Source: Authors.

- **Quick response to any disruptions** in the supply chain (for example, disruptions such as vehicle breakdowns clear up more rapidly).
- **Reduced travel time and expense** through the ability to call markets and obtain information instead of having to travel there.
- **Disintermediation and improved transportation efficiency** as mobile phones facilitate the assembly of product, which enables larger trucker/traders to buy sensible-sized loads directly in rural areas. Suppliers can use mobile phones to conduct real-time market research, and entire truckloads can be bought and sold while still on the road.
- **Synergies between investments**, so that combined investments in roads, telephone communications, and electricity have a greater aggregate benefit than separate investments ever could have. (If a single investment were to be made, however, the most cost-effective investment would probably be telephones.)
- Integrated rural infrastructure investments could include investments that improve agricultural productivity, rural roads, and rural markets (assembly or primary wholesale markets in particular) and that extend rural mobile phone coverage. As noted, in areas where phone signals are weak, a mobile phone amplifier located at a market would facilitate conversations and flows of information around market opportunities and needs, logistics, and prices.
- **Form innovative private-sector partnerships.** Better involvement and organization of stakeholders can improve farmers' access to information about inputs. Agribusinesses and input suppliers have an incentive to invest in ICT services that provide input information because of the potential benefits that can be realized from increasing input sales. Moreover, input suppliers and dealers can come together to create partnerships to facilitate access to inputs. They can do so by combining their data and communicating via SMS. For example, input supply companies can use ICT to remind farmers to purchase inputs, alert them to input arrivals, and provide timely advice on proper use, such as for treating emerging pest and disease problems.

Principles and Guidelines for Potential Interventions

A combination of economic intuition, observation, and research indicates that important synergies can be created from a confluence of investments:

- **Address policy issues around increasing access to the poorest.** Despite phenomenal growth in telephone lines and mobile phone networks, access is still highly inadequate and unequal. Today, the main beneficiaries of ICT are those who have the technology, enabling them to increase their profits. Not only are the poor and those living in rural areas at a disadvantage, but full utilization of the technology is impossible, even for those with access, until the digital divide is addressed (as discussed in the overview) and universal access is achieved. A full transformation of the logistics system will not happen until the technology becomes ubiquitous, intensifying competition and carrying the potential long-term benefits of reducing transaction costs.
- **Create an integrated rural infrastructure investment program.** Investments that help to remove intermediaries are believed to have strong potential for improving marketing efficiencies and lowering transaction costs. Studies in South America have demonstrated synergies between investments in roads, telephones, and electricity, although individually telephones consistently show the highest returns (Jansen, Morley, and Torero 2007).
- **Use ICT to improve governance of subsidy programs.** ICT offers a means of delivering subsidies to the intended beneficiaries. It enables community procurement of inputs and input delivery through the private sector. Embedded e-payment systems guarantee timely payment from the government and encourage the emergence of a private network of input suppliers.
- **Education and information dissemination are key components of supplying inputs through ICT.** It is critical for farmers to have a rooted understanding of the potential long-term implications for productivity and profits of using better inputs in a timely manner. On a more practical level, farmers need information about how to source inputs and identify counterfeit supplies, which remain a significant productivity drain.

Case Study: TruTrade in Uganda—Paying Smallholders a Fairer Share of Their Produce Value

TruTrade offers IBM cloud-based mobile and online applications to allow price setting, tracking produce from collection to delivery, and tracking payments from buyer to farmer. Established as a private, for-profit company in Kenya in 2012, it has expanded into Uganda and is planning to develop operational capacity in Tanzania. Its application links

smallholders to buyers with controls that enforce quality and transparency and thereby embed trust, enhance market efficiency, manage risks, and allow farmers to share in value-addition processes.

TruTrade has a franchise network of brokers and field agents to manage transactions on the ground. As produce is sorted, graded, cleaned, pressed, milled, and packaged to meet buyer requirements, farmers that use TruTrade are rewarded for quality and capture a share of the value addition. TruTrade's financing mechanism pays farmers when the crop is delivered to company collection points. Those farmers are also awarded a bonus from value addition or when savings are made.

TruTrade's Transaction Security Service (TSS) ensures that benefits are awarded to farmers, traders, and buyers. Farmers receive better prices, more reliable access to markets, and can benefit from value-addition opportunities. Traders can grow their businesses, earning a commission and building relationships as a trusted service provider. Buyers receive produce that meets their demand for quality and volume, reliability, and traceability (TruTrade 2015).

As of 2015, three of TruTrade's franchisees in northern Uganda were sourcing sorghum and barley from smallholders to supply East African Breweries (EABL) in Kampala. Another of its franchisees, AgriNet Ltd, is sourcing maize from smallholders to supply flour to base-of-the-pyramid urban consumers. TruTrade provides a transparent and secure way to link farmers with the buyer.

Farmers can bring whatever produce they have to TruTrade's registered agents, who weigh and check the quality of the produce and pay the agreed-on price. TruTrade encourages farmers to receive payment through mobile money as it is more secure and easy for the company to track. TruTrade covers the withdrawal charges, and farmers are also eligible for a bonus.

Through its TSS business model, TruTrade gives farmers the best deal possible because the company earns commissions on each transaction linked to the price the farmer receives. The process is transparent, ensuring that farmers know the price the buyer is paying and all the different costs that are involved in getting the produce from the farm gate to the end buyer. TSS has been accepted as "fair to farmers" by the Kenya Federation of Alternative Trade and the World Fair Trade Organization.

To show how this business model works in practice, table 9.5 presents average figures from the recent 2015/16 season for

white sorghum. In a typical remote area, a farmer going to a TruTrade collection point receives UgSh 700 per kilogram of sorghum. The buyer pays UgSh 1,150 per kilogram of cleaned sorghum, and the costs of the intermediate transactions are broken down per kilogram.

Assuming a deal goes well (the logistics work out, trucks are all full, all produce is accepted by the buyer, and payment is timely), TruTrade will pass any profit back to farmers. In the case shown in table 9.5, the profit results in a bonus of UgSh 50 per kilogram for farmers. When farmers do well, TruTrade's network commissions also increase (TruTrade 2015).

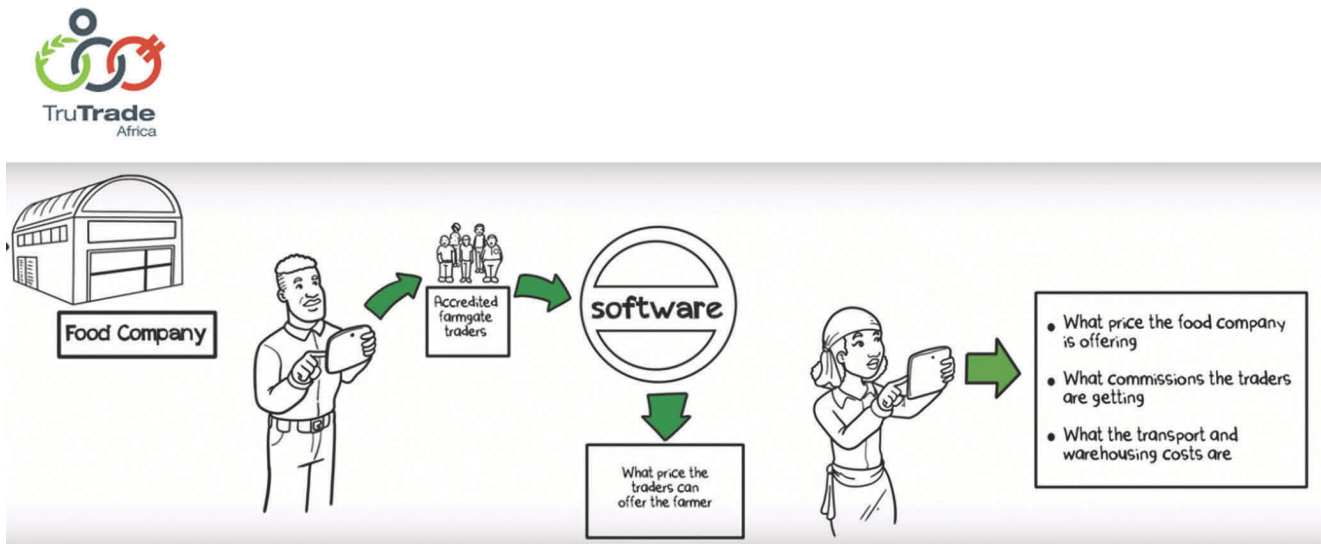
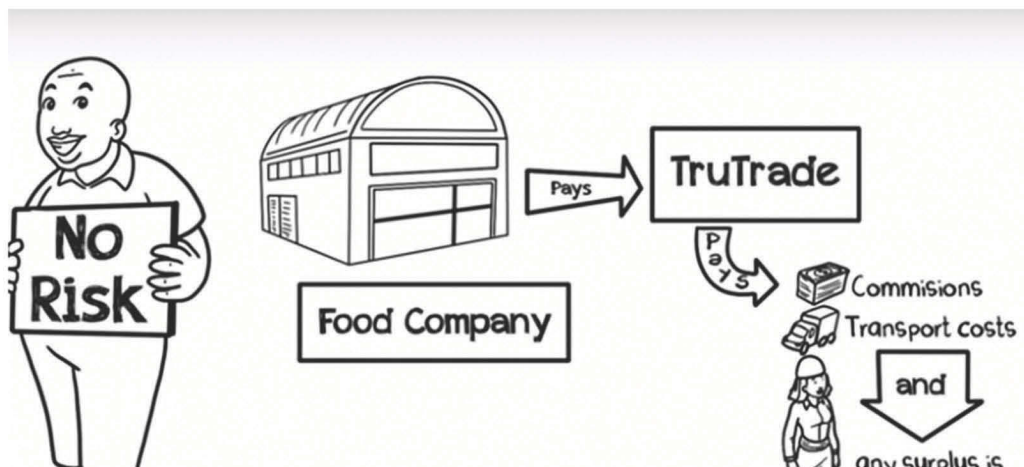
TruTrade's approach gives farmers a strong understanding of costs, which helps them to negotiate better with other buyers or market their other crops. It also helps other supply chain players to define and analyze the costs accurately before deciding to engage in a specific deal.

TruTrade's experience with ICT in agriculture demonstrates the importance of user-led programming and peer exchange learning. The field operations evolved over many years of intensive peer exchange among the value chain actors, mentored by Rural African Ventures Investments (RAVI). Insights gained on the ground were then communicated to programmers in Webgate to build the ICT tools for TSS.

In 2016, TruTrade continued to work with broker networks across the region to use its application to improve smallholder prices and provide produce to a whole range of buyers, from large-scale processors like breweries to small vendors serving base-of-the-pyramid urban consumers (see image 9.2).

TABLE 9.5. TruTrade Transactions and Payments to White Sorghum Producers, Uganda, 2015/16

TRANSACTION	PAYMENT (UGANDAN SHILLINGS)
Farmer	750 (700 down payment + 50 bonus)
Storage	10 (collection point)
Cleaning/packaging	50
Transportation to Kampala	135
Loading/unloading	9
Bags/labeling	30 (100 kg for sourcing; 50 kg for cleaned)
Local tax	10
Trade finance/insurance	30
TSS agent	50
Commissions	45 (TruTrade 3%; network manager 3%)
Process loss	31 (2–3% of the total volume sourced)
Total	1,150

IMAGE 9.2. Schematic Presentation of TruTrade Africa**a. Accurate price information provided to the farmer****b. Gains from efficient and transparent transactions benefit farmers****Case Study: E-Wallet Scheme in Nigeria—Using Mobile Phones to Increase Access to Subsidized Inputs**

In the 1960s, Nigeria was an agricultural powerhouse and supplied 95 percent of its local food needs. With the advent of oil and gas, policy and investment in agriculture were significantly reduced. To revitalize this essential sector, the Government of Nigeria launched its E-Wallet Scheme in 2012 as part of its broader Growth Enhancement Support (GES) program.

E-Wallet provides Nigerian farmers with an electronic wallet that is accessible via a mobile phone or through unique identification codes. Using this scheme, farmers can directly access government subsidies on inputs.

Of the approximately 14 million Nigerians who claim farming as their occupation, 4.2 million in 36 states have registered with the scheme. Of these farmers, 1.2 million have redeemed their vouchers and received subsidized fertilizer and improved seeds. Approximately 198,000 women farmers have registered, and 49,000 have received subsidized fertilizer and improved seeds (Adubi 2016).

The low number of farmers who have redeemed vouchers can be explained by a number of factors, including the poor trust in government, the delayed start of the program, and the general disbelief that the government is serious about addressing agricultural challenges (Adubi 2016). Throughout the wider supply chain, 1,080 agro-dealers were certified and

registered to participate, and 804 redemption centers were established. Over 25 companies producing fertilizer and seeds participated in supplying the agro-dealers.

According to the Nigerian minister of agriculture and rural development, Akinwumi Adesina, fertilizer companies sold US\$100 million worth of product directly to farmers instead of the government through the E-Wallet Scheme. Meanwhile, seed companies sold US\$10 million worth of seed directly to farmers, and banks lent US\$20 million to seed and fertilizer companies and agro-dealers (IFAD 2013).

Despite the program's initial success, a number of challenges remain in realizing its potential. It is challenging to ensure that all parties with a stake in the outcome implement their part of the solution effectively and in good time. Farmers will need to adapt to the new system. It is also essential to ensure that agro-dealers have sufficient financing to maintain inventory. Going forward, the significant physical logistics of moving inputs to remote parts of Nigeria also need to be considered (Adubi 2016). The potential of this program remains enormous, however. Once farmers can be identified through their registration data and are accessible through their mobile phones, a range of new services become possible—for instance, microinsurance, e-extension, mobile trading platforms, market price information, and more extensive financial services can be developed.

Case Study: e-Krishok and Zero Cost in Bangladesh—Providing Extension and Advisory Services through Mobile Phones

Agriculture contributes 16 percent of national gross domestic product (GDP) in Bangladesh (the second-largest share) and employs 47 percent of the workforce (Central

Intelligence Agency 2016). Only recently, however, have public and private stakeholders started to focus on strategies for agriculture to benefit from ICT. The government's vision of "Digital Bangladesh" gave major impetus to the development of the ICT sector and led the government to revise the National Agriculture Policy to include e-agriculture as one of its major objectives.

The mobile network and Internet penetration have grown rapidly across Bangladesh. The country has almost 132 million mobile phone users and 56 million Internet subscribers, of whom 53 million are mobile Internet subscribers (BTRC 2016). No data are available on the number of smartphone users, but trends show that their numbers are growing as smartphones become more affordable. This environment has encouraged service providers such as mobile operators, non-governmental organizations (NGOs), and the private sector to develop ICT-enabled products and services for agriculture.

The Bangladesh Institute of ICT in Development (BIID) was founded in 2008 as a private-sector-inclusive business initiative. It launched e-Krishok, a service for ICT-enabled agricultural products and services, including an information and advisory portal delivered through a network of local information centers.

Following piloting and testing, e-Krishok evolved to include the Farmbook business planning solution, the Zero Cost phone-line, and extension.org, a knowledge repository portal. As of 2016, BIID also focused on integrating gender-inclusive and nutrition-sensitive messages in agricultural extension practices. It is developing an Irrigation Scheduling Application in collaboration with the University of Twente (the Netherlands) and CIMMYT.

The Zero Cost Extension and Advisory Service was launched in October 2015 in partnership with the Bangladesh Seed Association (BSA) and Catalyst, a development agency funded by multiple donors. Zero Cost enables farmers to access extension and advisory services by phone for free. A farmer leaves a missed call to a Zero Cost phone number (image 9.3), and an agriculturist calls back immediately to respond to any queries that the farmer has. The core principle behind this service is that it is essential to facilitate easy access to advice and promote the use of quality seeds, fertilizer, and pesticides, and other inputs.

As the use of smartphones is comparatively low in rural areas, this phone-line

IMAGE 9.3. Billboard for Zero-Cost EAS



service advises farmers on the selection and application of inputs, taking into account the cropping season, geographical region, productivity, and other factors. This free service is funded by partners whose products are promoted and who can access business intelligence through farmer data. BIID is now in the process of scaling up this model and commercializing it through various input suppliers, including financial service providers in the agricultural sector.

SMALLHOLDER INCLUSION IN COMMERCIAL SUPPLY CHAINS

Trends and Issues

ICT facilitates exchanges and flows of information between parties all along the supply chain and can be used to manage transactions, arrange logistics, and ensure that quality specifications are clearly understood. Under the right circumstances, agribusinesses have the incentives, capacity, and resources to create and apply technologies that support inclusion. Public organizations play an important role by implementing supportive policies and fostering public-private collaboration to develop ICT applications.

Smallholders can raise their incomes by participating in commercial supply chains, but including smallholders entails significant challenges for agribusinesses and smallholders. For agribusinesses, interacting with a large group of smallholders implies high transaction and monitoring costs to ensure quality, safety, and timely delivery. For smallholders, participation can be risky, requiring access to inputs and training to satisfy stringent quality requirements.

Market forces do not in and of themselves guarantee smallholders' inclusion in modern supply chains. When possible, companies might seek to source from larger producers, which can deliver economies of scale, often are better educated, and typically also have better access to finance. Including smallholders can present significant challenges for both the agribusiness and smallholder, but a strong business case can be made for both sides to work together.

ICT can foster smallholders' inclusion and overcome the risks associated with commercial supply chains by reducing the costs of coordination (collection of production, distribution of inputs, and so on) and increasing transparency in decision making between partners. They can also reduce transaction costs and disseminate market demand and price information. Additionally they can disseminate information on weather, pest and risk management, and best practices to meet quality and certification standards. They can also collect management data from the field and ensure traceability.

Functions of SCM Systems

SCM software running on networked computers and hand-held devices typically performs some or all of the following functions:

- **Stores information about suppliers.** This function allows a food-processing company to know the details of its farmers, their previous transactions, and previous performance.
- **Enables customers to transmit orders to farmers in an efficient manner.** The order would specify what is required, by which date it will be collected, and how much will be paid for it.
- **Monitors production,** making it possible to manage quality and incentivize high-performing suppliers or support poorer performers. The software could provide answers to questions such as which farmers are on schedule, which are behind, and how much product has already been collected from each farmer. If connected to the bank accounts or mobile transaction accounts of the procurer and supplier, such software might also transfer payments when orders are fulfilled.
- **Tracks the transportation of goods** from the farm gate to the warehouse or retailer.

Varying Types of ICT-Supported SCM Systems

No single ICT application is ideally suited for all smallholder farmers, other supply chain actors, and procurement contexts. Organizations vary in size, budget, and operations. Some source perishables; others source staple grains. Supply chains encompass larger and smaller ranges of regions and producers (whose languages and education levels also vary).

Not surprisingly, the varying degree of sophistication in ICT applications reflects this diversity. Bigger firms can extend their SCM solutions, while smaller firms turn to off-the-shelf software or applications for increasingly widely available mobile phones. Others may still rely on spreadsheets. Some applications handle everything from transactions to logistics and quality control. Others focus on a smaller subset of areas. They rely on different combinations of software and hardware; but a combination of mobile phones, personal digital assistants (PDAs), networked computers, and centralized databases figure prominently in the architecture of most applications.

Finally, the applications differ in their commercial approach. Some are public goods that do not have a revenue-generating model, while others adopt a one-time installation fee. Others are based on a fee-per-transaction approach, while many

follow an embedded service model in which revenues are generated from commercial trading transactions and a fee for the ICT service is not charged to farmers.

ICT applications can be the glue that holds together complex supply-chain partnerships. The rapid flow of information between buyers and producers that such applications allow minimizes misunderstandings, allows for risk management, provides higher levels of transparency, and ultimately fosters trust.

The development of ICT applications for SCM can be driven by a wide variety of agents in the private and public sectors; but collaborative partnerships appear to yield more effective applications. For example, agribusiness companies, mobile network operators, third-party service providers, and software firms as well as development institutions and research institutes may participate. It is rare for applications to be developed independently by any one party; collaborative partnerships focused on smallholder inclusion or value-chain competitiveness are much more common.

Challenges of ICT-Supported SCM Systems

The lack of context-appropriate software, the prohibitive cost of hardware, and the lack of supporting infrastructure can make it difficult to use SCM systems in developing countries, and thus include smallholder farmers as key suppliers. The diffusion of ICT devices (especially mobile phones) and infrastructure has eased these constraints by making it possible to aggregate smallholders virtually.

Issues Faced by Supply Chains. Although participation in commercial supply chains presents an opportunity for smallholders to attain higher incomes (between 10 and 100 percent; see World Bank 2008,127) and reduce poverty, these outcomes are not certain unless other important factors are addressed. For example, actual income changes depend on the crop, the time needed for farmers to learn to produce the crop more efficiently, and the quality and other standards required. Changes in income may not be sustainable unless accompanied by improved practices such as postharvest handling and risk management.

The application of ICT for including smallholders in commercial supply chains suggests that these technologies can solve many problems associated with transactions (ordering, invoicing, payment), logistics (collection, storage, transportation), quality assurance (safety, traceability), process management (production oversight, input distribution, extension support), and product differentiation (specialization in organic, fair trade, or regional labels).

A particular area of concern for stakeholders is that one side will not uphold the preexisting agreement. When prices are high, farmers have an incentive to sell to the spot market (side-sell) instead of to agribusinesses. Similarly, when market demand for certain products changes or is lower than expected, procurers have an incentive to buy less than promised or to offer a lower price (finding produce to be of insufficient quality is a common tactic).

Better communication between farmers and procurers, and systems that allow farmers to be paid faster, can reduce such myopic behavior and help relationships endure. If farmers know that side-selling this season will have repercussions in the next one because the company keeps electronic records, they might be less likely to engage in this behavior.

Effective SCM systems can also play a role in eliminating unnecessary intermediaries from transactions. To illustrate this point, Cropster Hub was launched in February 2016 as an online trading platform for anyone with Internet access to create an account and purchase green coffee from cooperatives or traders around the world. The platform enables coffee sellers to better manage their information and to connect to previously inaccessible markets. Because it is a business-to-business platform, coffee sellers have ownership of their own data and marketing information. Facilitating direct trade means that intermediaries are eliminated, transactions are faster and more efficient, and prices are lower (Cropster 2015).

There is a consensus that ICT applications have a positive effect on smallholders' inclusion in commercial value chains, but the extent to which ICT enhances or dilutes that effect requires further research. The application of ICT can be expensive from the perspective of software development or purchase, implementation, training, and so forth. The costs may not be justified in all cases. Better information on the potential impact can help to make this determination.

Public Sector Role. The public sector can help smallholders participate in commercial supply chains by helping them to develop relationships with agribusinesses and to grow products that the market demands. Public organizations have facilitated the creation and deployment of various ICT applications to reduce the transaction costs associated with the interaction between producers and procurers, better monitor the production process, and improve traceability. As these technologies and their applications become more appropriate to local contexts and needs over time, they are likely to become indispensable for smallholder inclusion.

Public organizations also have a unique role to play in enhancing competition, facilitating smallholders' participation in

commercial supply chains, and ensuring higher earnings for those that do participate. Public organizations can push for policy changes and make systematic interventions as well as coordinate partnerships between parties in the supply chain that create value but would be difficult for any single player to facilitate. They can also invest in both ICT and non-ICT infrastructure.

Private Initiatives. Private companies often source from smallholders out of competitive necessity, even if doing so can be difficult (Barrett et al. 2010). Quality and certification demands by consumers and export markets also force agribusinesses to assert more control and link backward to the producers in the supply chain. Often, there is no choice but to source from numerous smallholders, because they dominate production of certain goods. Corporate social responsibility initiatives may encourage procurement from smallholders; the political context may require it—the ramifications of ignoring smallholders may be significant.

Food processors and retailers, especially in India and Latin America, are turning to procurement models that bypass traditional wholesale markets to engage directly with farmers. Through SCM software on networked computers and mobile phones, ICT facilitates this process in headquarters, field offices, collection centers, the offices of farmer cooperatives, and in the hands of farmers and extension workers. The sophistication and source of the technology, as well as the extent of its reach to smallholders, vary.

Many large organizations simply extend the use of their current enterprise resource planning (ERP) software to manage their smallholder suppliers. Such software is used by large organizations to centrally store organizational data and manage data transmission and use between departments within the organization and external partners, such as suppliers. In 2002 the typical costs of owning an SCM system averaged about US\$15 million and could range from US\$500,000 to US\$300 million (Sysoptima 2005). These costs represent fees for software, consultants required for installation, and hardware.

ICT for Smaller Operations. For smaller operations, world-class SCM systems may be neither necessary nor cost-effective. These players develop modest systems in house to manage sourcing challenges. A market for cheaper ICT solutions has developed owing to the growing trend toward direct sourcing as well as the large number of procurers that cannot afford SCM systems but can no longer get by with simple spreadsheets. The market has grown, especially because applications are needed to perform specific

supply-chain functions that are common for procurers working with smallholders, such as tracking data about producers and their performance over time, communicating orders to farmers, managing production, speeding collection and payment at harvest, and tracing materials along the chain to comply with certification requirements.

Also in demand are applications that can run on mobile phones or other lower-cost ICT devices such as PDAs. Supply-chain solutions relying on such devices are better suited for use in developing contexts, where computers and Internet connectivity are generally less accessible than mobile phones and wireless service. Several private firms have produced such solutions, and others have been created in joint efforts by private and public organizations.

Access to Information. ICT applications can improve linkages between procurers and smallholders in indirect ways also. A phenomenon not limited to India, but highly prevalent there, is agro-dealers' practice of running retail distribution and collection centers in rural areas. These centers (sometimes, simple kiosks) offer ICT-based access to information and extension services to attract farmers to the centers. Farmers are consumers of household items and agricultural inputs sold in these places, but they are also suppliers of agricultural produce. In some instances, farmers have the option of visiting multiple centers nearby; but in other cases, a company that procures the major crop grown in a place might have the sole collection center in the area.

By offering access to information and other services through their rural centers, companies build farmers' trust and loyalty. Come harvest time, farmers familiar with the center are likely to sell their produce at the distribution center, which reduces the company's cost of procuring raw material. In exchange, farmers have access to information that improves the productivity and quality of their crops.

Lessons Learned

ICT applications may create opportunities to incorporate smallholders more effectively into supply chains, but their impact will be limited without the requisite supporting infrastructure, policy, and culture of collaboration:

- **Infrastructure.** Physical infrastructure is particularly critical for ICT devices, which often require reliable electrical power and telecommunications networks. The presence of complementary infrastructure also has much to do with the success of ICT interventions for smallholder inclusion, such as roads, storage facilities, transportation, and financial infrastructure.

- **Business environment.** Commercial value chains prosper in an enabling business environment; policies that support such an environment are indirectly quite important to the effectiveness of ICT applications in supply chains. Policies can also discourage or encourage smallholder inclusion. In India, for example, limits on the size of landholdings make it difficult for agribusinesses to avoid smallholders in favor of larger producers. Until quite recently, policy barriers made it difficult to source directly from farmers at all.
- **Public sector.** The public sector can play a number of roles in ensuring smallholder inclusion. It can rigorously evaluate current ICT applications to determine their impact on smallholder inclusion and incomes. Quantitative and qualitative evaluation can include a variety of indicators to document outcomes, such as production volumes, net income; distribution of income, product quality, and the distribution of costs.

Public intervention in the private sector's use of ICT in supply chains can focus specifically on improvements in the policy environment and the competitiveness of smallholders. An important role of the public sector might be to incentivize smallholder inclusion and provide guidance on technologies that can be used to do so. The public sector might also work to organize farmers into groups and spread financial literacy (ICT can help here, too; see Module 8).

Donor-funded projects present unique challenges to scale and sustainability. Low-cost, context-specific software, for example, can have difficulty supporting higher volumes, and in such cases success can lead to collapse. In other cases, the products are too specialized and cannot be applied to other projects. ICT applications are not one-time interventions. Hardware and software must be maintained and upgraded. The funds and human capacity to do so might be in short supply after a project is completed, unless special care is taken to ensure sustainability:

- **Private sector.** Private companies and other stakeholders can be effective in developing and deploying ICT tools to procure directly from farmers. Providing services (information, advice, inputs, finance, and other resources) to farmers can be an effective incentive for them to participate in commercial value chains.
- **Public-private partnerships.** Partnerships have proven critical in developing ICT applications targeted toward smallholder inclusion. Public organizations lack the technical capacity, and technology companies are reluctant to absorb the risk of producing products

unless they are assured of markets. Public institutions can lead such collaborative efforts if they are willing to share rights to outputs of the joint activities.

- **Getting around market failures.** Farmers often join value chains to solve market failures in insurance, financial, input, and information markets (Barrett et. al. 2010,13). The numerous instances of rural collection centers creating links with farmers by providing access to weather, extension, or other services through Internet-connected computers appear to be effective.

The wide array of private information services available for agribusiness actors to communicate with or manage their interactions with farmers is still growing. Care must be taken to identify the actual problems that prohibit farmers from participating prior to the implementation of an ICT solution. ICT interventions are not one-time efforts. Technologies and business needs continually change, and the deployment of ICT must continue to evolve as well.

Principles and Guidelines for Potential Interventions

Key qualitative or skills-based indicators that have an impact on farmers' incomes can include key skills related to the nature and quality of the relationship between farmers and trading intermediaries, improvement in bargaining power, and governance functions.

For supply chains linked to high-value markets, additional attention should be paid to issues related to product and process upgrading and collective innovation as the chain adapts to increasingly demanding market conditions. While this process does not occur fully at the farmer level, the existence of this skill set is critical for the entire system's continuing competitiveness. Unlocking innovation and opportunities for smallholders is a critical element of impact, because it leads to benefits that help drive farmers' incentives for inclusion (K. Kumar, personal communication).

When beginning an intervention, ascertain whether the barriers to smallholder inclusion are best addressed by an ICT application. Care should be taken to ensure the presence of key enablers—special attention is required to include women and other vulnerable groups. It is also important to consider the full cost of ownership beyond any one-time software and hardware fees. Installation charges, maintenance, upgrades, and the cost of training users must also be included.

If an ICT application is deemed appropriate, consider existing commercial products before attempting to develop

new products. If the development of a new product cannot be avoided, sustainability should be made a priority, and local partners must be included. A focus on developing standards for ICT applications and systems will allow interoperability between technologies and make it easier to develop new applications when necessary.

Finally, human capacity is critical for the development and uptake of ICT applications in supply chains. Farmers or farmer associations may find ICT tools challenging to use (illiteracy, a lack of training, or simply a lack of comfort with modern ICT devices are typical barriers). Nor can ICT applications be developed or deployed well if a technical talent pool with an entrepreneurial spirit is lacking.

Case Study: Farmforce in Guatemala—SCM Tool Facilitates Sustainability Certification for Smallholders

Farmforce is a software program that simplifies the management of smallholder farmers, increases traceability in the supply chain, and enables smallholders to gain access to formal markets. It is used to manage outgrower schemes and contract farming programs efficiently. Through mobile phone technology, it modernizes smallholder management by tracking growing activities, harvests, and audits in real time. It was developed by the Syngenta Foundation for Sustainable Agriculture and cofunded by the State Secretariat for Economic Affairs of Switzerland.

Reasons for using Farmforce differ depending on the stakeholder. Producers use Farmforce to efficiently organize, manage, and monitor large numbers of farmers to improve productivity and reduce risks. Cooperatives, agribusinesses, and agricultural processors can obtain real-time information on yield forecasts and harvests to make postharvest operations easier to manage. All stakeholders can use the tool to increase traceability and reduce the auditing costs associated with certification schemes and compliance with food standards (Farmforce 2016).

Formal markets require traceability and compliance with food safety standards, issues that have proven challenging and time-consuming for smallholder farmers. Increasingly, international food processors and retailers are seeking sustainability certification standards for their products (Global GAP, Fairtrade, Rainforest Alliance, and others) as an additional point of differentiation and quality assurance. Farmforce uses mobile technology to address this need and make these standards an integral part of smallholder production.

In 2010 Adisagua, a Guatemalan smallholder initiative, set out to pursue Global GAP certification. Smallholders must adhere to guidelines on quality and pesticide use to qualify for Global GAP certification. Adisagua faced a number of challenges in collecting the required information on farmers and their harvesting activity. As smallholders were spread across vast distances, field agents were required to spend half a day every week collecting data and sending it to headquarters. This system also meant that it was impossible for management to collect data on activities at specific farms, because information was available only at the farmer group level (Farmforce 2016).

Adisagua signed up to Farmforce to improve its capacity to manage growers. Collecting data from each farmer allows the performance of individual smallholders to be evaluated and helps to ensure that technical assistance and training are targeted where they are needed most.

In August 2013, Farmforce technology was rolled out across 150 hectares on which smallholders operated 220 farms producing French beans. Information about the farmers, field profiles, and harvested yields was collected and uploaded in real time. Within the first year, Farmforce covered 16 percent of the farmers in Adisagua. By 2014, all 1,350 smallholders across 500 hectares were enrolled in the scheme. The technology has had a number of positive results. It has been easier for producers to comply with Global GAP requirements. Information is transferred more efficiently between the field and head office, decreasing the time required from several days to an hour. Traceability of smallholder groups is now also 10 times more precise (Farmforce 2016); see image 9.4.

Case Study: Farmbook in Africa—Enabling Smallholders to Develop Business Plans and Locate Buyers More Effectively

Farmbook is an application designed by Catholic Relief Services (CRS) to help smallholder farmers plan their businesses and locate buyers more effectively. It was built and tested in parallel between May 2010 to November 2012 in Malawi, Zambia, Zimbabwe, and Madagascar.

Business development is a challenge for many smallholder farmers and field agents. Most smallholders do not keep records, and many field agents have not received any formal education in business management. Farmbook offers field agents and farmers a business-planning process that focuses on both production practices and market opportunities (CRS 2015).

IMAGE 9.4. Timely and Efficient Data Collection by Farmforce Frees Time for Farmer Training



IMAGE 9.5. Steps of the Farmbook Business Support Program



Farmbook was formally launched in May 2012 and has 994 farmers logged into the system from 55 farmer groups. There are currently 24 business plans in progress, with farmers working on a range of crops including soybeans, corn, beans, chilies, and cucumbers. CRS has also provided training in Tanzania, Kenya, Ghana, Burkina Faso, Ethiopia, and Bangladesh (CRS 2015).

The application enables field agents to help farmers plan their businesses and locate buyers more effectively in four primary ways. It enables collective sales (which increase bargaining power) and tracks costs to assess the profitability of marketing strategies. It also upgrades production to meet marketing needs and catalogues results from one season

to improve marketing activities in subsequent seasons.

Project teams can use Farmbook to register farmers and farmer groups, assigning each person or group a barcode. The Map & Track application collects data to streamline farmer registration and business planning. SMART Skills courses provide agro-enterprise training to help farmers to increase production, grow their incomes, and engage with markets. The Farmbook Business Planner tool guides field agents and farmers through the process of creating business plans. Finally, Farmbook collects farmers' feedback in various ways to help project managers adjust to farmers' needs

(CRS 2015); see image 9.5.

Case Study: Digital Green in Africa and Asia—Transforming Agricultural Extension Systems and Creating Routes to Market

Digital Green (www.digitalgreen.org) leverages low-cost, peer-to-peer, video-based knowledge exchange to amplify existing agricultural extension systems in Asia and Africa. Digital Green trains extension agents and peer farmers to produce short videos featuring local farmers demonstrating improved agricultural practices or sharing testimonials using low-cost pocket video cameras, microphones, and tripods. The videos are distributed using mobile, battery-operated projectors among small groups of farmers. In a controlled evaluation, Digital Green's participatory, video-based approach was found to increase the cost-effectiveness of an existing extension by a factor of 10 times on a cost-per-adoption basis (Gandhi et al. 2009).

Digital Green's approach, along with its established network of trusted village agents, has proven to be an effective tool to improve farmers' access to global supply chains. In Karnataka state in India, Digital Green is using its participatory-video approach to reach 1,600 gherkin farmers and improve their access to the supply chain of the multinational company Marcatus QED. In Ghana, Digital Green is training local partners of the Cocoa Board and the World Cocoa Foundation to improve the way they train 3,200 cocoa farmers on practices required to effectively tap into the global cocoa market (Digital Green 2016c).

Digital Green is also working to enhance the ability of farmers to find the best price for their produce through an aggregation and transportation initiative in Bihar state in India called

Loop. Accessing local markets represents formidable barriers for many smallholder farmers, particularly with perishable commodities like vegetables. In many cases, quantities are small, the quality is variable, and farmers have scant ability to bargain for better prices. Timing and logistics are also challenges. Loop was launched in August 2015; and by using a trusted network of extension agents, Digital Green is managing the transportation and logistics of perishable produce to local markets, increasing incomes for participating farmers (Digital Green 2016).

Loop has sold over 500 tons of vegetables, like okra and sponge gourds, that would have otherwise fetched a lower price, required more time and effort to sell, or gone to waste. This has led to payments of around US\$32,500 to farmers since its launch. Digital technology in the form of e-receipts and ledger information is increasing transparency, speeding payouts to farmers, and enhancing the ability of the aggregator to assess price trends and choose the best destination each day (Digital Green 2016).

As it has proven to consistently deliver a large volume of produce to the market, Loop has also negotiated discounts from traders on the commissions they charge; dropping the costs per kilogram and increasing returns to the farmer. Results have shown that overall, farmers save approximately 50 percent of the cost of paying for transportation to a market themselves and save up to eight hours of time per day, enabling farmers to spend time on other duties. By focusing on the problem of logistics and transportation for perishable produce, Digital Green is finding it can increase farmers' ability to access untapped markets, increase their incomes, and increase another precious commodity that all farmers have in short supply: time (Digital Green 2016).

REFERENCES AND FURTHER READING

- ACDI/VOCA (Agricultural Cooperative Development International/Volunteers in Overseas Cooperative Assistance). 2011. "India: Growth-Oriented Microenterprise Development Program (GMED)." <http://www.acdivoca.org/site/ID/indiaGMED>.
- Action for Enterprise and USAID (United States Agency for International Development). 2009. "Facilitating the Development of Outgrower Operations: A Manual." Arlington, VA: Action for Enterprise. <http://www.actionforenterprise.org/paper-usaid.pdf>.
- Adubi, A. 2016. "E-Wallet Program in Nigeria." Presentation at ICT in Agriculture Community of Practice event, February.
- AECF (Africa Enterprise Challenge Fund). 2009. "AECF Portfolio and FAQ." Africa Enterprise Challenge Fund. <http://www.acismoz.com/acisofala/UserFiles/file/Noticeboard/AECF%205%20pager%20November%202009.pdf>.
- Aker, J. C. 2008. "Does Digital Divide or Provide? The Impact of Mobile Phones on Grain Markets in Niger." Center for Global Development Working Paper 154. <http://www.cgdev.org/content/publications/detail/894410>.
- Annamalai, K., and S. Rao. 2003. "Indiagriline by EID Parry." Corporate Strategy and International Business, Case Study Series, Michigan Business School. Next Billion Net. http://www.nextbillion.net/lib/assets/documents/EIDParry_Case_Study.pdf.
- Annerose, D. 2010. "ICT for Social and Economic Development." Presentation by Manobi at the World Bank, Washington, DC, August.
- Athawale, S., 2014. "APMC and E-Trading for Financial Inclusiveness in Karnataka". *IBM RD's Journal of Management and Research*.
- BTRC (Bangladesh Telecommunications Regulatory Commission). 2016. Mobile Phone Subscribers in Bangladesh, 2016. <http://www.btrc.gov.bd/telco/mobile>.
- Banjo, G., H. Gordon, and J. Riverson. 2010. "Rural Transport: Improving Its Contribution to Rural Growth and Poverty Reduction in Sub-Saharan Africa." World Bank, Washington, DC.
- Barrett, C. B., M. E. Bachke, M. F. Bellemare, H. C. Michelson, S. Narayanan, and T. F. Walker. 2010. "Smallholder Participation in Agricultural Value Chains: Comparative Evidence from Three Continents." MPRA Paper, University Library of Munich. Econ papers, <http://econpapers.repec.org/RePEc:pra:mprapa:27829>, accessed July 2011.
- CARE. 2008. "TIPCEE Program Profile Brief." <http://edu.care.org/Documents/Program%20Profile%20Brief%20TIPCEE.pdf>.
- Central Intelligence Agency. 2016. The World Factbook. South-Asia: Bangladesh. <https://www.cia.gov/library/publications/the-world-factbook/geos/bg.html>.
- CESS (Centre for Economic and Social Studies). 2007. "Preparatory Study for the Multi-State Agricultural Competitiveness Project." Unpublished study, CESS, Hyderabad.
- Chemonics International. 2006. "Trade and Investment Program for a Competitive Export Economy (TIPCEE): Annual Report for Partners October 2005–September 2006." USAID. http://pdf.usaid.gov/pdf_docs/PDACJ151.pdf.
- . 2010. "FS Series #9: Enabling Mobile Money Interventions: Primer, Diagnostic Checklist, and Model Scopes of Work." http://pdf.usaid.gov/pdf_docs/PNADW294.pdf.
- Chong, A., V. Galdo, and M. Torero. 2005. "Does Privatization Deliver? Access to Telephone Services and Household Income in Poor Rural Areas Using a Quasi-Natural Experiment in Peru." Inter-American Development Bank Working Paper 535. Inter-American Development Bank, Washington, DC.
- Cropster. 2010. "USAID Profit." Zambia Case Study. <http://bit.ly/fCPqHQ>.
- . 2015. "Why We Developed Cropster Hub" (accessed February 20, 2016), <https://www.cropster.com/en/news/news-detail/news/why-we-develop-cropster-hub/>.
- CRS (Catholic Relief Services). 2015. "ICT for Agribusiness and Rural Development" (accessed February 29, 2016), <http://>

- www.ics.crs.org/resource/farmbook-suite-ict-agribusiness-and-rural-development.
- Digital Green. 2016a. "About Us" (accessed February 29, 2016), <https://www.digitalgreen.org/about/>.
- . 2016b. "Digital Green: Transforming Agricultural Extension Systems with Market-Based Solutions." Shared with author.
- . 2016c. <https://www.digitalgreen.org/connect/>.
- Dixie, G. 2007. "Marketing Extension: A Powerful Six-Step Process from Bangladesh." Presentation at the University of Illinois at Urbana-Champaign. http://lightning.itcs.uiuc.edu/india2007/grahame_dixie.html.
- Ducker, M., and J. Payne. 2010. "Information Communication Technology as a Catalyst to Enterprise Competitiveness." Business Growth Initiative / USAID. http://pdf.usaid.gov/pdf_docs/PNADU068.pdf.
- Duflo, E., M. Kremer, and J. Robinson. 2009. "Nudging Farmers to Use Fertilizer: Theory and Experimental Evidence from Kenya." NBER Working Paper 15131. National Bureau of Economic Research, Cambridge, MA. Poverty Action Lab. http://www.povertyactionlab.org/sites/default/files/publications/99_Understanding_Technology_Adoption.pdf.
- Dymond, A., and S. Esselaar. 2010. "Mobile Applications for Rural Development." Presentation for Intelcon, December 1, Washington, DC.
- Economic Times*. 2012. "Farmers Using Facebook to Discuss Prices and Plan Strategy" (accessed March 7, 2016), http://articles.economictimes.indiatimes.com/2012-02-10/news/31046360_1_turmeric-farmers-social-media-sangli-district.
- Egyir, I. S., R. Al-Hassan, and J. K. Abakah. 2010. "The Effect of ICT-Based Market Information Services on the Performance of Agricultural Markets: Experiences from Ghana." Unpublished draft report, University of Ghana, Legon.
- EID Parry. 2010. "Profit and Loss Account: Annual Report 2010." EID Parry, <http://www.eidparry.com/inc/P&L.pdf>.
- eMarketer. 2015. "Latin America Home to 155.9 Million Smartphone Users" (accessed March 8, 2016), <http://www.emarketer.com/Article/Latin-America-Home-1559-Million-Smartphone-Users/1012794#sthash.S1kOtTmt.dpuf>.
- Esoko. 2015. "About" (accessed February 25, 2016), <https://esoko.com/about/>.
- Evaluation Cooperation Group. 2011a. "Evaluative Lessons for Agriculture and Agribusiness." ECG Paper 3. Washington, DC: World Bank. <http://blogs.worldbank.org/files/developmenttalk/Evaluative%20Lessons%20for%20Agriculture.pdf>.
- . 2011b. "Farmers and Beyond." EID Parry, <http://www.eidparry.com/EmployeeandBeyond.asp>.
- . 2011c. "Indiagriline." EID Parry, <http://www.indiagriline.com/english/corp/frame.html?pc/index.htm&2>.
- Facebook. 2016a. "Announcing the Winners of the Internet.org Innovation Challenge in India." <https://info.internet.org/en/2015/10/20/innovationchallengeindia/>, accessed March 8, 2016.
- . 2016b. "Our Impact" (accessed 8 March 2016), <https://info.internet.org/en/impact/>.
- Fafchamps, M., and B. Minten. n.d. "Impact of SMS-Based Agricultural Information on Indian Farmers." Unpublished draft report.
- FarmERP. n.d. "About FarmERP" <http://farmerp.com/about-farmerp.html>.
- Farmforce. 2016a. "About" (accessed February 24, 2016), <http://www.farmforce.com/en>.
- . 2016b. "Case Studies: Adisagua" (accessed February 24, 2016), <http://www.farmforce.com/case-studies/adisagua>.
- FAO (Food and Agriculture Organization). 2005. "Case Study: Community Based Information Systems, India, EID Parry Indiagriline." <http://www.fao.org/rdd/doc/EID%20Parry%20%20Indiagriline.pdf>.
- Ferris, S., P. Engoru, and E. Kaganzi. 2008. "Making Market Information Services Work Better for the Poor in Uganda." CAPRI Working Paper 77. CGIAR Systemwide Program on Collective Action and Property Rights (CAPRI), Washington, DC.
- Finnpartnership. 2013. "Sibesonke's Mobile Service to Help Millions of Farmers in East Africa" (accessed February 29, 2016), http://www.finnpartnership.fi/www/en/finnpartnership/success_stories/index.php?we_objectID=2452.
- Financial Express*. "Godrej Agrovet Empowers Rural India With SAP." *The Financial Express*, August 18, <http://www.financialexpress.com/news/godrej-agrovet-empowers-rural-india-with-sap/662088/0>.
- Forbes*. 2016. "In India, Fierce Opposition Builds against Facebook's Free Basics" (accessed March 23, 2016), <http://www.forbes.com/sites/saritharai/2016/01/04/in-india-fierce-opposition-builds-against-facebooks-free-basics/#2a663c3e7619>.
- Gandhi, R., R. Veeraraghavan, K. Toyama and V. Ramprasad. 2009. "Digital Green: Participatory Video for Agricultural Extension," Information Technologies for International Development, MIT Press.
- Gehlhar, M. 2009. "Global Food Markets: Global Food Industry Structure." United States Department of Agriculture (accessed February 11, 2011), <http://www.ers.usda.gov/Briefing/GlobalFoodMarkets/Industry.htm>.
- Google. 2016. "How Loon Works" (accessed March 8, 2016), <https://www.google.com/loon/how/>.
- Goyal, A. 2008. "Information Technology and Rural Markets: Theory and Evidence from a Unique Intervention in Central India." University of Maryland, College Park.
- GSMA Intelligence. 2014. "Country Overview: Bangladesh" (accessed March 7, 2016), <https://gsmaintelligence.com/research/?file=140820-bangladesh.pdf&download>.
- Guardian*. 2016. "Project Loon: Google Balloon That Beams Down Internet Reaches Sri Lanka" (accessed March 8, 2016), <http://www.theguardian.com/technology/2016/feb/16/project-loon-google-balloon-that-beams-down-internet-reaches-sri-lanka>.
- The Hindu*. 2015. "Govt Allocates Rs. 200 Crore for National Agriculture Market" (accessed 22 March 2016), <http://www.thehindu.com/news/national/govt-allocates-rs-200-crore-for-national-agriculture-market/article7378470.ece>.

- Hildebrandt, N., Y. Nyarko, G. Romagnoli, and E. Soldani. 2015. "Price Information, Inter-Village Networks, and Bargaining Spillovers: Experimental Evidence from Ghana." New York University.
- IFAD (International Fund for Agricultural Development). 2013. "Statement by Dr. Akinwumi Adesina, Honourable Minister of Agriculture and Rural Development, Federal Republic of Nigeria, Governor from Nigeria, at the 36th Session of the IFAD Governing Council" (accessed February 29, 2016), <http://www.ifad.org/events/gc/36/speech/nigeria.htm>.
- IFC (International Finance Corporation). 2006. "Suguna—Summary of Proposed Investment." <http://www.ifc.org/ifcext/spiwebsite1.nsf/1ca07340e47a35cd85256efb00700cee/EE798D87DA090FBE852576BA000E28D5>.
- Ilahiane, H. 2007. "Impacts of Information and Communication Technologies in Agriculture: Farmers and Mobile Phones in Morocco." Paper presented at the Annual Meetings of the American Anthropological Association, December 1, Washington, DC.
- ITC. 2010. *ITC e-Choupal's Agri Interventions*.
- ITU (International Telecommunication Union). 2008. "2008 Global SMS Prices." ITU, Geneva.
- ITU and Cisco. 2016. *Harnessing the Internet of Things for Global Development*. <https://www.itu.int/en/action/broadband/Documents/Harnessing-IoT-Global-Development.pdf>
- Jaleta, M., and G. Gardebreek. 2007. "Farm-Gate Tomato Price Negotiations under Asymmetric Information." *Agricultural Economics* 36 (2): 245–51.
- Jansen, H.G.P., S. Morley, and M. Torero. 2007. "The Impact of the Central America Free Trade Agreement on Agriculture in Five Central American Countries." Working Paper 26. San José, Costa Rica: Regional Unit for Technical Assistance (RUTA).
- Jensen, R. 2007. "The Digital Divide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector." *Quarterly Journal of Economics* 122 (3): 879–924.
- Kaganzi, E., S. Ferris, J. Barham, A. Abenakyo, P. Sanginga, and J. Njuki. 2008. "Sustaining Linkages to High-Value Markets through Collective Action in Uganda: The Case of the Nyabyumba Potato Farmers." CAPRI Working Paper 75. CGIAR Systemwide Program on Collective Action and Property Rights (CAPRI), Washington, DC.
- Kakunta, C. n.d. "Distributing Food Inputs via Mobile Phone." *Zambia Daily Mail*. <http://www.daily-mail.co.zm/media/news/viewnews.cgi?category=20&id=1277968851>.
- Kumar, P.S.K. n.d. "Mapping and Preliminary Evaluation of ICT Applications Supporting Agricultural Development: An IFC-Sponsored Study in Uganda, India, and Indonesia." Presentation, ACIDI/VOCA, [http://www.acdivoca.org/site/Lookup/ACDIVOCA_MappingEvaluationofICTAppsforAg/\\$file/ACDIVOCA_MappingEvaluationofICTAppsforAg.pdf](http://www.acdivoca.org/site/Lookup/ACDIVOCA_MappingEvaluationofICTAppsforAg/$file/ACDIVOCA_MappingEvaluationofICTAppsforAg.pdf).
- Kunaka, C. 2010. *Logistics in Lagging Regions: Overcoming Local Barriers to Global Connectivity*. Washington, DC: World Bank.
- . 2011. *Logistics in Lagging Regions: Overcoming Local Barriers to Global Connectivity*. Washington, DC: World Bank.
- Labonne, J., and R. S. Chase. 2009. "The Power of Information: The Impact of Mobile Phones on Farmers' Welfare in the Philippines." World Bank Policy Research Working Paper 4996. Washington, DC: World Bank.
- Lokanathan, S., H. de Silva, and I. Fernando. 2010. *Price Transparency in Agricultural Produce Markets: Sri Lanka*. Draft. ENRAP, http://www.enrap.org/research/icts-for-livelihoods-research/icts-for-livelihoods-research-papers/ICT4RLPaper_V6.doc/view, accessed February 2011.
- McCarthy, S., K. Kumar, and A. Pavlovic. 2009. "New ICT Solutions to Age-Old Problems: Case of the IGP India Project." SEEP Network, Washington, DC. http://www.seepnetwork.org/Resources/ICT_Solutions_Value_Chain.pdf, accessed January 2011.
- McGrath, B. 2010. "Mobile Transactions Overview Presentation." CRS ICT4D Conference, September 23, Washington, DC.
- Minten, B., T. Reardon, and K. Chen. n.d. The Quiet Revolution of "Traditional" Agricultural Value Chains in Asia: Evidence from Staple Food Supply to Four Mega-Cities. Unpublished draft, International Food Policy Research Institute, Washington, DC.
- Mittal, S., S. Gandhi, and G. Tripathi. 2010. "Socio-Economic Impact of Mobile Phones on Indian Agriculture." Working Paper 246. Delhi: Indian Council for Research on International Economic Relations (ICRIER). <http://www.icrier.org/pdf/WorkingPaper246.pdf>.
- Muddy Boots. 2007. "Muddy Boots: Greenlight." <http://www.muddyboots.com/products/gl.aspx>.
- Muto, M., and T. Yamano. 2009. "The Impact of Mobile Phone Coverage Expansion on Market Participation: Panel Data Evidence from Uganda." *World Development* 37 (12): 1887–96.
- myAgro. 2016. "Our Model" (accessed March 24, 2016), <http://www.myagro.org/model/our-model/>.
- NDAA (National Department of Agriculture). 2000. "The South African Horticulture Market." Training Papers 2 and 3. Pretoria.
- Okello, J. 2010. "Effect of ICT-Based MIS Projects and the Use of ICT Tools and Services on Transaction Costs and Market Performance: The Case of Kenya." Unpublished draft.
- Oracle. 2006. "Suguna Goes Live on Oracle Applications." Oracle, India, http://www.oracle.com/global/in/pressroom/IN_310706_SugunaGoLive.html.
- Overa, R. 2006. "Networks, Distance, and Trust: Telecommunications Development and Changing Trading Practices in Ghana." *World Development* 34 (7): 1301–15.
- Payne, J. 2010. "ICT Applications for Distribution and Supply Chain Management in Sub-Saharan African Agriculture." MicroLinks (December). http://www.microlinks.org/ev_en.php?ID=46725_201&ID2=DO_TOPIC.
- Ratnadiwakara, D., H. de Silva, and S. Soysa. 2008. "Transaction Costs in Agriculture: From Planting Decision to Selling at the Wholesale Market: A Case-Study on the Feeder Area of the Dambulla Dedicated Economic Centre in Sri Lanka." 3rd Communication Policy Research South (CPRSOUTH) Conference, Beijing. <http://ssrn.com/abstract=1555458>.
- Reardon, T., C. B. Barrett, J. A. Berdegue, and J. F. M. Swinnen. 2009. "Agrifood Industry Transformation and Small Farmers

- in Developing Countries." *World Development* 37 (11): 1717–27.
- Shaffril, H. A. M, M. S. Hassan, M. A. Hassan, and J. L. D'Silva. 2009. "Agro-Based Industry, Mobile Phone, and Youth: A Recipe for Success." *European Journal of Scientific Research* 36 (1): 41–8.
- Sieber, N. 1999. "Transporting the Yield." *Transport Reviews* 10 (3): 205–20.
- . 2009. "Freight Transport for Development Toolkit: Rural Transport." World Bank, Washington, DC.
- SourceTrace. 2011. "Agricultural Commodity Solutions." http://www.sourcetrace.com/solutions_agricultural_commodity_firms.php.
- Svensson, J., and D. Yanagizawa. 2009. "Getting Prices Right: The Impact of the Market Information Service in Uganda." *Journal of the European Economic Association* 7 (2–3): 435–45.
- Sysoptima. 2005. "Cost of ERP." Sysoptima.com, http://www.sysoptima.com/erp/cost_of_erp.php, accessed January 2011.
- TruTrade. 2015. "Giving Farmers a Better Deal" (accessed February 25, 2016), <http://www.trutrade.net/about-us>.
- USAID (United States Agency for International Development). 2009. "TIPCEE GIS Work." Cop Horti, http://www.cop-horti.net/IMG/pdf/TIPCEE_GIS_Work_Feb_2009.pdf.
- . 2011. "ICT Application for Distribution and Supply Chain Management in African Agriculture." MicroLinks (January). <http://microlinks.kdid.org/library/ict-application-distribution-and-supply-chain-management-african-agriculture>.
- . 2013. "Using ICT to Enhance Marketing for Small Agricultural Producers" (accessed February 26, 2016), https://agrilinks.org/sites/default/files/resource/files/Using_ICT_to_Enhance_Marketing_for_Small_Agricultural_Producers.pdf.
- Virtual City. 2009. "Case Study: Virtual City AgriManagr Solution." http://www.virtualcity.co.ke/cases/agrimanagr_case.pdf.
- Vodafone India. 2009. "India: The Impact of Mobile Phones." Vodafone Policy Paper, No. 9. http://www.vodafone.com/content/dam/vodafone/about/public_policy/policy_papers/public_policy_series_9.pdf.
- Warner, M., D. Kahan, and S. Lehel. 2008. "Market-Oriented Agricultural Infrastructure: Appraisal of Public-Private Partnerships." Food and Agriculture Organization, Rome. <http://www.fao.org/docrep/011/i0465e/i0465e00.HTM>.
- World Bank. 2008. *Agriculture for Development: World Development Report 2008*. Washington, DC: World Bank.
- World Economic Forum. 2009. *The Next Billions: Business Strategies to Enhance Food Value Chains and Empower the Poor*. Geneva: World Economic Forum. http://www3.weforum.org/docs/WEF_FB_FoodValueChainsAndPoor_Report_2009.pdf.
- Zachary, G. P. 2007. "Out of Africa: Cotton and Cash." *New York Times*, January 14.

Module 10 ICT APPLICATIONS FOR AGRICULTURAL RISK MANAGEMENT

SOHAM SEN (World Bank) and VIKAS CHOUDHARY (World Bank)

IN THIS MODULE

Overview. Risk and uncertainty are ubiquitous and varied in agriculture. They stem from uncertain weather, pests and diseases, and volatile market conditions and commodity prices. Managing agricultural risk is particularly important for smallholders because they lack resources to mitigate, transfer, and cope with risk. Risk also inhibits external parties from investing in agriculture. Timely information is essential for managing risk. Information and communication technology (ICT) has proven highly cost-effective instruments for collecting, storing, processing, and disseminating information about risk.

Topic Note 10.1: ICT Applications for Mitigating Agricultural Risk. ICT has reduced the costs of gathering, processing, and disseminating the information that helps farmers mitigate risk. Information services using mobile phones and radios can direct early warnings of inclement weather, market movements, and pest and disease outbreaks to farmers. With an early warning, steps can be taken to limit potential losses. Farmers can also access advisory services remotely to support their decisions related to risk-mitigating activities or to choose the most appropriate action in response to an early warning. These decision support systems are critical for transforming information into risk-mitigating action.

- **Through mKRISHI, Farmers Translate Information into Action to Mitigate Risk**

Topic Note 10.2: ICT Applications to Transfer Agricultural Risk. Applications of ICT to transfer agricultural risk through instruments such as insurance and futures contracts are still quite limited. The widespread use of these instruments seems to be hampered by low levels of institutional development, high costs, inability to customize products to meet smallholders' requirements, and poor financial literacy rather than by the information constraints that ICT can address. In a few instances, ICT applications are facilitating the design and delivery of index insurance. Although ICT has made it easier for smallholders to access and participate in spot commodity exchanges, their use of ICT to participate in futures contracts to hedge price risks remains a distant dream.

- **ICT Enables Innovative Index-Based Livestock Insurance in Kenya**
- **Kilimo Salama Delivers Index-Based Input Insurance in Kenya through ICT**

Topic Note 10.3: ICT Applications for Coping with Agricultural Risk. While there have been few applications of ICT to cope with agricultural shocks, those that exist are proving important and potentially transformative. Mobile phones enable ground personnel or affected persons to report more easily to whoever is coordinating a response to the shock. This communication leads to better-targeted relief efforts. In the event of a shock, ICT facilitates transfers and remittances to farmers from state and relief agencies as well as from farmers' extended social networks. Finally, disaster management is using more sophisticated applications to collect and synthesize information from the field. In the future, these disaster management applications might be applied to respond to agricultural shocks.

- **Electronic Vouchers Are a Targeted, Traceable Lifeline for Zambian Farmers**
- **Community Knowledge Workers in Uganda Link Farmers and Experts to Cope with Risk**

OVERVIEW

Risk and uncertainty are ubiquitous in agriculture and have numerous sources: the vagaries of weather, the unpredictable nature of biological processes, the pronounced seasonality of production and market cycles, the geographical separation of producers and end users of agricultural products, and the unique and uncertain political economy of food and agriculture within and among nations. Managing agricultural risk is particularly important for smallholder farmers, who are usually already vulnerable to poverty and lack the resources to absorb shocks. Typical shocks, such as a drought (image 10.1) or a pronounced drop in market prices, prevent poor households from acquiring assets or making the most of the assets they have (Cole et al. 2008). They push families into poverty and cause extreme hardship for those already living in poverty.

Exposure to risk prevents farmers from easily planning ahead and making investments. In turn, risk inhibits external parties' willingness to invest in agriculture because of the uncertainty about the expected returns. Improved management of agricultural risk has significant potential to increase productivity-enhancing investments in agriculture (World Bank 2005).

This module discusses experiences with emerging ICT applications that channel critical information for mitigating agricultural risk in developing countries, reduce the costs of delivering insurance to remote rural users, and deliver vouchers to farm households affected by droughts and floods. Although unproven, such applications offer glimpses of how ICT is likely to be used to manage agricultural risk.

IMAGE 10.1. Unexpected Changes in Climate Contribute to Risk



Source: World Bank.

The module begins by distinguishing among the kinds of risks that affect agriculture and then describes three major strategies for managing risk: risk mitigation, risk transfer, and coping. The crucial role played by information and ICT in each major risk management strategy is described, along with lessons from experience to date. Topic notes and innovative practice summaries detail specific applications, their lessons, and principles for success.

Defining and Describing Risk

The terms “risk” and “uncertainty” indicate exposure to events that can result in losses. Although the terms are often used interchangeably, they have slightly different meanings. Risk can be defined as imperfect knowledge where the probabilities are known; uncertainty exists when these probabilities are not known. Many of the losses expected from the risks inherent in modern agrifood systems are in fact related to uncertain events for which there are no known probabilities, although subjective probabilities can be conjured by expert opinion (Jaffee, Siegel, and Andrews 2010).

The “traditional” risks to agriculture in developing countries include inclement weather of all kinds (floods, droughts, hail, snow, windstorms, hurricanes, cyclones), pest and disease outbreaks, fire, theft, violent conflict, and hardships of the sort that farmers have always feared. “Newer,” less familiar risks have appeared with the commercialization and global integration of commodity chains, including commodity price volatility, input price volatility, sanitary and phytosanitary risks, the risk of social compliance, and so forth. Regardless of whether these risks are old or new, their sudden occurrence and the inability to manage them can push millions of farmers into poverty traps and undermine the economies of countries that depend heavily on agriculture.

Risk in agriculture can be further classified according to whether it predominantly affects the immediate production environment, markets, or the broad institutional context in which commodities are produced and supplied:

- **Production risks** include bad weather, pests and diseases, fire, soil erosion, other kinds of environmental degradation, illness and loss of labor in the farm family, and other events that negatively affect the production of agricultural

commodities. These risks have a direct, immediate impact on local agricultural production, but it is essential to understand that their effects are transmitted from the farm all along the supply chain.

- **Market risks** can include volatile prices of agricultural commodities, inputs (fertilizer, pesticide, seeds, and so on), and exchange rates, as well as counterparty risks, theft, risk of failure to comply with quality or sanitary standards, or risks imposed by logistics. These risks usually emanate from market actors (such as traders and exporters), and their effects are transmitted back to the farm.
- **Enabling environment risks** can include political risks, the risk that regulations will suddenly be applied, risks of armed conflict, institutional collapse, and other major risks that lead to financial losses for stakeholders all along agricultural supply chains.

Risks can be idiosyncratic—affecting only individual farms or firms (for example, illness of the owner or laborers, acidic soil, particular plant and animal pests and diseases); or covariate—affecting many farms and firms simultaneously (major droughts or floods, fluctuating market prices). The high propensity for covariate risk in rural areas is a major reason that informal risk management arrangements break down and that formal financial institutions hesitate to provide commercial loans for agriculture (Jaffee, Siegel, and Andrews 2010).

Risk Management Strategies

Agrarian communities have traditionally employed various formal and informal strategies to manage agricultural risk, either before or after the effects of risk are felt. Ex ante strategies (adopted before a risky event occurs) can reduce risk (by eradicating pests, for example) or limit exposure to risk (a farmer can grow pest-resistant varieties or diversify into crops unaffected by those pests). Risk can also be mitigated ex ante by buying insurance or through other responses to expected losses, such as self-insurance (precautionary savings) or reliance on social networks (for access to community savings, for example).

Ex post strategies (adopted to cope with losses from risks that have already occurred) include selling assets, seeking temporary employment, and migrating. Governments sometime forgive debts or provide formal safety nets such as subsidies, rural public works programs, and food aid to help farms and firms (and their laborers) cope with negative impacts of risky events.

Although ex ante measures allow farms and firms to eliminate or reduce risks, reduce their exposure to risk, and/or mitigate losses associated with risky events, they present real and/or opportunity costs before a risky event actually occurs. In contrast, ex post risk management measures respond only to losses that actually occur, but they can have very high real and opportunity costs when that happens. Farmers make decisions based on their evaluation of risks and the resources at their disposal.

Each strategy for managing risk can be carried out through a variety of instruments, each with different private and public costs and benefits, which might either increase or decrease the vulnerability of individual participants and the supply chain. When selecting a mix of risk responses, it is essential to consider the many links between risk management strategies and instruments (Jaffee, Siegel, and Andrews 2010).

To sum up, agricultural risk management strategies can be classified into three broad categories:

- **Risk mitigation.** These actions prevent events from occurring, limit their occurrence, or reduce the severity of the resulting losses. Examples include pest and disease management strategies, crop diversification, and extension advice.
- **Risk transfer.** These actions transfer risk to a willing third party, at a cost. Financial transfer mechanisms trigger compensation or reduce losses generated by a given risk, and they can include insurance, reinsurance, and financial hedging tools.
- **Risk coping.** These actions help the victims of a risky event (a shock such as a drought, flood, or pest epidemic) cope with the losses it causes, and they can include government assistance to farmers, debt restructuring, and remittances. Government and other public institutions, through their social safety net programs, play a big role in helping farmers cope with risk.

There is a distinct role for both public and private institutions in helping smallholders manage agricultural risk. Private interventions include individual actions and private arrangements among individuals (either informal arrangements or formal, contractual arrangements). Governments have a supporting role to play here, which may include providing infrastructure, information, and a suitable framework for private institutions. As noted, governments and civil society also have a role as providers of safety nets.

Central Role of Information and ICT in Risk Management

All of the above-mentioned strategies—risk mitigation, risk transfer, and coping—have limitations, and farmers often deploy a combination of strategies to manage their risks. The mix of strategies often depends on factors like the availability and understanding of different risk management instruments, institutional and physical infrastructure, a farmer's capabilities and resource endowment, and a farmer's social network. Information about what needs to be done—when, how, and why—is fundamental for smallholders and other stakeholders in the agricultural sector to implement actions to mitigate risk, transfer risk before it occurs, and determine how to cope once those events have occurred.

Farmers' information needs and sources are varied and change throughout the agricultural production cycle (table 10.1), but all farmers require a comprehensive package of information to make decisions related to risk.

Farmers typically have been poorly informed. As the founder of a market information service noted:

Most [farmers] have long relied on a patchy network of local middlemen, a handful of progressive farmers, and local shop owners to receive decision-critical information, whose reliability, accuracy, and timeliness can have a critical impact on their decision making and therefore livelihood. These are fundamental decisions, such as what price to sell the crop, where to sell (given the numerous fragmented markets), when to harvest, and when to spray pesticides to save the crop.

Mehra 2010

Research in Sri Lanka found that the cost of information, from the time the farmer decides what to plant until produce is sold at the wholesale market, can be up to 11 percent of production costs. The study also found that information asymmetry is an important contributor to overall transaction costs (De Silva 2008). ICT applications—such as the Internet, networked computers, mobile phones—and smart phones

are the latest in a long line of technologies (the newspaper, telegraph, telephone, radio, and television) that support risk management practices by collecting, processing, distributing, and exchanging information (World Bank 2007).

A survey of current ICT applications for managing agricultural risk suggests that they are valuable for two primary reasons. First, these applications channel information, advice, and finance to farmers who are difficult to reach using conventional channels. Second, they reduce the costs for organizations to provide risk management services, because they can greatly reduce the costs of collecting, storing, processing, and disseminating information.

These cost reductions have produced two effects that encourage private investment in ICT to manage agricultural risk. First, previously unprofitable activities have become profitable. Second, reductions in operating costs can reduce prices for the end user. Products and services that were once too expensive for the poor have come within reach, opening a new market segment for risk management products.

The use of ICT to manage agricultural risk is at such an early stage that it is difficult to discern trends, but interesting developments are under way. Increasingly, the private and public sectors are collaborating to invest in ICT applications that can deliver timely information to farmers. With continuing improvements in technology, software, and infrastructure, the quality and richness of this information are improving over time to address the specific needs of individual farmers.

Information services will allow farmers ever more interactive, two-way communication with agricultural experts and others in the agricultural innovation system (see Module 6). With the incorporation of ICT, supply chains are becoming far more transparent and capable of including smallholders. The technology seems to help farmers avoid default risks and produce to consistent quality specifications, which is an important step toward participating in more lucrative commodity markets.

As observed earlier, the encouraging trend in risk transfer products is the use of ICT to design insurance contracts,

TABLE 10.1. Farmers' Information Needs in Relation to the Crop Cycle and Market

BEFORE PLANTING	BEFORE HARVEST	AFTER HARVEST	MARKET INFORMATION
<ul style="list-style-type: none"> • Information on agricultural inputs such as seeds, fertilizer, pesticide • Credit • Weather • Soil testing 	<ul style="list-style-type: none"> • Good agricultural practices • Pest management • Harvesting time and techniques • Packaging 	<ul style="list-style-type: none"> • Postharvest management • Storage • Grading and standardization • Logistics • Market information 	<ul style="list-style-type: none"> • Alternative market channels • Commodity prices • Wholesale market price information • Consumer behavior

Source: Adapted from Narula and Sharma 2008.

deliver insurance policies, assess crop damage, and deliver indemnity payments. Although the agricultural insurance markets in developing countries are very small, ICT applications clearly have features that should help broaden those markets.

With regard to risk coping, technologies that allow real-time visualization and assessment of damage are beginning to be applied to agricultural shocks such as floods. Two other technologies—mobile money and electronic voucher systems—are expected to be more regularly incorporated into the operations of multilaterals and governments that must transfer funds to beneficiaries without access to financial institutions (see Module 7).

KEY CHALLENGES AND ENABLERS

If it is difficult to ascertain trends from nascent activities such as those described in the topic notes, it is even more challenging to assess outcomes and draw lessons. Many of these activities should be evaluated rigorously to determine their impacts and critique their approaches to using ICT in managing agricultural risk. Despite these caveats, several preliminary insights, crosscutting challenges, and key enablers for risk mitigation, risk transfer, and risk coping should be noted.

First, in some instances, farmers will pay for risk management services, particularly information services, customized to their needs. However, before adequate customization occurs, most risk management services need public or private funding to support farmers' initial access. Thus partnerships are central to assembling the combination of knowledge, skills, and resources required to manage risk through the use of ICT.

Successful efforts display cooperation between software developers, hardware manufacturers, agricultural experts, financial intermediaries, state governments and institutions, donors, nongovernmental organizations (NGOs), mobile operators, and others in the private sector. These partners might have different incentives for participation that may not always be compatible, and different stakeholders may have different time horizons. To hold such partnerships together, an appropriate balance must be struck between stakeholders' competing interests and short- and long-term gains.

Because partnerships, particularly with the participation of the private sector, are so vital in risk management, an enabling policy environment and institutional framework supporting business and entrepreneurship are also critical to incentivizing private investment to cope with or transfer risk. Additional fundamental elements are adequate physical

and telecommunications infrastructure for the cost-effective deployment of ICT. Where costs are sufficiently low because mobile infrastructure is already available, more profitable opportunities may exist. Successful ventures will offer insight into ways of ensuring sustainability and use on a wide scale.

Farmer capacity is also challenging. Rural areas, where risk management services are so desperately needed, also lack education services, financial services, and even agricultural services. Many aspects of human capacity—such as financial literacy, knowledge of best agricultural practices, and familiarity with technology—are prerequisites for using risk management tools successfully.

Highly developed software programming skills and technical expertise are also critical for deploying ICT. Many risk management services were able to leverage the significant human resources of larger organizations, such as Reuters and Tata Consulting Services, to develop their software (see Topic Note 10.1). This capacity is not universally available. In addition, providers must be able to assess and thoroughly understand the needs of their clients; experience shows that most technology-driven projects that do not connect with and address users' needs have higher rates of failure.

Women and other vulnerable groups do not have equal access to risk management tools. Traditional cultural norms in many societies restrict women's mobility, education, assertiveness, and awareness, all of which affect their ability to acquire information or advisory services to help manage agricultural risks. The underlying structural gender constraints make them passive recipients rather than active seekers of information. Even when women proactively seek information, their access to information and ability to use it are hampered by gender norms and stereotypes (ILO 2001,6).

Theoretically, the impersonal nature of ICT overcomes some of the traditional barriers and gender asymmetries that women face in accessing information. A mobile phone, for example, does not differentiate between a female farmer and a male farmer, but a male extension worker might. It is often difficult for women farmers to travel long distances to ascertain market prices, but a short messaging service (SMS) might deliver that information without breaking any traditional stereotypes and gender norms. Very little data, disaggregated by the gender of beneficiaries, are available on the impact of ICT applications in agricultural risk management. Increasing gender-disaggregated data and analyzing the effects of risk management instruments on

women's agricultural experience over the long term could provide useful guidance for improving women's access to such instruments.

Trust in information and trust in transfer products are also critical issues for risk management. The information delivery mechanism seems to influence farmers' confidence and trust in the information as well as how they use it. Farmers are more likely to act upon information received directly from an expert than on information provided by an automated database. Farmers are also more likely to trust and act on information they receive from a person standing in front of them than from somebody on the phone or an automated phone message.

Because most initiatives discussed in this module have yet to be studied rigorously, it is difficult to draw quantitatively sound causal relationships between ICT for risk management interventions and gains in risk reduction. Support is needed for research to establish the impact of ICT in risk mitigation, transfer, and coping systems. Such evidence would not only improve the interventions but also garner support to scale up effective innovations.

In nearly every instance in which investments in ICT have helped agricultural stakeholders to manage risk, external support has been critical for providing complementary public goods, including:

- **Infrastructure**, especially electricity delivery and mobile network coverage.
- **Institutional and regulatory reform**, especially with regard to commodity markets that raise barriers to the adoption of ICT for risk management.
- **Business climate reforms** to encourage continued participation and innovation from the private sector. Donors can also encourage and foster cooperation among public and private sector actors.
- **Technological, agricultural, and financial literacy among smallholder farmers**. Low literacy represents a significant barrier to smallholders' effective use of ICT to manage risk.

Donors such as the World Bank can also monitor innovative applications for risk management, evaluate their impact on small-scale farmers and the agricultural sector, and provide research and technical support where necessary.

Topic Note 10.1: ICT APPLICATIONS FOR MITIGATING AGRICULTURAL RISK

TRENDS AND ISSUES

While agriculture will continue to be risky, many risks can be mitigated by timely action and through the application of best practices. Typical risk mitigation actions might be spraying crops with the appropriate pesticides in response to an early warning of a nearby pest outbreak or optimally altering cropping patterns in response to news from commodity futures markets.

Information is the most critical requirement for effective risk mitigation, and farmers need a variety of information to make choices to manage risk. Two types of information are most important for risk mitigation:

- **Early warnings** about the likely occurrence of inclement weather, pest and disease outbreaks, and market price volatility.
- **Advisory information** to help farmers decide upon a course of action to manage production risks optimally or to respond to early warnings.

The connection between agricultural advisory services and risk mitigation is an important one, because information

alone is often not sufficient to manage risk. In Uganda, for example, the Grameen Foundation found that even if a farmer knew that a banana disease was spreading nearby, he or she required help in choosing the right action to prevent infection of the plants they owned (Grameen Foundation 2010a).

In many cases, the early warning or decision support information already exists. State meteorological services generally collect weather information and create forecasts. Similarly, agricultural institutes, research universities, or extension services are typically well aware of best practices in crop selection, production techniques, input use, pest management, global commodity trends, and other topics critical to smallholder farmers. International organizations also generate early warning and decision support information. USAID's Famine Early Warning System (<http://www.fews.net>) provides information for governments to manage food security risk, for example. A similar system at FAO helps to manage food security risk—the Global Information and Early Warning System (<http://www.fao.org/gIEWS/english/index.htm>).

One difficulty has been to collect and process this information so that it is relevant to individual farmers. Another has been to transmit the information to rural populations in poorly connected areas in cost-effective ways. ICT applications have made it easier and cheaper to achieve these objectives.

There is some doubt about whether an early warning alone can help farmers mitigate risk. Many of these causal links have not been tested empirically. Latent demand for advice in addition to warnings appears to exist, but it is not clear whether farmers are willing to pay for such advice delivered using ICT or whether the private sector can deliver such information sustainably. Public sector and development institutions should remain active in this space and keep a close eye on pilots in countries such as India, Uganda, and Kenya.

RECENT ICT APPLICATIONS FOR RISK MITIGATION

Farmers in many countries receive news of impending bad weather and catastrophic events, pest and disease outbreaks, and price volatility in commodity markets. The use of ICT has reduced the cost and increased the profitability of providing this information, which has attracted private sector participation in a space traditionally dominated by state extension services or agricultural institutes. The private sector originally developed services to provide market price information, but most of these services have evolved to deliver news about impending catastrophic and inclement weather.

Risk-Mitigating Information

The quintessential example of applying ICT to agriculture is the Indian agribusiness giant ITC and its e-Choupal service (<http://www.itcportal.com/rural-development/echoupal.htm>), detailed in Module 9. This extensive network provides approximately 4 million farmers with information on market prices, the weather, pest and disease outbreaks, and expert advice. The service is free; ITC profits by using its information service kiosks to procure commodities and market agricultural inputs to farmers (ITC 2010).

Reuters Market Light (<http://www.marketlight.org/>), detailed in Module 3, modifies the information delivery model of e-Choupal by eliminating the kiosks and reaching out directly to farmers (box 10.1). Developed by the Thompson Reuters information company, the service provides highly personalized, professional information to India's farming community. It covers over 250 crops, 1,000 markets, and 3,000 weather locations across

BOX 10.1. Reuters Market Light Disseminates Early Warnings to Mitigate Risk

The main task of Reuters Market Light (RML) is to give farmers price information to increase their bargaining power in markets, but it also provides early warning information that can be used to mitigate risk. Two pieces of the service are particularly relevant here:

- **Farmers receive daily SMS messages** containing weather information for their particular locations. This information includes predictions of rainfall, humidity, and inclement weather.
- **Farmers receive three types of news** for crops specified when they subscribe to the Reuters service: (1) news regarding outbreaks of pests or diseases, (2) news and analysis from global markets, and (3) government policy information regarding, for example, farmer support programs, schemes, and subsidies.

That timely weather forecasts might help mitigate risk is not difficult to ascertain, as this anecdote from Reuters indicates. A farmer is quoted as saying, "I got message on relative humidity going up to 70 percent. As a precaution, I put a spray of US\$10. My friend did not know this. He lost nearly US\$8,000 of his crop that day."

Source: Authors, drawing on Reuters 2007, Preethi 2009, and Mehra 2010.

13 Indian states in 8 local languages (Mehra 2010). The information is delivered directly to farmers' mobile phones through SMS. RML subscription cards can be purchased from local shops, input suppliers, banks, and post offices.

Rigorous, empirical evaluations have yet to be carried out to determine the quantitative relationship between information availability and the implications for risk mitigation. A preliminary study in Sri Lanka concluded that 40 percent of post-production losses could be mitigated with timely information (Mittal, Gandhi, and Tripathi 2010). From an internal study, Thompson Reuters claims that through information sharing, an estimated 1 million farmers in over 15,000 villages have used the service and received high returns on their investment, amounting to over US\$4,000 from additional profits and US\$8,000 on saved costs, far exceeding the service fee (International Chamber of Commerce 2010).

Through the Esoko platform (<http://www.esoko.com/>) described in Module 3, West African farmers and traders

receive targeted, scheduled text messages on commodity prices or offers from buyers. The focus is on creating a transparent, stable market and reducing transaction costs. Similarly, the Kenya Agricultural Commodity Exchange (<http://www.kacekenya.co.ke/>) makes prices on the exchange available by text message (KACE 2010). These services improve farmers' ability to negotiate prices and serve to partially mitigate price risk. Even so, they cannot mitigate the more significant price volatility that originates in global markets.

Research institutes are also innovating in the delivery of information services. MTT Agrifood Research Finland is piloting the EVISENSE project (https://portal.mtt.fi/portal/page/portal/mtt_en/ruralenterprise/tomorrowsfarm/envisenseforecast) to provide 24-hour disease forecasts to Finnish farmers using a combination of technologies such as weather sensors, databases, mobile phone SMS, GPS, and online management systems. Sensor networks across the country feed weather data to a centralized server. This centralized database contains farmer-specific cropping information provided by the farmer. Computer models use the site-specific data along with the weather data to predict pest outbreaks. If an outbreak is predicted, farmers receive messages on their mobile phones and can then log onto the Internet to download additional information from a farm management information system. The online system recommends which spray agents to use and when to combat the impending attack.

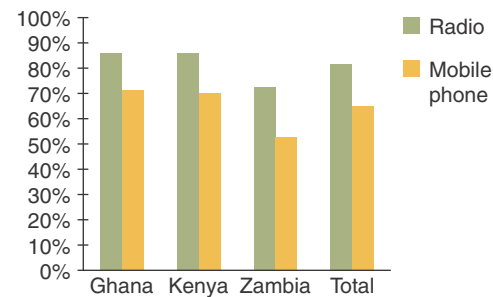
Through EVISENSE, farmers can mitigate the risk of disease by spraying their crops with the appropriate pesticide ahead of an outbreak. The spraying plan can be sent to the computer on the tractor's sprayer to carry out the spraying. Once it is entered into the tractor's system, the plan can be fine-tuned using GPS on the tractor and location-specific data on moisture, wind, and predicted rainfall from MTT's SoilWeather system. For example, if rain is predicted within three hours of spraying, the spraying will be discontinued. This information prevents expensive inputs from being washed away and damaging the environment (MTT 2009).

Mobile phones are not the only way to deliver early warning information. Radio remains very important: More farmers are likely to receive information from the radio than from any other source. Recent data show that in Sub-Saharan Africa, even among more developed nations, the penetration of radio still exceeds that of the mobile phone (figure 10.1).

Decision Support Systems

Besides fostering the delivery of timely and accurate information to mitigate risk, ICT applications also act as decision support systems. These systems help stakeholders choose the

FIGURE 10.1. Ownership of Radios and Mobile Phones in Ghana, Kenya, and Zambia, 2010



Source: InterMedia AudienceScapes Surveys 2010.

best course of action to manage risks in production or respond appropriately to early warnings. For instance, weather information and advisory services are in place in many countries to help stakeholders make optimal decisions from crop planning to crop sale to manage risks. Again it is important to emphasize that such advisory services are important for risk mitigation because they help farmers translate good information into practical actions that reduce their exposure to risk.

Such services enable farmers to interact in various ways (such as voice interaction or SMS queries using mobile phones) with an automated database containing best practices and recommendations to handle most routine queries. Common queries might include ideal planting times, optimal input applications, or suggestions on which crops to plant based on market trends. In unique cases, queries are referred to agricultural experts. In other cases, the farmer is able to speak directly with extension personnel.

The mKRISHI service, recently piloted by Tata Consulting Services in India, is a prototypical example of remote extension services that allow two-way interactions. ("Krishi" is "farming" in Hindi.) A farmer uses the platform to access best practices and query agricultural experts through low-cost mobile phones, mostly using SMS (Banerjee 2010).

MKRISHI is not the only program of its kind to offer remote extension services heavily reliant on ICT. Other countries have experimented with slightly different ways of linking the farmer to extension information. The Kenya Farmers Helpline ("Huduma Kwa Wakulima") (http://www.kencall.com/index.php/site/kenya_farmers_helpline/) was launched in 2009 by KenCall, a Kenyan business process outsourcing company, with support from the Rockefeller Foundation. Instead of using SMS, farmers call the Helpline and speak to an agricultural expert in English or Swahili (Lukorito 2010). Kisan Call Centre (India) and Jigyasha 7676 (Bangladesh) are similar operations that provide customized, expert advice to farmers.

Radio (a traditional source of extension advice) is becoming a more interactive source of advice with the advent of mobile phones and call-in (or text-in) programs. The African Farm Radio Research Initiative (<http://www.farmradio.org/english/partners/afri/>) of FarmRadioInternational (<http://www.farmradio.org/>) creates content that can be broadly described as agricultural extension information, including weather forecasts, price news, and early warnings about pests and diseases. (For details, see Topic Note 6.2.)

Supply Chain Integration and Traceability

ICT applications are also helping supply chains become more vertically integrated. Better cooperation between farmers and buyers along the supply chain mitigates default risk. Amul in India has installed Automatic Milk Collection Unit Systems in village dairy cooperatives. These systems enhance the transparency of transactions between the farmer and the cooperative and have lowered processing times and costs. The application uses computers connected to the Internet at the milk collection centers to document supply chain data such as fat content, milk volumes procured, and amount payable to the member (Bowonder, Raghu Prasad, and Kotla 2005) (for considerably more detail, see IPS “IT Tools for India’s Dairy Industry,” in Module 8).

Dairy Information Services Kiosks at collection centers describe best practices in animal care to enhance milk yield and quality and assists dairy cooperatives to effectively schedule and organize veterinary, artificial insemination, cattle feed, and related services (Rama Rao 2001). Delivery of such comprehensive information helps to improve integration of the supply chain, thus reducing default risk. The early detection of production volatility makes it possible to take preemptive measures to address the underlying risk.

ICT applications, particularly GIS and RFID technologies, have had an impact in mitigating two additional forms of risk in the supply chain: sanitary and phytosanitary (SPS) risk and default risk. Larger aggregators and traders use software systems to collect and track information about who is growing what and whether farmers are adhering to the food safety and quality standards imposed in Europe and North America, especially for perishable foods. Traceability technologies and software to increase integration in supply chains, such as Muddy Boots (<http://en.muddyboots.com/>) (see Module 10), help to mitigate default risk when suppliers rely on large numbers of small-scale farmers. Fruiléma (<http://www.fruilema.com/>), an association of fruit and vegetable producers and exporters in Mali, launched a Web platform for potential buyers to track the entire mango production chain and enables Fruiléma to comply with Global G.A.P. standards (see IPS “Mango Traceability System Links Malian Smallholders and Exporters to Global Consumers” in Module 11).

LESSONS LEARNED

A number of insights emerge from recent experiences in using ICT to mitigate agricultural risk. One important insight is that the missing link in providing risk-mitigating information to farmers was not the information itself but the challenge of aggregating, personalizing, and disseminating it in a timely and cost-effective way. The content that farmers need is already produced by universities and government institutes.

Any use of ICT applications to mitigate agricultural risk must ensure that the fundamental requirements described above are present or can be developed easily. For example, farmers’ familiarity with ICT should be assessed before initiating an intervention. Similarly, there should be a baseline understanding of whether farmers have the capacity to make good use of the information. Do farmers have access to rural finance, markets, transportation, technology, inputs, and so on? If not, consider awareness and education programs regarding risk-mitigating strategies or appropriate responses to early warnings.

One difficulty in providing early warning or advisory services to farmers was not that the information was lacking, but that it could not be delivered effectively. ICT applications make it easier to collect information from the universities and institutes that produce it and then to personalize it and provide it directly to farmers. The medium matters, however. A radio announcement is different from a phone call, which is again different from a text message.

Collaboration between the private and public sectors is increasing. The public sector generates early warnings and provides expert advice, while the private sector has found that it can leverage ICT applications (particularly mobile phones and back-end data collection and processing systems) to deliver this content to farmers quickly. Profitability remains a challenge. In many instances, the upfront investment and capital costs (such as the cost of investing in weather and ICT infrastructure), as well as the operational costs, are high. A longer-term horizon and significant economies of scales are required to break even.

The ability to deliver highly personalized information is another key to earning revenue. Farmers naturally want information relevant to themselves—their crops, their plant and livestock disease, their markets—in the language they speak. It is difficult to elicit direct payment for services from farmers, but if farmers see a value proposition, they are often willing to pay for a service.

As a result, private participation in delivering information should be encouraged where possible, but the commercial sustainability of such initiatives should be analyzed rigorously. Information service providers should be encouraged to partner with the public sector to source content. It is difficult

to imagine that the private sector would find it profitable to invest in generating content as well as delivering it (unless delivering it to farmers they contract). State-funded institutions have been critical partners in sharing their knowledge and resources without cost. Cooperation and connectivity are critical between information distributors (mobile application developers) and information creators (universities, news organizations, meteorological services, government data services).

IMAGE 10.2. The mKRISHI Interface



Source: TATA Consulting Services.

Technology considerations are also critical. Even though farmers can get weather information from the radio, those reports come only at a certain time and are easily missed, because farmers are often in transit or working in the field away from the radio. Text messages, which can be stored and accessed at any time, are preferred because they ensure that farmers receive the critical early warning. Mobile infrastructure is vital for most services that transmit risk-mitigating information to farmers (except for services relying on radio).

New capacities in technology may lead to even better risk mitigation strategies. The growing sophistication of mobile phones and falling costs of weather sensors make it likely that farmers will soon have access to a richer variety of information that is even more tailored to their location, crop choice, and general information needs. Java-enabled phones, for instance, are cheaper and allow farmers to access information using menus instead of simply sending SMS queries back and forth. Two-way interaction between farmers and advisers, in which farmers can ask and receive answers to specific questions, are likely to increase but also to command a premium. A direct connection overcomes literacy and language barriers, though these barriers should also ease as voice recognition technology improves.

INNOVATIVE PRACTICE SUMMARY

Through mKRISHI, Farmers Translate Information into Action to Mitigate Risk

mKRISHI is innovative because it enables farmers to transform information into risk-mitigating actions ("TCS' mKRISHI on Pilot Run in Maharashtra," *Financial Express* 2009). The mKRISHI platform, developed by Tata Consultancy Services in 2007, enables farmers to access best-practice information and agricultural experts through low-cost mobile phones using SMS (Banerjee 2010) (image 10.2). The connection between agricultural advisory services and risk mitigation is an important one, because information alone is often not sufficient to manage risk.

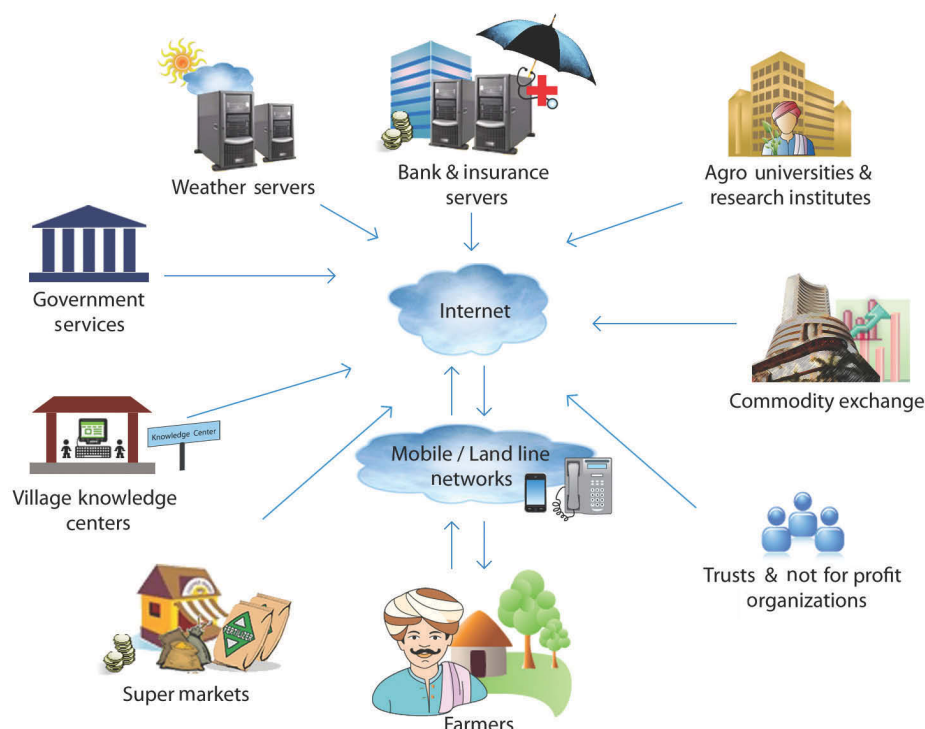
Through the advisory service, farmers might inquire how much fertilizer or pesticide to use, so they can optimize their use of these costly inputs. Similarly, farmers might inquire about when to harvest to avoid inclement weather. Farmers with cameras in their phones can submit photographs to supplement their messages. While responding to farmers' queries, experts are able to incorporate soil information by accessing the soil sensor nearest to the caller's location (Pande et al. 2009). Farmers can also request a voice- or SMS-based expert response.

Growth and Development

mKRISHI was conceived and developed at the innovation lab of Tata Consulting Services (TCS). The first pilot was deployed in 2010 to an estimated 500 farmers in Uttar Pradesh and Punjab, who pay US\$1–2 per month to use the service. The service is being provided at a subsidized cost, as farmers were unwilling to pay the unspecified higher cost at which the service was initially offered (Pande 2010). However, mKRISHI has found that farmers may be more willing to pay if information on market linkages and the facilitation of credit is offered along with the advisory services.

Like RML, mKRISHI disseminates a wide range of personalized information; the critical difference is that experts can respond to farmers' queries. To provide the early warning and news information, the system relies on a Web-based mobile platform that ties into many information sources. Data are gathered from commodity exchanges, agricultural research institutions (often state supported, such as Punjab Agricultural University), banks, weather servers, local markets, and solar-powered weather and soil sensors distributed throughout the areas where the service is offered (figure 10.2) (Pande et al. 2009).

To respond to farmers' queries, mKRISHI relies on an automated database of frequently asked questions. The database

FIGURE 10.2. The mKRISHI Infrastructure

Source: TATA Consulting Services.

Note: CDMA = Code Division Multiple Access, a standard used by mobile phone companies.

can handle most questions, which are usually generic, but more specific or sophisticated questions are forwarded to 10 experts with Internet access. These experts interact with a system that resembles email; they are able to see attached photos and soil sensor information with each message, and their response is sent back to the farmer by SMS.

Impact, Scale, and Sustainability

Farmers reportedly use mKRISHI to choose planting strategies, optimize fertilizer use, and time the harvest to avoid bad weather. Such choices surely contribute to risk mitigation, and some early data from the pilot studies and interactions with farmers show promise in this regard.

If productivity increases can be partially attributed to superior risk mitigation, then indirect quantitative research suggests that an agricultural advisory service such as mKRISHI improves risk mitigation. Much evidence supports the idea that effective delivery of traditional extension services to farmers improves productivity. Returns to extension services vary by crop and by geography, but studies show them to be quite high: “75–90 percent in Paraguay, 13–500+ percent in Brazil, and 34–80+ percent in a group of countries in Asia, Africa, and Latin America” (Birkhaeuser, Evenson, and Feder

1991,643). Again, however, the implication of delivering such services remotely is still to be tested.

As noted, mKRISHI was made available to 500 farmers in two Indian states as of 2010, and there are plans to offer the service across India. There are also discussions about launching similar services in the Philippines and Ghana (Banerjee 2010).

The sustainability of the mKRISHI platform is still questionable. The complexity of the platform and the numerous pieces that are tied together, from people to technologies to automatic sensors, imply a difficult and expensive challenge to sustainability. Another challenge is posed by the inability to collect the full marginal cost of the service from farmers (Pande 2010).

The independent development and implementation of the project by a large private company suggests, however, that the program might be able to sustain itself until it can resolve operational challenges to profitability, which seems to be occurring. Much of the basic information comes from public sources, and mKRISHI has been able to organize and personalize it through a large consortium of partners. The ready availability of the basic information (a public good) thus becomes one of the prerequisites for building and sustaining such operations.

Topic Note 10.2: ICT APPLICATIONS TO TRANSFER AGRICULTURAL RISK

TRENDS AND ISSUES

Farmers face many important risks that they can do little to mitigate through better agronomic practices or the use of early warning information, as described in Topic Note 10.1. Among these risks, price volatility and bad weather risk can be particularly devastating. Low prices at harvest can significantly reduce a farmer's income, while weather risk in the form of floods or droughts can reduce yields or destroy crops.

Farmers (or farmer groups) in developed nations can use specific instruments to transfer their risk to a third party in exchange for a fee. The third party can be a public or private insurance company in the case of weather risk, or a commodity futures exchange in the case of price risk. In developing countries, the availability of such instruments is limited, although pilot projects are starting to introduce them.

ICT devices are playing a critical role in these pilot studies on risk transfer. Advances in mobile phone applications for money transfers, improvements in the resolution and cost of satellite imagery, and the pyramiding of multiple ICT tools (mobile phone, GIS, remote sensing data) to create newer applications are all promising trends that could be leveraged to transfer agricultural risks.

The heightened volatility of international commodity prices and the threat of climate change have increased developing-country stakeholders' interest in risk transfer instruments. Now the bigger challenge is to make risk transfer instruments such as insurance and price hedging more relevant and affordable for smallholders. The ability of ICT applications to reduce transaction costs, deliver information and financial transactions, provide real-time data about hazards, and perform remote damage assessment can also help in piloting and scaling up risk transfer instruments.

Instruments to Transfer Risk

Transferring risk through insurance has several important benefits. Insurance stabilizes asset accumulation by reducing the negative impact of weather shocks. Insurance also fosters investment, because it reduces the uncertainty of returns (Mude et al. 2009) (box 10.2).

Insurance contracts are complex, however, and profitable insurance operations face numerous challenges. These challenges include the difficulty of designing contracts to avoid

BOX 10.2. How Does Insurance Work?

Insurance allows risk to be transferred to a third party for a fee. In exchange for this fee (premium), a farmer receives an policy or insurance contract that is likely to have the following features, among others: (1) a specified time period during which the risk is partially or wholly borne by the third party; (2) the events that are covered (a single peril such as hail, for example, or multiple perils such as drought, hail, fire, and theft); and (3) the payout in the event that the risk event occurs (indemnity), and possibly some gradation of the payout depending on the severity of the loss.

The insurance company profits by pooling risk across large numbers of clients and charging a premium that exceeds the likelihood of the peril occurring, multiplied by the losses that will accrue as a result. For a peril to be insurable, the resulting loss has to be definite, accidental, large, and calculable or able to be estimated; and the total payout must be limited in the event of a catastrophe.

Source: Greene 2010.

problems of moral hazard and adverse selection; insufficient data; high administrative costs in delivering the product, assessing damages, collecting premiums, and making payments; and weak institutional and policy environments (Wenner and Arias 2003). Low trust and financial literacy have also limited the effective demand for insurance and limited the willingness to pay for policies (Giné, Townsend, and Vickery 2008). In recent years, a modified form of insurance, weather-based index insurance, has been piloted in several parts of the world to address the moral hazard and adverse selection challenges and to lower the costs of damage assessments (box 10.3).

Farmers can use other means of transferring risk to avoid the problems caused by large fluctuations in the prices of the commodities they produce. By transferring risk through futures contracts traded on commodity futures exchanges, farmers gain a means of managing the price volatility of agriculture commodities, which lends greater certainty to their production planning and farm investment decisions (UNCTAD 2009,17–18) (box 10.4).

BOX 10.3. What Is Index Insurance?

The unique feature of index insurance is that it reduces the cost of assessing damage by substituting individual loss assessments with an indicator that is easy to measure as a proxy for the loss. Weather events or visible vegetation have served as typical indicators. Besides reducing transaction costs, another advantage of index-based insurance is that it reduces problems of adverse selection, because the insured cannot influence the index or the loss assessment.

The disadvantage is basis risk: the imperfect relationship between the policy holder's potential loss and the index behavior. It is not always possible to perfectly match one farmer's loss from drought to that of all others. Undoubtedly, some farmers will lose more and some less.

Source: Mude et al. 2009.

BOX 10.4. Commodity Futures Markets

A recent report by the United Nations Conference on Trade and Development describes a commodity exchange as:

... a market in which multiple buyers and sellers trade commodity-linked contracts on the basis of rules and procedures laid down by the exchange. Such exchanges typically act as a platform for trade in futures contracts, or for standardized contracts for future delivery. Often, in the developing world, a commodity exchange may act in a broader range of ways, in order to stimulate trade in the commodity sector. This may be through the use of instruments other than futures, such as the cash or 'spot' trade for immediate delivery, forward contracts on the basis of warehouse receipts, or the trade of farmers' repurchase agreements for financing.

Source: UNCTAD 2009,17.

Like insurance, commodity futures exchanges have significant requirements, particularly with regard to policies, regulation, and financial literacy. Exchanges must be governed by clear rules, operated transparently, and regulated properly to ensure the level of confidence that traders demand. Such institutional capacity is often limited in developing nations. The trading of futures contracts also requires specialized

knowledge that most farmers or farmer cooperatives do not have. Even in the United States, fewer than 10 percent of farmers interact directly with commodity futures exchanges. They do make use of futures prices to make planting and production decisions, however (Cole et al. 2008). Efforts are under way in China (UNCTAD 2009,13) and India to teach farmers how to make use of futures markets, but ICT applications do not play a central role (Cole et al. 2008).

ICT Applications and Risk Transfer Instruments

Although ICT applications have made it easier for farmers to access information from commodity futures markets, such applications have not served to facilitate greater interaction with the futures markets to transfer price risk.

With respect to insurance, however, ICT applications seem to be easing constraints arising from the lack of data and high administrative costs. Data requirements can be intensive; for example, weather insurance contracts require time-series data on weather and associated losses for farmers. High-resolution satellite imagery has made data available to design insurance contracts that once would have been impossible to develop, given the lack of data in many countries. Advances in ICT can help overcome gaps in weather data by creating synthetic data based on satellite information. Together, new data and lower costs have facilitated the development of innovative index insurance products that are currently in various stages of testing.

For example, AGROASEMEX (<http://www.agroasemex.gob.mx/>), a Mexican national insurance institution focused on the rural sector, was a pioneer of indexed weather insurance (and now offers catastrophic risk insurance). In 2007, the institution began to offer an insurance product for pasture land based on an analysis of vegetation detected by satellite (called Normalized Difference Vegetation Index, or NDVI) (IFAD and WFP 2010,65–73). Satellite data also allowed the International Livestock Research Institute (ILRI) and its partners to overcome data limitations and create an index-based livestock insurance program in which damage is assessed through remote sensing (see IPS "ICT Enables Innovative Index-Based Livestock Insurance in Kenya," later in this note).

In Nicaragua and Honduras, synthetic data were created through a public-private partnership in collaboration with the local meteorological agency. Three insurance companies (Equidad in Honduras and LAFISE and INISER in Nicaragua) currently use these data to design index insurance contracts for farmers.

Another novel insurance scheme, Kenya's Kilimo Salama (<http://kilimosalama.wordpress.com/>), is described in the

innovative practice summary at the end of this note. It uses weather indicators as a proxy for input losses.

LESSONS LEARNED

Compared to the range of applications for risk mitigation, ICT applications to transfer weather and price risk to third parties are limited. Risk transfer instruments such as insurance and futures contracts have fared poorly in developing countries in general. Such instruments often require well-developed institutions and high levels of financial literacy, which are often lacking in rural areas of developing countries.

The critical message here is that ICT applications reduce the cost of delivering insurance and improve the dissemination of prices from international futures markets, but by themselves they are unlikely to foster widespread use of risk transfer instruments. Before ICT tools can be used to transfer risk, the environment must be conducive. Appropriate infrastructure, institutional structures, and policies for developing and delivering such instruments must be in place. Farmers must exhibit sufficient demand for the instruments. High levels of financial literacy and technical skills are also required. Technical expertise is absolutely vital for accessing and interpreting satellite data and designing actuarially sound policies.

Unique partnerships are essential to incorporate ICT into risk transfer products such as index insurance. The array of partners must have the vital technical skills just described and must be able to access distribution channels, provide financial support, and assist with implementation. There is a role for the public sector to develop and disseminate basic information about risk, because such information in the public domain facilitates the creation of risk markets. Governments can also have a role in planning emergency response to infrequent but catastrophic risks, while allowing private markets to handle insurance. Partners must also be willing to collect data and make it available for insurance companies to price policies correctly or, in the case of index insurance, to create the index that links weather events to specific losses.

An enabling regulatory and policy environment is fundamental for risk transfer tools to work and is characterized by such traits as the rule of law, contract enforcement, and private property rights. For commodity markets, a rules- or principles-based approach to regulation and governance, instead of a discretionary approach, is essential for success (UNCTAD 2009). In the case of insurance, the insurance

providers need to be regulated to ensure that they can deliver on payouts.

The application of ICT to risk transfer products has yet to mature, and interventions should be undertaken with extreme caution. This topic note describes promising examples, but any attempt to replicate them should take the local context into account. Furthermore, the current pilot programs should be subject to impact analysis to quantify their value. In the meantime, efforts can focus on improving the coverage and quality of ICT infrastructure, improving the institutional framework required to support risk transfer products, and improving the awareness of transfer products and their proper use among farmers and cooperatives.

INNOVATIVE PRACTICE SUMMARY

ICT Enables Innovative Index-Based Livestock Insurance in Kenya

ICT has enabled International Livestock Research Institute (ILRI) and its partners to overcome data limitations and prohibitive administrative costs to create an index-based livestock insurance product. Damage is assessed by remote sensing, and the insurance is distributed through wirelessly connected point-of-sale systems deployed across the country.

ILRI, part of the Consultative Group on International Agricultural Research (CGIAR) (www.cgiar.org), developed its Index-Based Livestock Insurance product (<http://www.ilri.org/ibli/>) in 2009 in collaboration with a wide array of partners, including private and government players (ILRI 2009). Initiated in 2010, the pilot program provides farmers with livestock insurance for 6–8 animals per year for a premium of US\$50–100 (Waruru 2009).

Index-based livestock insurance seeks to interrupt the downward spiral of vulnerability, drought, and poverty in northern Kenya—a process that is exacerbated by climate change. Northern Kenya is home to 3 million pastoralist households and is prone to severe droughts (Mude et al. 2009). Pastoralists earn a livelihood by grazing cattle (also sheep, pigs, and poultry) on semiarid to arid land and by selling meat, milk, and eggs (image 10.3). Livestock account for 95 percent of family income in an area where the incidence of poverty is 65 percent, the highest in the country (FAO–AGAL 2005,3). If a drought occurs, the vegetation that the cattle graze upon is lost. Cattle starve, depriving vulnerable pastoral families of their sole source of income.

Livestock insurance allows farmers to pay a premium to transfer the risk of livestock dying in a drought to an insurance company. If a drought occurs, the policy indemnifies the pastoralists' loss. Previous insurance programs were not sustainable. The administrative costs of assessing the losses of remote pastoral communities, collecting premiums, and paying out indemnities were prohibitive.

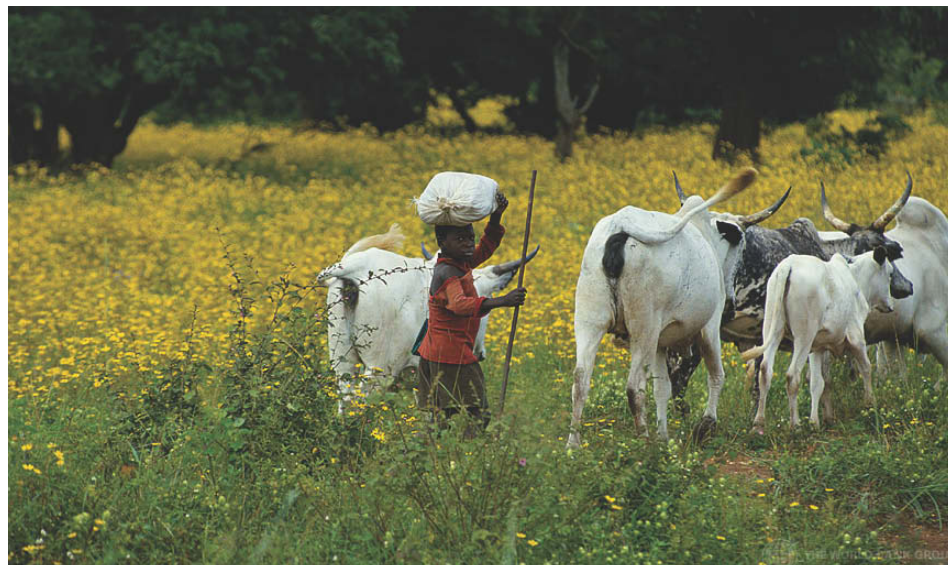
It is unclear whether the advent of ICT will make such programs more sustainable, because other factors affect sustainability, such as creating effective demand or minimizing basis risk. Programs such as index-based livestock insurance are being attempted, however, because ICT applications greatly reduce the administrative costs that crippled previous programs. As noted, ILRI's index-based program was designed using satellite data; damages are assessed by satellite; and delivery, premium collection, and indemnity payments are all done through wireless point-of-sale systems.

Growth and Development

Much of the technical work on the insurance product was done by Cornell University and the University of Wisconsin BASIS program in collaboration with Syracuse University and the Index Insurance and Innovation Initiative. As with the design of any index insurance, the challenge was to find sufficient data on both the peril as well as the indicator. Both kinds of data are necessary; data on the indicator are used to statistically predict the peril and price the insurance correctly.

The innovation in this case was to use vegetation as the indicator, because vegetation can be measured objectively by satellite to indicate the level of drought. Fortunately, the United States' National Oceanic and Atmospheric Administration has collected the high-quality imagery necessary to construct a Normalized Difference Vegetation Index since 1981, and the imagery is available free of charge.

IMAGE 10.3. Pastoralism in Africa Is a Critical Means to Rural Livelihoods



Source: Curt Carnemark, World Bank.

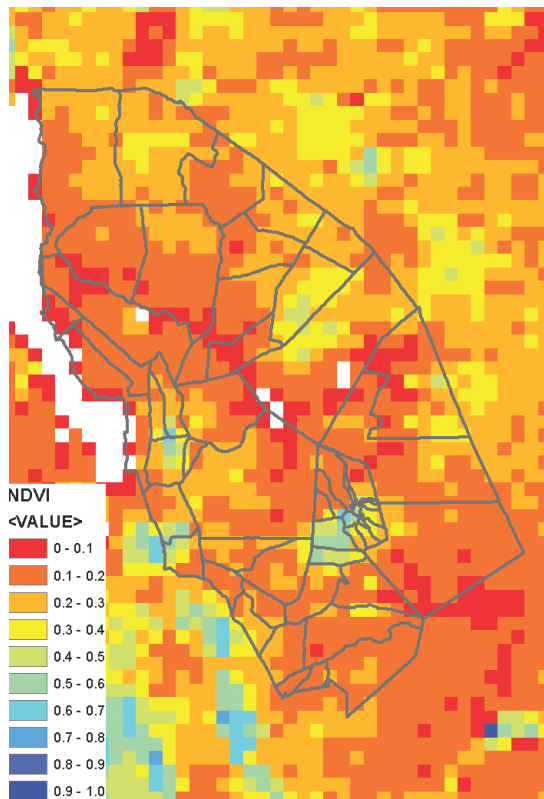
Statisticians used data on livestock losses for Marsabit District, the pilot region, to create an index to predict livestock mortality based on the remotely collected vegetation data (image 10.4). This procedure allowed for actuarially fair pricing of the index insurance (Mude et al. 2009).

The project is being implemented with Equity Insurance Agency, UAP Insurance Limited, Financial Sector Deepening Kenya, and three government departments: the Kenya Meteorological Department, the Ministry of Development of Northern Kenya and Other Arid Lands, and the Ministry of Livestock (ILRI 2009).

Two significant operational challenges arose: creating effective demand and delivering the insurance cost-effectively. Education by way of experimental games proved critical to generate effective demand. Before a farmer would pay for an insurance program, he or she would need to understand what value the product added and how it would work. The challenge was exacerbated by low literacy (Mude et al. 2009).

In a vast region with so few market channels, cost-effective delivery of the insurance product was also a significant challenge. Policies were sold through Equity Bank's point-of-sale system based on handheld mobile devices, which have been rolled out to 150 areas across northern Kenya. This channel was primarily developed for another program (DFID's Hunger Safety Net Program).

IMAGE 10.4. Normalized Difference Vegetation Index, Marsabit District, Kenya, February 2010



Source: ILRI.

Impact, Scalability, and Sustainability

It is too early in the pilot stage to assess the program's actual effectiveness in managing risk and ultimately reducing poverty. An evaluation is to be conducted by the University of Wisconsin at the end of the pilot. The results will help design any modifications in the insurance program and influence decisions on scaling up the pilot to other areas. The plan is to expand the program throughout the country if it proves successful in Marsabit District (Mude et al. 2009). Meanwhile, an ex ante assessment of the insurance found that:

... household initial herd size—i.e., ex ante wealth—is the key determinant of IBLI [index-based livestock insurance] performance, more so than household risk preferences or basis risk exposure. IBLI works least well for the poorest, whose meager endowments effectively condemn them to herd collapse given prevailing herd dynamics. By contrast, IBLI is most valuable for the vulnerable nonpoor, for whom insurance can stem collapses onto a trajectory of herd decumulation following predictable shocks.

District-level aggregate demand appears highly price elastic with potentially limited demand for contracts with

commercially viable premium loadings. Because willingness to pay is especially price sensitive among the most vulnerable pastoralists (i.e., those not currently caught in a poverty trap, but on the verge of falling into one) for whom the product is potentially most beneficial, subsidization of asset insurance as a safety net intervention may prove worthwhile. Simple simulations find that relatively inexpensive, partial subsidization targeted to households with herd sizes in specific ranges can significantly increase average wealth and decrease poverty, at a rate of just \$20 per capita per one percent reduction in the poverty headcount rate."

Chantararat et al. 2009

This last point has implications for sustainability, which faces substantial financial hurdles if the product cannot be commercially viable. The development and pilot of the program were funded by Financial Sector Deepening Trust in Kenya, the UK Department for International Development (DFID), and USAID (Waruru 2009), but plans to expand nationally would require substantial private investment.

There are also questions of dependency on other programs. The satellite data, for example, are critical. If they are lost, there would be sustainability concerns. Similarly, the point-of-sale system used to deliver the insurance is funded by a separate program; any changes to that program might threaten the insurance program.

INNOVATIVE PRACTICE SUMMARY

Kilimo Salama Delivers Index-Based Input Insurance in Kenya through ICT

The Kenyan insurance scheme Kilimo Salama (<http://kilimosalama.wordpress.com/>) (its name means "safe farming" in Swahili) innovates by using mobile phones to collect premiums and distribute payouts, thereby reducing assessment and administrative costs. Weather indicators are used as a proxy for the loss of inputs. Under Kilimo Salama's "pay-as-you-plant" model, agrodealers sell insurance policies according to the quantity of inputs purchased.

Kilimo Salama was developed by the Syngenta Foundation for Sustainable Agriculture in partnership with Safaricom, UAP Insurance, MEA Fertilizers, and Syngenta East Africa Limited. The program specifically insures the cost of inputs in case of poor weather over the planting season. Plans are in place to offer a crop loss product in addition to the input loss insurance.

The premium amount is 10 percent of the input cost, which is shared equally by farmers and the input companies

(50 percent each). The farmer thus pays a premium of 11 cents on a bag of higher-yielding corn seeds that costs US\$2.20 or 31 cents on a 10-kilogram bag of fertilizer that sells for US\$6.20 (Kilimo Salama n.d.)

When the products are sold, the seller activates the insurance policy using the Kilimo Salama application on the seller's handset by (1) scanning a product-specific bar code with the camera phone, (2) entering the farmer's mobile number, and (3) linking the farmer to the local weather station (image 10.5). The buyer receives an SMS confirming the insurance policy ("First Micro-Insurance Plan Uses Mobile Phones and Weather Stations to Shield Kenya's Farmers," *Science Daily*, 2010).

ICT applications are used in every part of the operation. Thirty solar-powered weather stations automatically monitor the weather; paperless channels are used to sell product; the Safaricom 3G network is used to cheaply and quickly transmit monitoring, sales, and payout data; and M-PESA (owned by Safaricom) is the platform used to make indemnity payments electronically. The Kenya Meteorological Department provided the supporting weather data to create the index and correlate it to crop losses and therefore to input-investment losses (Ogodo 2010).

Each insurance policy sold requires the farmer to be registered to the nearest weather station (Ogodo 2010). If there is excess rain or insufficient rain, as measured by the weather reporting stations, the index correlating rainfall and crop growth defines the payout due. Then the payment is made straight to the farmer's handset using M-PESA (see IPS "M-PESA's Pioneering Money Transfer Service," in Module 2).

The insurance program was piloted to 200 farmers linked to two weather stations in 2009 in Laikipia District. There was a drought in both areas, and 80 percent of the input investment was returned to farmers linked to one weather station, whereas the other station reported a less severe drought and

the payout was 30 percent of the investment ("First Micro-Insurance Plan Uses Mobile Phones and Weather Stations to Shield Kenya's Farmers," *Science Daily*, 2010).

The value of the insurance generally is not disputed, but Kilimo Salama has just finished the pilot program and impact has yet to be rigorously assessed. Even so, the business model, privately cofinanced by input sellers, seems to be growing on its own. In 2010, 12,000 farmers had registered for the insurance, and there were plans to make the product available to 50,000 farmers in Kenya by 2011 (Ogodo 2010).

IMAGE 10.5. Weather Station in Kenya



Source: Syngenta Foundation.

Topic Note 10.3: ICT APPLICATIONS FOR COPING WITH AGRICULTURAL RISK

TRENDS AND ISSUES

Regardless of the best efforts to mitigate or transfer risk, agricultural production is inevitably susceptible to risks of floods, droughts, and disease, among others. Such risks, when they materialize, can force farmers to deviate from their agricultural

activities, disrupt them, or, in the worst case, shut them down (Jaffee, Siegel, and Andrews 2010,21). Coping involves responding to a shock in ways that immediately curtail further losses in the short term, protect remaining life and assets in the medium term, and enable recovery in the long term.

Left to their own devices to cope with unmitigated risks, farmers typically employ strategies that are expensive in the long run. They may quickly sell productive land and other assets at below-market prices to generate cash; deplete personal savings, if they have any; pull children out of school; or borrow at high interest rates (Cole et al. 2008). Farmers also turn to their social networks for support, but this strategy does not work when entire villages are affected. When a farmer loses crops to floods, he or she may not be able to rely on family members in the same village who have suffered the same fate.

To prevent people from resorting to expensive coping strategies, governments and relief organizations attempt to quickly identify and assist those affected by shocks. Timely assistance can stem further losses and begin the recovery process. Assistance might be provided in the form of food vouchers, low-interest loans, technical assistance to resume productive activity, subsidized fertilizers, and loan cancellations.

RECENT APPLICATIONS

A few ICT applications are used to cope with agricultural shocks such as droughts, floods, and disease outbreaks, but they are proving important and potentially transformative. First, ICT applications such as mobile phones (particularly those equipped with GIS and cameras) can be used to collect information after a shock about the extent of the damage, numbers of individuals affected, and who needs relief. These field data have proven vital to relief efforts, especially for better targeting and coordinating an effective response. Second, ICT tools (particularly mobile phones) have been used to address the problem of disbursing remittances or aid vouchers to individuals affected by agricultural shocks. Farmers are difficult to reach and lack access to financial institutions, but increasingly they have mobile phones.

The use of ICT applications to assess the nature and extent of risks and improve the coordination and targeting of coping strategies has been particularly noteworthy for disease outbreaks. Rapid assessment and response are critical to controlling disease outbreaks. Only after a farmer has recognized the symptoms and identified the disease can he or she adopt the appropriate control methods.

Mobile technologies are being used to collect information from the field to assess damage or monitor outbreaks. For example, to monitor the threat of bird flu, the Animal Husbandry and Veterinary Services of the Government of

India created an SMS-based reporting service to track animal health. Fieldworkers collected information about the health of animals and reported it to the directorate for analysis via text message (E-Agriculture 2008). MKRISHI helps farmers cope with similar shocks. If an outbreak occurs, farmers can submit photos or describe the outbreak through SMS to receive assistance in identifying the disease or pest and recommendations for managing the outbreak.

The Community-Level Crop Disease Surveillance Project (CLCDS), discussed in an innovative practice summary following this note, takes this activity a step further. Piloted in Uganda by the Grameen Foundation, the project employs community knowledge workers to help identify diseases and advise on control methods.

Another significant challenge in coping with shocks is the need to disburse transfers and remittances rapidly to affected farmers, many of whom have limited access to formal financial services. The advent of mobile money has dramatically eased this constraint, making it faster for farmers to receive remittances from their social networks or receive transfers from governments and relief agencies.

The leader in this space is Safaricom's M-PESA (<http://www.safaricom.co.ke/index.php?id=745>), a money transfer system that allows individuals to deposit, send, and withdraw funds using SMS. M-PESA has grown rapidly, and is currently reaching approximately 38 percent of Kenya's adult population. The M-PESA model has been copied with little modification worldwide (Jack and Suri 2009,6), but it has yet to be applied specifically to agricultural risk. (See IPS "M-PESA's Pioneering Money Transfer Service," in Module 2, for an overview.)

A Zambian company, Mobile Transactions (<http://www.mtzl.net/>), delivers electronic payments, vouchers, and loan disbursements using mobile phones, scratch cards, and a countrywide agent network (see the innovative practice summary following this topic note). The voucher system primarily targets organizations that regularly make transfers to a large number of beneficiaries, such as the World Food Programme.

Another promising approach is the combined application of remote sensing, GIS applications, and crowdsourcing technologies to allow real-time damage assessment. Aside from improving the identification of affected areas, real-time assessments reduce the time lag between the shock and the delivery of assistance. These tools have not yet been used in response to agricultural shocks, but their use in response

IMAGE 10.6. Map of Flood Reports, Pakistan

Source: A screenshot of the Pak Relief homepage.

to catastrophic floods in Pakistan suggests that agricultural applications are worth examining.

Crowdsourcing has become more sophisticated through platforms such as Ushahidi (<http://www.ushahidi.com/>), which have the capacity to aggregate, synthesize, and visualize data on a map. The software allows anyone with access to the Internet or mobile technologies to submit reports of damage or requests for assistance. These reports are verified manually or automatically using computer programs. The data are then synthesized onto a GIS map, which relief and recovery agencies use to target and coordinate their response. Ushahidi is open source software and has been quickly set up following catastrophic events such as the earthquakes in Haiti and Chile and the floods in Pakistan (IRIN 2010) (image 10.6).

LESSONS LEARNED

There is much to learn regarding the robustness or effectiveness of applying ICT to cope with risk. Based on the limited experience to date, early preparation and deployment seem to be the keys to success. Damage assessment tools, electronic voucher systems, or disease response advisory services cannot be deployed quickly after a shock occurs; they must be in place beforehand as a part of a robust disaster response plan.

The combination of trained personnel and information services delivered through various ICT channels might be the most effective way to help farmers cope with disease outbreaks that require a rapid response. The ICT applications serve to reduce the training required, which in turn reduces the administrative costs of such programs. Reducing the required qualifications also expands the supply of people eligible for the job.

Public institutions, governments, and NGOs often play a big role in helping farmers cope with risks. ICT applications can equip these institutions with better tools to manage their social safety net programs. Mobile money and electronic vouchers seem to have matured sufficiently to be replicated in other contexts and incorporated into plans to transfer funds to farmers affected by a drought or flooding. Similarly, information ser-

vices that empower people without formal education in agriculture to serve as agricultural extension workers might also be a replicable approach, provided that the infrastructure and human capacity are present. Their effectiveness, however, should be determined first. Finally, because ICT applications for risk coping are still maturing, their incorporation into a risk coping strategy should ensure that alternative coping mechanisms can be used in the event that the technology fails.

INNOVATIVE PRACTICE SUMMARY

Electronic Vouchers Are a Targeted, Traceable Lifeline for Zambian Farmers

Mobile Transactions (<http://www.mtzl.net/>) is a private Zambian company that began operating in January 2010. Through mobile phones (image 10.7), scratch cards, and a national network of agents, the company provides access to banking services for rural Zambians. It has also designed a voucher system for organizations that regularly make transfers to a large number of beneficiaries, such as food vouchers that help rural people cope with shocks such as droughts and floods.

The vouchers are quickly delivered through the Mobile Transactions system in a targeted, transparent, and traceable

IMAGE 10.7. Transactions Using Mobile Phones

Source: Mobile Transactions Zambia.

way. Between January and August of 2006, the World Food Programme used the system to deliver food subsidies worth US\$500,000 to 32,000 Zambian recipients. FAO used Mobile Transactions to subsidize the purchase of agricultural implements worth US\$600,000 for 6,000 recipients (Hesse 2010).

How the Voucher System Works

Operationally, there are two key aspects to the mobile voucher system: (1) setup and voucher distribution, and (2) voucher redemption. Farmers themselves do not need phones; nor is continuous mobile coverage necessary (McGrath 2010).

Mobile Transactions clients sign a contract and an account is set up for them to deposit the funds they wish to disburse. They are also given access to an Internet-based system that indicates the level of funds disbursed, when, and to whom (WFP 2010).

Vouchers can be redeemed only for subsidized items (food, farm implements, and so forth) at previously authorized retail locations. The participating retailers are given a phone and a Mobile Transactions account and are trained to use the system. Retailers are also familiarized with the paper vouchers. Once the client and retailers are set up, the client deposits funds into the Mobile Transactions account at a regular bank. This money is credited to the client's account within the Mobile Transactions system.

The remaining step is to register beneficiaries, who are identified by their national identification cards and assigned a unique number. The unique reference number on each voucher card can be linked to any registered beneficiary number. This linkage is made using a mobile phone when the beneficiary collects the voucher by presenting his or her national identification card.

Redemption of the voucher requires the following steps: (1) the farmer takes the scratch card to an authorized retail agent; (2) the Mobile Transactions system validates the card against the farmer's beneficiary PIN on the voucher, which is revealed by scratching; and (3) if the system responds with a national identification number that matches the identification

card the farmer presents, the retailer provides the subsidized product. The retailer, in turn, (4) receives an electronic payment into his or her account in the Mobile Transactions system. Finally (5), this transaction becomes visible to the client immediately through the Internet-based system.

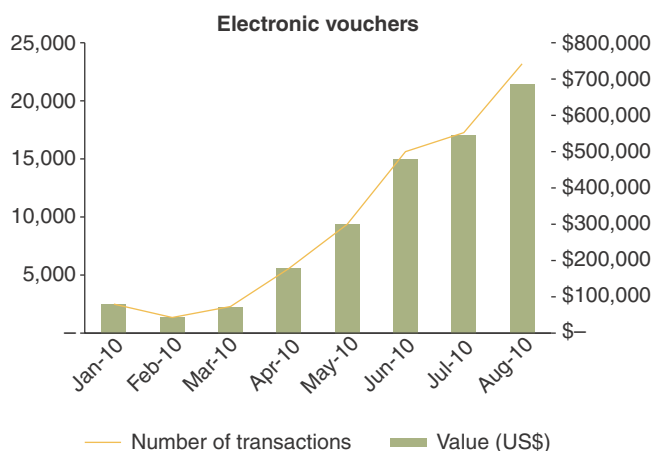
The electronic money service is simpler than paper vouchers. Agents throughout the country who have gone through the setup process are able to accept money from individual payers and transmit the payment to the recipient using the mobile phone and a unique code. The recipient can use that unique code to redeem his or her payment from a nearby agent for cash.

Impact, Scalability, and Sustainability

The World Food Programme has not yet used the Mobile Transactions system to help people cope after a shock. The infrastructure is there, however, in the event that food rations need to be increased to allow farmers to cope with threats to food security. Most such threats in Zambia are agricultural: floods, droughts, and cattle disease (WFP 2010).

No rigorous impact evaluation of this electronic voucher system has been conducted. Though quite different in some respects, the impact of mobile money might be used to approximate the impact of the Mobile Transactions

FIGURE 10.3. Value and Quantity of Electronic Voucher Transactions in Zambia, 2010



Source: McGrath 2010.

system. Studies of Kenya's M-PESA indicate there are significant impacts. Those relevant to risk are: (1) more efficient risk sharing through the expanded geographic reach of social networks; and the (2) facilitation of timely transfers of small amounts of money, which enable support networks to keep shocks manageable (Jack and Suri 2009,11).

Mobile Transactions has grown rapidly over its brief existence, from 2,500 voucher transactions worth US\$60,000 in January 2010 to about 23,000 transactions worth US\$700,000 in August 2010 (figure 10.3). The company is working to replicate the model internationally through partners in Zimbabwe.

Mobile Transactions earns revenue from fees charged, which are approximately 5,000 kwacha (ZMK), or about US\$1.08 per transaction. The company is searching for additional capital to supplement the financing it has already received from venture capital firms and grants. It also hopes to begin transferring payments on behalf of the Government of Zambia.

INNOVATIVE PRACTICE SUMMARY

Community Knowledge Workers in Uganda Link Farmers and Experts to Cope with Risk

Community knowledge workers are also discussed in detail in Module 4, which considers gender implications; as well as in Module 2, which focuses on regulatory

issues. This summary is concerned largely with their role in helping communities cope with risk.

The Community-Level Crop Disease Surveillance Project (CLCDS) provides Ugandan farmers with real-time advice for coping with pest and disease outbreaks. CLCDS was piloted in Bushenyi and Mbale districts between December 2008 and August 2009 as part of the Grameen Foundation's larger Community Knowledge Workers project (<http://www.grameenfoundation.org/section/community-knowledge-worker-project>).

Primary funding for the pilot came from the Bill & Melinda Gates Foundation. Community knowledge workers in the pilot districts used mobile phones equipped with extension information to identify diseases and offer advice about control methods (image 10.8). The workers were also trained to collect disease outbreak data and transmit it to experts. With the data, experts can recommend appropriate responses. If this can be done quickly, individual outbreaks can be contained before they become epidemics (Grameen Foundation 2010a,66).

Development and Growth

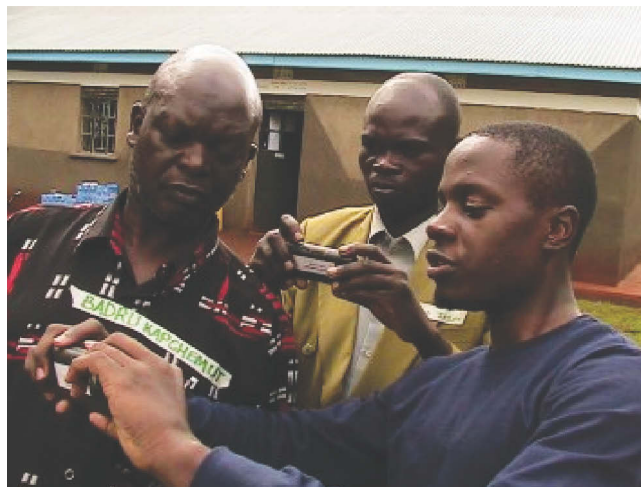
CLCDS responds to the gap between scientific recommendations and on-farm practices in controlling crop diseases. The difficulty of collecting timely data on spreading diseases and the limited effectiveness of on-farm control methods aggravate disease epidemics, which reduce crop yields, quality, and income at the household, community, and national levels (Grameen Foundation 2010a,58). In Uganda, three diseases threaten banana production. Of these, banana bacterial wilt alone is responsible for losses of US\$70–200 million in Uganda (Grameen Foundation 2010a,59).

For CLCDS, Grameen Foundation partnered with the International Institute of Tropical Agriculture (IITA), the National Agricultural Research Organisation (NARO), and MTN-Uganda (a mobile network operator) to develop and test a disease surveillance system. They used several ICT tools to bridge the gap between agricultural experts and farmers: mobile phone applications, a centralized database of disease information, and GIS. The community knowledge workers tie all of these people and pieces together.

To respond comprehensively to farmers' queries, knowledge workers had access to seven information services

IMAGE 10.8. Community Knowledge Workers

Source: Grameen Foundation.



(Gantt and Cantor 2010), several of which offer the kinds of information needed to mitigate or cope with risk. See box 10.5 for details.

Impact, Scalability, and Sustainability

The CLCDS team recruited and trained 38 community knowledge workers, who completed over 6,000 surveys (2,991 related to banana disease) and had more than 14,000

interactions with smallholder farmers (Gantt and Cantor 2010). The initial group of 38 CKWs has now grown to 98 operating in eastern Uganda (Grameen Foundation 2010b).

By the end of the pilot, knowledge workers had trained over 3,000 farmers in the appropriate methods for banana disease identification, preventive measures, and control procedures. The CKWs were estimated to have reached 500–1,000 farm households in their communities (Grameen Foundation

BOX 10.5. Information Services Used by Community Knowledge Workers in Uganda

- **Google SMS Farmer's Friend.** A database of locally relevant, organic tips and advice, plus a three-day and seasonal weather forecast. The knowledge worker searches the database through codes sent via SMS. (See IPS "Farmer's Friend Offers Information on Demand, One Query at a Time," in Module 2.)
- **Google SMS Trader.** A user-generated trading bulletin that provides farmers with the contact details of traders and vice versa through SMS posting and notifications. Developed in partnership with MTN-Uganda and Google.
- **AppLab Question Box.** Community knowledge workers phone this service to speak to an operator with access to an Internet database and expert agricultural advice from NARO. This tool was developed in partnership with the NGO Open Mind and NARO.
- **CKW Search.** A series of forms, presented in Java, guides community knowledge workers through a menu to search for agronomic techniques for banana and coffee production. Content was provided by NARO, the Uganda Coffee Development Authority, and IITA.

(continued)

BOX 10.5. *continued*

- **Input Supplier Directory.** An SMS-based keyword search service gives the location and contact details of shops offering specific agricultural inputs such as seeds, pesticide, and fertilizer. Content was provided by the Uganda National Input Dealer Association.
- **Banana Disease Control Tips.** Preloaded HTML pages show control measures for specific banana diseases. Content was provided by IITA.
- **Market Prices.** An SMS-based keyword search service gives retail and wholesale prices for 46 commodities in 20 markets. Information provided by FIT Uganda, a local market price provider.

The AppLap Question Box and CKW Search draw from a database that the project team has built and continues to expand and refine. This database of actionable agricultural information is populated by agricultural research organizations and other experts and reviewed by an Expert Review Board for further dissemination to farmers through knowledge workers.

Sources: Author; Grameen Foundation 2010b.

2010b). Farmers reported increased revenue and decreased losses upon using the helpline information to treat livestock and plant diseases (Gantt and Cantor 2010).

CLCDS also showed how a mobile survey system could enhance scientists' ability to monitor disease outbreaks in real time and deliver information to farmers in remote areas through the knowledge workers, particularly to areas where extension officers and agricultural researchers do not regularly visit (Grameen Foundation 2010a,66). Once CKWs submitted their survey results, scientists could access and view the data directly from the Web and download the results for analysis. The surveys provided data showing the spatial distribution of banana disease in the communities. The team of scientists viewed thousands of digital photos of disease symptoms, which knowledge workers submitted with their surveys (Gantt and Cantor 2010).

With this information, scientists could map disease incidence. Over time, they began to better understand the spread of diseases, the adoption of control techniques in different areas, and how these and many other factors intersect to impact farmers' livelihoods. This information is used to prioritize actions and communicate recommendations to farmers via the knowledge workers (Grameen Foundation 2010a,67).

Having up-to-date information that included details of the exact locations of a disease, agricultural experts could

develop a plan of preventive measures and allow the rapid dispersal of information that would decrease the spread of the disease. The GIS data could then help scientists to pinpoint sites to collect plant samples of new or suspicious disease reports for subsequent diagnosis in the laboratory (Gantt and Cantor 2010).

Given the pilot's success, CLCDS will be scaled up with additional support from the Bill & Melinda Gates Foundation over four years to provide the service to 200,000 farmers across Uganda (Grameen Foundation 2010a). The bottleneck is the limited number of knowledge workers. Grameen Foundation is training new ones and attempting to partner with existing extension services (Grameen Foundation 2010b). Farmers are not currently charged for the service (they are compensated for participating in surveys, however), and it is not yet clear how the program will continue when external funding ends.

The operational success of the CLCDS to date has depended on the ability to (1) recruit excellent knowledge workers; (2) make information accessible to them through mobile phone applications; (3) train them in disease identification and control; (4) train them in the use of ICT tools for data collection and effective dissemination of information; and (5) maintain partnerships with experts to verify and analyze information to provide actionable advice to support the knowledge workers.

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REFERENCES AND FURTHER READING

- Banerjee, D. 2010. "Mobile-Phone Farming." *Wall Street Journal*, August 24. <http://bit.ly/cB2Ofn>, accessed September 2010.
- Barrett, C. B., E. Aryeetey, A. Quisumbing, A. Ahmed, J. Hoddinott, F. Naschold, J. Vanderpuye-Orgle, and T. Woldehanna. 2007. "Local Risk Management: Protecting Household Asset Building and Farm Productivity from Idiosyncratic Shocks." BASIS Brief, BASIS CRSP, BASIS, Madison. <http://www.basis.wisc.edu/live/amabrief07-03.pdf>, accessed September 2010.
- Birkhaeuser, D., R. Evenson, and G. Feder. 1991. "The Economic Impact of Agricultural Extension: A Review." *Economic Development and Cultural Change* 39: 607–50.
- Bowonder, B., B. R. Raghu Prasad, and A. Kotla. 2005. "ICT Application in a Dairy Industry: The e-Experience of Amul." *International Journal of Services Technology and Management* 6 (3/4/5): 241–65.
- Chantararat, S., A. G. Mude, C. B. Barrett, and C. G. Turvey. 2009. "The Performance of Index-Based Livestock Insurance: Ex Ante Assessment in the Presence of a Poverty Trap." Cornell University. International Livestock Research Institute. <http://www.basis.wisc.edu/i4/barrett.pdf>, accessed September 2010.
- Cole, S., R. Chattopadhyay, S. Hunt, J. Tobacman, and P. Topalova. 2008. "Weather Insurance, Price Information, and Hedging: Helping the Poor Manage Risk." BASIS Brief, BASIS CRSP, BASIS, Madison. <http://www.basis.wisc.edu/live/amabrief08-01.pdf>, accessed September 2010.
- De Silva, H., and D. Ratnadiwakara. 2008. "Using ICT to Reduce Transaction Costs in Agriculture through Better Communication: A Case-Study from Sri Lanka." LIRNEasia. <http://lirneasia.net/wp-content/uploads/2008/11/transactioncosts.pdf>, accessed January 2011.
- E-Agriculture. 2007. "Mobile Phone Network and Pest Warnings in Finland." December 17. http://www.e-agriculture.org/240.html?&tx_ttnews%5btt_news%5d=455&tx_ttnews%5bbackPid%5d=325&no_cache=1, accessed September 2010.
- . 2008. "SMS Helped Check Bird Flu in Orissa." October 15. [http://www.e-agriculture.org/240.html?&tx_ttnews\[tt_news\]=743&tx_ttnews\[backPid\]=204&cHash=1852b8404a](http://www.e-agriculture.org/240.html?&tx_ttnews[tt_news]=743&tx_ttnews[backPid]=204&cHash=1852b8404a), accessed October 2010.
- ECX (Ethiopian Commodity Exchange) Operations. 2010. <http://www.ecx.com.et/Operations.aspx>, accessed September 2010.
- FAO (Food and Agriculture Organization). 2006. "About US." FAO Rural Radio. <http://www.fao.org/sd/ruralradio/en/23589/index.html>, accessed September 2010.
- FAO–AGAL (Food and Agriculture Organization Livestock Sector Analysis). 2005. "Livestock Sector Brief: Kenya." Rome.
- Farm Radio International. 2010. "African Farm Radio Research Initiative (AFRI)." <http://www.farmradio.org/english/partners/afri/>, accessed September 2010.
- Financial Express*. 2009. "TCS' mKRISHI on Pilot Run in Maharashtra." December 22. <http://www.financialexpress.com/news/tcs-mkrishi-on-pilot-run-in-maharashtra/557468/>, accessed July 2011.
- Gantt, W., and E. Cantor. 2010. "Direct Data on Demand: Mobile Apps Deliver a Broad Range of Information to Ugandan Farmers." *ICT Update* 53, January. <http://ictupdate.cta.int/en/Feature-Articles/Direct-data-on-demand>, accessed September 2010.
- Giné, X., R. Townsend, and J. Vickery. 2008. "Patterns of Rainfall Insurance Participation in Rural India." *World Bank Economic Review* 22 (3): 539–66.
- Grameen Foundation. 2010a. "Community Knowledge Worker Pilot Report." <http://www.grameenfoundation.applab.org/ckw/uploads/pdf/Grameen%20Foundation%20Community%20Knowledge%20Worker%20Pilot%20Report%204.24.2010.pdf>, accessed October 2010.
- . 2010b. "Community Knowledge Worker: The Farmer's Oracle." <http://www.grameenfoundation.applab.org/ckw/section/about-ckw>, accessed October 2010.
- Greene, M.R. 2010. "Insurance." *Encyclopædia Britannica Online*. <http://www.britannica.com/EBchecked/topic/289537/insurance>, accessed September 2010.
- Hesse, H. 2010. Interview by Soham Sen, manger of Voucher Unit at Mobile Transactions, October 6.
- IFAD and WFP (International Fund for Agricultural Development and World Food Programme). 2010. *The Potential for Scale and Sustainability in Weather Index Insurance for Agriculture and Rural Livelihoods*. Rome: IFAD.
- ILRI (International Livestock Research Institute). 2009. "Index-Based Livestock Insurance." <http://www.ilri.org/ibli/index.php>, accessed October 2010.
- ILO (International Labour Organisation). 2001. "Information Technology: Bridging the Digital Divide." *World of Work* 38 (January/February). http://www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/documents/publication/dwcoms_080617.pdf, accessed July 2011.
- InterMedia AudienceScapes Surveys. 2010. "InterMedia AudienceScapes: Data Analysis Tool." <http://www.audiencescapes.org>, accessed October 2010.

- International Chamber of Commerce. 2010. "Winners of 2010 World Business and Development Awards." <http://www.iccwbo.org/WBA/id7032/index.html>, accessed October 2010.
- IRIN Integrated Regional Information Network. 2010. "Pakistan Using SMS to Pinpoint Humanitarian Needs." Reuters AlertNet, September 28. <http://mobile.alertnet.org/thenews/newsdesk/IRIN/d9dcececdcbcb4d3440ad5b0d1ba1edc.htm>, accessed October 2010.
- ITC. 2010. "ITC's E-Choupal Movement." ITC Portal. http://www.itcportal.com/ruraldevp_philosophy/echoupal.htm, accessed September 2010.
- Jack, W., and T. Suri. 2009. "Mobile Money: The Economics of M-PESA." Stanford University. <http://hci.stanford.edu/courses/cs379/readings/M-PESA.pdf>, accessed October 2010.
- Jaffee, S., P. Siegel, and C. Andrews. 2010. *Rapid Agricultural Supply Chain Risk Assessment: A Conceptual Framework*. Washington, DC: World Bank.
- KACE (Kenya Agricultural Commodity Exchange Ltd). 2010. "KACE Faqs." <http://www.kacekenya.co.ke/faqs.asp>, accessed September 24, 2010.
- Kilimo Salama. n.d. "Sample Farmer Brochure for Embu." Syngenta Foundation. http://www.syngentafoundation.org/__temp/Sample_farmers_brochure.pdf, accessed October 2010.
- Lukorito, C. 2010. "Kenya Farmers Helpline." KenCall. http://www.kencall.com/news/ICPAC_review.pdf, accessed September 2010.
- Manobi Development Foundation. 2008. "Manobi Fresh Food Trace Solution to Boost European Market Access to Malian Mango Growers." <http://www.manobi.net/foundation/index.php?M=5&SM=1&IDComm=4>, accessed September 2010.
- McGrath, B. 2010. "Mobile Transactions Overview." Presentation at CRS ICT4D Conference, Washington, DC, September 23.
- Mehra, A. 2010. "Small Technologies Fuel Big Results in the Developing World." *Huffington Post*, September 13. http://www.huffingtonpost.com/amit-mehra/small-technologies-fuel-b_b_715274.html, accessed October 2010.
- Mittal, S., S. Gandhi, and G. Tripathi. 2010. "Socio-Economic Impact of Mobile Phones on Indian Agriculture." Indian Council for Research on International Economic Relations (ICRIER), New Delhi.
- Muddy Boots. 2007. "Muddy Boots: Greenlight." <http://www.muddyboots.com/products/gl.aspx>, accessed September 2010.
- Mude, A., C. B. Barrett, M. R. Carter, S. Chantarat, M. Ikegami, and J. McPeak. 2010. "Index-Based Livestock Insurance for Northern Kenya's Arid and Semi-Arid Lands: The Marsabit Pilot." International Livestock Research Institute (ILRI), Nairobi.
- Mukhebi, A., and J. Kundu. 2009. "KACE: Linking Farmers to Markets." UNCTAD. <http://www.unctad.info/upload/SUC/LusakaWorkshop/KenyanCommodityExchanges.pdf>, accessed September 2010.
- Narula, S., and N. Sharma. 2008. "Implementing ICTs in Indian Agribusiness." I4D (Information for Development). <http://www.i4donline.net/articles/current-article.asp?articleid=2162&typ=eagriculture>, accessed October 2010.
- NRI (Natural Resources Institute). 2006. "Warehouse Receipt Systems." <http://www.nri.org/projects/wrs/index.htm>, accessed September 2010.
- Ogodo, O. 2010. "Kenyan Farmers Get Micro-insurance." *Science and Development Network News*, March 22. <http://www.scidev.net/en/news/kenyan-farmers-get-micro-insurance.html>, accessed September 2010.
- Pak Flood Incident Reporting System. 2010. "Pak Flood Incident Reporting System." <http://pakreport.org/ushahidi/>, accessed October 2010.
- Pande, A. 2010. "mKRISHI: Connecting India's Rural Farmers." CSR360 Global Partner Network. <http://www.csr360gpn.org/magazine/feature/mkrishi-connecting-indias-rural-farmers>, accessed September 2010.
- Pande, A., et al. [anon.]. 2009. "mKRISHI: Mobile Based Agro Advisory System." Department of Computer Science and Engineering, IIT Bombay. www.cse.iitb.ac.in/~gise/abstracts/arun_pande.pdf, accessed October 2010.
- Preethi, J. 2009. "Reuters Market Light Goes Pan-India with Nokia." MediaNama. <http://www.medianama.com/2009/04/223-reuters-market-light-goes-to-himachal-pan-india-with-nokia-txt-vs-gprs-vs-voice/>, accessed October 2010.
- Rama Rao, T. P. 2001. "Dairy Information Services Kiosk and Dairy Portal." IIMA Center for Electronic Governance. <http://www.iimahd.ernet.in/egov/documents/disk-and-dairy-portal.pdf>, accessed October 2010.
- Reuters. 2007. "Reuters Launches SMS Crop Service for Indian Farmers." <http://www.reuters.com/article/idUSL0134842920071001>, accessed September 2010.
- Reuters Market Light. 2009. "IDEA Partners with Reuters Market Light to Launch a Unique Service for Rural Markets." Press Release. <http://www.1888pressrelease.com/idea-partners-with-reuters-market-light-to-launch-a-unique-s-pr-148099.html>, accessed October 7, 2010.
- Santana-Boado, L. 2010. "Introduction to Commodity Markets." United Nations Development Programme. http://www.et.undp.org/ecxknowledge/Looking_forward_What_Are_The_Stakes_For_Africa.pdf, accessed September 2010.
- Science Daily*. 2010. "First Micro-Insurance Plan Uses Mobile Phones and Weather Stations to Shield Kenya's Farmers." *Science Daily*, March 4. <http://www.sciencedaily.com/releases/2010/03/100304202242.htm>, accessed September 2010.
- Spence, R., and M. Smith. 2009. "ICTs, Human Development, Growth, and Poverty Reduction: A Background Paper." International Development Research Centre. http://www.idrc.ca/ict4d/ev-139409-201-1-DO_TOPIC.html, accessed September 2010.

- Thompson Reuters. 2007. "RML Now Available in Local Post Offices across Maharashtra." http://thomsonreuters.com/content/press_room/reuters/reuters_pr_3112, accessed October 2010.
- Tollens, E. 2006. "Market Information Systems in Sub-Saharan Africa: Challenges and Opportunities." Poster presentation, International Association of Agricultural Economists Conference, August 12–18, Gold Coast, Australia.
- UNCTAD (United Nations Conference on Trade and Development). 2009. *Development Impacts of Commodity Exchanges*. Geneva: UNCTAD.
- Waruru, M. 2009. "Satellite Insurance to Pay Farmers If Land Turns Brown." Science and Development Network. <http://www.scidev.net/en/news/satellite-insurance-to-pay-farmers-if-land-turns-b.html>, accessed October 2010.
- Wenner, M., and D. Arias. 2003. "Agricultural Insurance in Latin America: Where Are We?" BASIS-CRSP. www.basis.wisc.edu/live/rfc/cs_03b.pdf, accessed September 26, 2010.
- WFP (World Food Programme). 2010. "Zambia: Mobile Delivery and Tracking System." <http://www.wfp.org/countries/Zambia/Media/Mobile-Delivery-and-Tracking-system>, accessed October 2010.
- World Bank. 2005. "Managing Agricultural Risk, Vulnerability, and Disaster." In *Agriculture Investment Sourcebook*. Module 11. Washington, DC: World Bank.
- . 2007. *World Development Report 2008: Agriculture for Development*. Washington, DC: World Bank.

Module 11 GLOBAL MARKETS, GLOBAL CHALLENGES: IMPROVING FOOD SAFETY AND TRACEABILITY WHILE EMPOWERING SMALLHOLDERS THROUGH ICT

TINA GEORGE KARIPPACHERIL (World Bank), LUZ DIAZ RIOS (World Bank), and LARA SRIVASTAVA (Webster University)

IN THIS MODULE

Overview. The market for safe and traceable food can exclude small-scale producers who lack the resources to comply with strict standards. Wider access to information and communication technology (ICT) may lift some of these barriers. The proliferation of mobile devices, advances in communications, and greater affordability of nanotechnology offer potential for small-scale producers to implement traceability systems and connect to global markets. This module examines the effects of food traceability requirements and describes traceability systems implemented in the developing world. For small-scale producers, group systems development and certification may ease some of the constraints in implementing traceability systems, along with capacity strengthening in selecting appropriate technologies for traceability. Networks and partnerships with public, private, or nonprofit organizations can help finance and build traceability systems. Traceability technologies implemented for high-value crops may also expand smallholders' ability to reach key markets.

Topic Note 11.1: The Importance of Standard Setting and Compliance. Traceability is becoming an increasingly common element of public (both regulatory and voluntary) interventions and of private systems for monitoring compliance with quality, environmental, and other standards. Stringent food safety and traceability requirements trigger new transaction costs for small-scale producers without adequate capital investment and public infrastructure. This note provides an overview of the wide and growing array of public and private standards, domestic and international standards, and data standards, with special attention to issues that impinge on developing countries' capacity to comply with them.

- **Mango Traceability System Links Malian Smallholders and Exporters to Global Consumers**

Topic Note 11.2: Traceability Technologies, Solutions, and Applications. Smallholders face serious challenges in complying with standards, particularly with tracking requirements. The mobile wireless and nanotechnology revolution offers the potential to change all that as remote producers and smallholders gain access to ICT. Mobile phones, radio-frequency identification (RFID) systems, wireless sensor networks, and global positioning systems (GPS) are some technologies that enable compliance with food safety and traceability standards. They also make it possible to monitor environmental and location-based variables and communicate them to databases for analysis.

- **ShellCatch in Chile Guarantees Origin of the Catch from Artisanal Fishers and Divers**

OVERVIEW

Food production and distribution systems are becoming more interdependent, integrated, and globalized. At the same time, escalating and heavily publicized outbreaks of foodborne diseases have raised awareness of the need to ensure food quality and safety. This need drives much of the technological innovation to trace food consistently and efficiently from the point of origin to the point of consumption.

Traceability is an increasingly common element of public¹ and private systems for monitoring compliance with quality, environmental, and other product and/or process attributes related to food. Small-scale farmers may lack the resources to comply with increasingly strict food safety standards, particularly traceability requirements. Given the role of

¹ Both regulatory (mandatory) and nonregulatory (voluntary).

traceability in protecting consumers, ensuring food safety, and managing reputational risks and liability, it is vital to integrate and empower small-scale agricultural producers in the food supply chain through ICT.

Defining Traceability

“Traceability” is a concept developed in industrial engineering and was originally seen as a tool to ensure the quality of production and products (Wall 1994). Economic literature from supply-chain management defines traceability as the information system necessary to provide the history of a product or a process from origin to point of final sale (Wilson and Clarke 1998; Jack, Pardoe, and Ritchie 1998; Timon and O'Reilly 1998).

Traceability (or product tracing) systems differentiate products for a number of reasons. Food traceability systems allow supply chain actors and regulatory authorities to identify the source of a food safety or quality problem and initiate procedures to remedy it. While traceability in the food sector has focused increasingly on food safety (Smyth and Phillips 2002), agrifood and nonfood sectors such as forestry and textiles (particularly cotton) have instituted traceability requirements for product identification, differentiation, and historical monitoring. Specific standards for food traceability have been mandated internationally; by law in the European Union (EU), Japan, and more recently the United States; and by private firms and associations.

In the context of agricultural policy, traceability refers to full traceability along the supply chain, with the identification of products and historical monitoring, and not just the separation of products under specific criteria at one or more stages of the chain. The Codex Alimentarius Commission² (CAC 2006) defines traceability as:

the ability to follow the movement of a food through specified stage(s) of production, processing and distribution. . . . The traceability/product tracing tool should be able to identify at any specified stage of the food chain (from production to distribution) from where the food came (one step back) and to where the food went (one step forward), as appropriate to the objectives of the food inspection and certification system.

2 Established in 1963 by the Food and Agriculture Organization of the United Nations and the World Health Organization, the Codex Alimentarius (Latin for “food code” or “food book”) is a collection of internationally recognized standards, codes of practice, guidelines, and recommendations on food, food production, and food safety.

The International Organization for Standardization (ISO) ISO/DIS 22005 (November 20, 2006, N36Rev1) has largely adopted this definition; however, it is a bit broader in scope as traceability is viewed not only as a tool for meeting food safety objectives but also for achieving a number of other objectives in other sectors—for instance, in forestry for chain of custody traceability, sustainable certifications, geographical indicators, or animal health.

The EU General Food Law, Article 18 Regulation (EC) No 178/2002, defines traceability as “the ability to track food, feed, food-producing animal or substance intended to be, or expected to be used for these products at all of the stages of production, processing, and distribution.”³ In comparison to some international and commercial standards for traceability, the EU does not require internal traceability⁴ (that is, it does not require all inputs to match all outputs) (Campden BRI 2009).

For food products that are genetically modified, many countries use identity preservation schemes, but only the EU requires traceability. The EU (Directive 2001/18/EC) additionally defines traceability in relation to genetically modified organisms (GMOs) and products as:

. . . the ability to trace GMOs and products produced from GMOs at all stages of the placing on the market throughout the production and distribution chains facilitating quality control and also the possibility to withdraw products. Importantly, effective traceability provides a “safety net” should any unforeseen adverse effects be established.

As noted in CAC (2006), traceability can also help identify a product at any specified stage of the supply chain: where the food came from (one step back) and where the food went (one step forward). Simply knowing where a food product can be found in the supply chain does not improve food safety, but when traceability systems are combined with safety and quality management systems, they can make associated food safety measures more effective and efficient (CAC 2006).

By providing information on suppliers or customers involved in potential food safety issues, traceability can enable targeted product recalls or withdrawals. Similarly, the implementation of food safety management systems can support

3 “Food Safety,” Europa (official EU website), http://europa.eu/pol/food/index_en.htm, accessed July 2010.

4 See “Objectives of Food Traceability Systems” in the next section for a definition of internal traceability.

efficient, consistent traceability. For example, prerequisite programs such as good agricultural and management practices and the Hazard Analysis and Critical Control Point (HACCP) system include requirements for recordkeeping that can support requirements for traceability. The areas of animal identification, disease prevention and control, nutrient management, production safety, and certification for export all include practices that contribute to the efficacy of traceability systems. In summary, traceability can:

- **Improve the management of hazards** related to food safety and animal health.
- **Guarantee product authenticity** and provide reliable information to customers.
- **Enhance supply-side management** and improve product quality.

The benefits of traceability for consumers, government authorities, and business operators are widely recognized. Yet for small-scale farmers in developing countries, especially farmers producing horticultural and other fresh food products, traceability requirements can represent barriers to trade. The market for safe and traceable food can exclude small-scale agricultural producers who lack the resources to comply with increasingly strict standards, particularly requirements for tracking and monitoring environmental and supply chain variables through sophisticated technologies.

Wider access to ICT may lift some of these barriers. The proliferation of mobile devices, advances in communications, and greater affordability of nanotechnology offer potential for small-scale producers to implement traceability systems and connect to global markets. Mobile phones, radio-frequency identification (RFID) systems, wireless sensor networks, and global positioning systems (GPS) make it possible to monitor environmental and location-based variables, communicate them to databases for analysis, and comply with food safety and traceability standards. In the context of food safety and smallholders' participation in global markets, this module explores incentives for investing in traceability systems and the prospects for traceability to empower small-scale producers in the value chain. It includes detailed information on standards, technical solutions, and innovative practices.

Food Safety: A Challenge of Global Proportions

Foodborne disease outbreaks and incidents—including those arising from natural, accidental, and deliberate contamination of food—have been identified by the World Health Organization (WHO) as major global public health threats of the 21st century (WHO 2007b). WHO estimates that

2.2 million people die from diarrheal diseases largely attributed to contaminated food and water (WHO 2007a). The global burden of foodborne illness caused by bacteria, viruses, parasitic microorganisms, pesticides, contaminants (including toxins), and other food safety problems is unknown but thought to be considerable (Kuchenmüller et al. 2009).

Food safety issues have human, economic, and political costs. These costs are exacerbated by animal husbandry practices that increase the numbers of human pathogens, antibiotic-resistant bacteria, and zoonotic pathogens in meat and dairy products; unsafe agricultural practices involving the use of manure, chemical fertilizer, pesticide, and contaminated water on fresh fruits and vegetables; the progressive influence of time and temperature on globally traded products such as seafood, meat, and fresh produce; the contamination of processed food by bacteria, yeast, mold, viruses, parasites, and mycotoxins; the presence of foreign objects causing injury to the consumer such as glass, metal, stones, insects, and rodents; and the threat of bioterrorism (Safe Food International 2005).

Cases recorded in WHO's epidemiological records, medical journals, and other record systems over several decades demonstrate the extent of the problem (table 11.1). The Centers for Disease Control and Prevention (CDC) estimated that 48 million cases of foodborne illness occur each year in the United States, including 128,000 hospitalizations and 3,000 deaths.⁵ The three primary avenues of contamination are production, processing, and shipping and handling. In light of global food safety concerns, the WHO Global Strategy for Food Safety, endorsed in January 2002 by the WHO Executive Board, outlined a preventive approach to food safety, with increased surveillance and more rapid response to foodborne outbreaks and contamination incidents (WHO 2002). This approach substantially expands the ability to protect food supplies from natural and accidental threats and provides a framework for addressing terrorist threats to food (WHO 2008).

Components of Food Traceability Systems

Not only foodborne illnesses but also globalization, consumer demand, and terrorism threats have impelled the diffusion and growth of traceability systems in supply chains for food and agriculture. Food is a complex product (Golan, Krissof, and Kuchler 2004), and modern food production,

5 "Estimates of Foodborne Illness in the United States," CDC, <http://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html>, accessed February 2011.

TABLE 11.1. Examples of Food Safety Outbreaks, 1971–2008

YEAR	CASE
2008	• 294,000 children affected by adulterated formula tainted with melamine. More than 50,000 were hospitalized and 6 died. (China) ^a
2004–05	• Aflatoxin contamination of maize caused more than 150 deaths. (Kenya)
2001	• Cases of variant Creutzfeldt-Jakob disease (vCJD), which is caused by the same agent as bovine spongiform encephalopathy (BSE), stood at 117 world-wide. A number of animal studies suggest a theoretical vCJD risk from human blood donors in countries associated with the use of BSE-contaminated meat and bone meal and recycling of animals into the animal feed chain. ^b The BSE (“mad cow”) outbreak was highly publicized by the media. It remains etched in consumer consciousness as an example of an acute breakdown in food safety and quality in the developed world. • <i>E. coli</i> O157:H7, various animal foods, 20,000 cases, 177 deaths in Jiangsu and Anhui provinces. (China)
2000s	• Contaminated olive oil. (Spain) • <i>Staphylococcus</i> in milk. (Japan) • <i>E. coli</i> in spinach, carrot juice. (United States) • <i>Listeria</i> in ready-to-eat meat. (Canada) • <i>Salmonella</i> in peanut butter. (United States)
2000	• WHO noted the presence of antimicrobial-resistant <i>Salmonella</i> bacteria in food animals in Europe, Asia, and North America, which have caused diarrhea, sepsis, and death in humans, as well as <i>Enterococci</i> infections, which present severe treatment problems in immunocompromised patients. ^c
1990s	• <i>E. coli</i> in hamburgers. (United States) • BSE. (UK) • <i>Cyclospora</i> in raspberries. (United States/Canada) • Avian influenza. (Southeast Asia) • Dioxin in animal feed. (Belgium)
1999	• <i>Salmonella typhimurium</i> , more than 1,000 cases, meat products, Ningxia. (China)
1998	• Statistics from the Ministry of Health showed a marked increase in food poisoning attributed to <i>Vibrio parahaemolyticus</i> , from 292 incidents (5,241 cases) in 1996 to 850 incidents (12,346 cases) in 1998. One large outbreak of 691 cases was caused by boiled crabs in 1996; another involved 1,167 cases traced to catered meals in 1998 (Japan). Outbreaks were also documented in Bangladesh, India, Thailand, and the United States. ^d
1980s	• Beef hormones. (EU) • <i>Salmonella</i> in eggs and chicken. (UK) • Alar in apples. (United States) • Hepatitis A in raw oysters, 300,000 cases, Shanghai. (China)
1971–82	• Safe Food International, a global consumer organization, cited cases of foodborne illness arising from accidental or intentional adulteration: “During the winter of 1971–1972, wheat seeds intended for crop planting and treated with methylmercury were accidentally distributed in rural areas of Iraq. An estimated 50,000 people were exposed to the contaminated bread, of which 6,530 were hospitalized and 459 died. In Spain in 1981–1982, contaminated rapeseed oil killed more than 2,000 people and caused disabling injuries to another 20,000 many permanently.” ^e

Sources: Compiled by Tina George Karippacheril and Luz Diaz Rios; data on specific cases from (a) Ingelfinger 2008, (b) WHO 2001, (c) WHO 2000, (d) WHO 1999, and (e) Safe Food International (2005).

processing, and distribution systems may integrate and commingle food from multiple sources, farms, regions, and countries (Cannavan n.d.). Food products covered by traceability standards include fresh produce such as mangoes, avocados, and asparagus; bulk foods such as milk, soybeans, specialty coffee, and olive oil; fish and seafood; and livestock for meat and dairy. This module also touches on the role of ICT in animal identification, a prerequisite for implementing livestock traceability in the meat and dairy sectors.

Food products may be differentiated through systems of (1) identity-preserved production and marketing (IPPM), (2) segregation, and (3) traceability. IPPM systems are important for providing information to consumers about the provenance of a product when the attributes may not be visible or

detectable in the product. They are also useful for capturing product premiums. Segregation systems are used to prevent the mixing of novel varieties in the handling of like varieties or to discourage the mixing of a segregated product with like products if potential food safety concerns exist. Traceability systems, on the other hand, allow sources of contamination in the supply chain to be identified (Smyth and Phillips 2002), which enables a transparent chain of custody, raises credibility, and makes it possible to transfer information on the steps taken to alleviate food safety concerns (McKean 2001). Unsafe food can be recalled because information on all possible sources and supplies of contaminated food can be traced one step forward, one step back, or end to end.

Traceability systems can be classified according their capacity for (1) internal traceability and (2) chain traceability.

“Internal traceability” refers to data recorded within an organization or geographic location, whereas “chain traceability” involves recording and transferring data through a supply chain between various organizations and locations involved in the provenance of food. Food contamination may occur at the farm, during processing or distribution, in transit, at retail or food service establishments, or at home. Fundamentally, traceability systems involve the unique identification of food products and the documentation of their transformation through the chain of custody to facilitate supply chain tracking, management, and detection of possible sources of failure in food safety or quality.

The smallest traceable unit will vary by food product and industry. Some of the data elements may include the physical location that last handled the product, as well as the type of supply chain partner (producer, processor, or broker, for example); incoming lot numbers of product received; amount of product produced or shipped; physical location where cases were shipped; lot number of the product shipped to each location; date/time when the product was received or shipped; date/time each lot was produced or harvested; ingredients used in the production of the product, along with corresponding lot numbers; and immediate source of ingredients and when they were received.

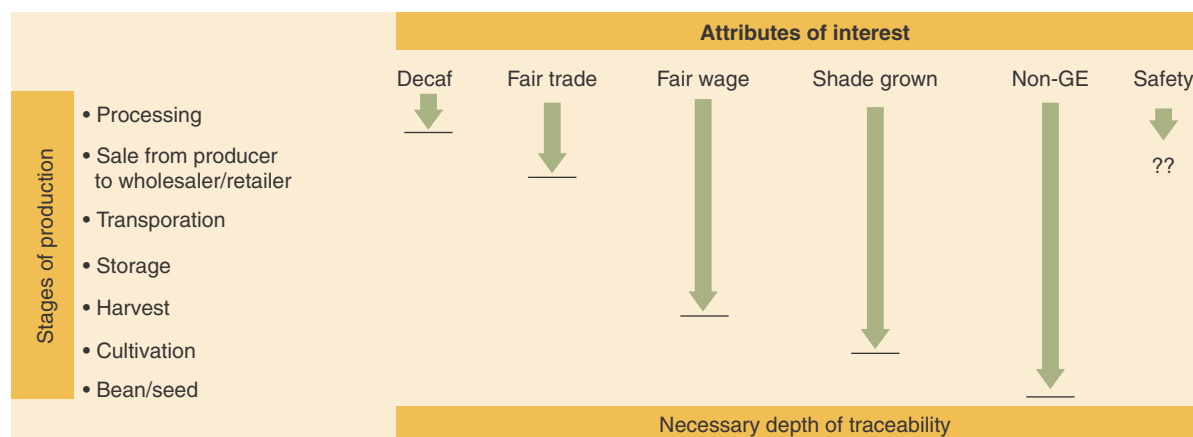
Good practices in traceability entail making the lot number and name of the production facility visible on each case of product and recording the lot number, quantity, and shipping location on invoices and bills of lading. Traceability requires each facility to record data when a product is moved between premises, transformed/further processed, or when data capture is necessary to trace the product. Such instances are

called critical tracking events. Data captured in critical tracking events are vital to linking products, both simple and complex, within a facility and across the supply chain (IFT 2009).

Traceability data can be static or dynamic, mandatory or optional. Static data do not change, whereas dynamic data can change over time and through the chain of custody (Folinas, Manikas, and Manos 2006). “Trace back” implies that a system can identify production/processing steps that resulted in the creation of the product. “Trace forward” implies that a system can identify all derivatives of the product used as an ingredient in numerous other products. Food traceability systems and definitions in standards, laws, and regulations are broadly conceptualized to permit producers to determine the breadth, depth, and precision of systems based on specific objectives (Golan et al. 2004). (For definitions and standards, see Topic Note 11.1.) “Breadth” denotes the amount of information a traceability system captures, “depth” refers to how far backward or forward the system tracks an item, and “precision” shows the degree to which the system can pinpoint food characteristics and movement. Figure 11.1 illustrates these concepts for the attributes of interest in the stages of coffee production.

Traceability data are recorded through media including but not limited to pen/paper, barcodes, RFIDs, wireless sensor networks, mobile devices and applications, enterprise resource planning (ERP) applications, and Internet-based applications. Information related to product tracing may be recorded and transmitted through management information systems or, in the case of smaller operations, paperwork such as invoices, purchase orders, and bills of lading. Traceability data may also

FIGURE 11.1. Coffee: Attributes of Interest and Depth of Traceability



Source: Golan et al. 2004.

Note: GE = genetically engineered.

be captured directly from products such as fresh produce, seafood, and livestock. Products may be tagged with barcodes or RFIDs, which store product and associated data. Wireless sensors may transmit data on temperature, spoilage, or location to RFIDs tagged to products. Topic Note 11.2 provides detailed information on traceability technologies and systems.

Implementing Food Traceability Systems in Developing Countries

Nearly 500 million people reside on small farms in developing countries (Hazell et al. 2006). Their participation in markets typically is constrained by inadequate farm-level resources, farm-to-market logistical bottlenecks, and more general transaction costs in matching and aggregating dispersed supplies to meet buyer and consumer demand. These “traditional” constraints have been amplified and in some cases surpassed by “new” challenges related to complying with product and process standards, including strict traceability requirements, set and enforced by governments and private supply chain leaders (Jaffee, Henson, and Diaz Rios, forthcoming).

The implementation of traceability systems and assurance standards is controversial (Schulze et al. 2008), but it can be especially so in the context of small-scale producers. Weinberger and Lumpkin (2009) have expressed concern that traceability requirements and sanitary and phytosanitary issues will increasingly constrict exports of food products from developing countries, where poor regulation of chemical use, pollutants, and a steep learning curve in traceability capacity restrict growers’ and processors’ participation.

Many developing countries lag in developing and implementing food safety and traceability standards, but some have selectively met demands in high-income export markets thanks to regulatory, technical, and administrative investments. From 1997 to 2003, more than half of the List 1 countries recognized by the EU as having equivalent standards of hygiene in the capture, processing, transportation, and storage of fish and fish products were low- or middle-income countries.

Jaffee and Henson (2004b) suggest that some countries use improved food quality and safety standards as a catalyst to reposition themselves in the global market; the key for developing countries is to “exploit their strengths and overcome their weaknesses such that they are overall gainers rather than losers in the emerging commercial and regulatory context.” As an example, the value of Kenya’s fresh vegetable exports increased from US\$23 million to US\$140 million between 1991 and 2003 after stricter food safety and quality

standards led producers to reorient their operations (Jaffee and Henson 2004b).

Any application of product traceability systems must take into account the specific capabilities of developing countries. If an importing country has objectives or outcomes of its food inspection and certification system that cannot be met by an exporting country, the importing country should consider providing assistance to the exporting country, especially if it is a developing country. Assistance may include longer time frames for implementation, flexibility of design, and technical assistance (CAC 2006). In recent years, a variety of traceability systems have been implemented in the developing world, including systems for fresh fruit, vegetables, grain, oilseeds, bulk foods, seafood, fish, and livestock (table 11.2). Aside from the examples in the table, the Republic of Korea has implemented systems for agricultural product tracing, and Jordan has established a framework for product tracing and uses a national digital database to track and investigate product and disease movement (Hashemite Kingdom of Jordan 2004).

TABLE 11.2. Traceability Systems Adopted in Developing Countries

CATEGORY	TRACEABILITY SYSTEM	COUNTRY
Fresh produce		
	Mangoes	Mali
	Avocados	Chile
Bulk foods		
	Specialty coffee	Colombia
	Green soybeans	Thailand
	Olive oil	Morocco
	Olive oil	Palestine
Seafood		
	Seafood	Chile
	Seafood	Vietnam
	Shrimp	Thailand
Livestock		
	Dairy	India
	Meat	Botswana
	Meat	China
	Meat	Korea, Rep.
	Meat	Malaysia
	Meat	Namibia
	Meat	South Africa

Source: Tina George Karippacheril.

Note: These examples from the agrifood sector include but are not limited to issues of food safety.

Support for traceability projects designed to connect small-scale producers to global markets comes from a variety of sources: (1) nonprofit organizations and development agencies (such as IICD for Fresh Food Trace in Mali and IFC for olive oil tracking in Palestine); (2) governments (Botswana and Korea for livestock tracking; Thailand and Vietnam for seafood); and (3) the private sector (ShellCatch for seafood tracking in Chile). The sections that follow provide examples of how food traceability systems have been implemented, particularly in low-income economies.

In addition to support systems for developing countries, mobile technology provides new opportunities for smallholders to connect with export markets. Mobile technologies have not only alleviated asymmetries in the flow of information from the market to smallholders (Muto and Yamano 2009), but also hold great potential for enabling the counterflow of information from small-scale producers to markets to meet traceability requirements (figure 11.2). For example, farmers may use a mobile device to input information on the variety grown, planting and harvest dates, and use of farming inputs. Data captured by smallholders can be integrated with information systems and centralized databases to provide greater transparency to supply chain partners and consumers on the farming process, inputs, and output. The integration of wireless sensor networks, RFIDs, and mobile technology could yield sophisticated means to capture data during farming and minimize the need for manual data input through mobile devices.

By fostering more linkages, socialization, and networks between small-scale producers, the diffusion of mobile technology can address issues of geographic dispersion

and linkages to traders, other farmers, or market groups for quality assurance, marketing, and sales. Empowering Smallholder Farmers in Markets,⁶ a research project, found that international trader-led linkages can empower smallholders to supply high-quality, traceable produce and gain from quality-linked awards funded by the trader. For example, Italian coffee roaster Illycaffè increased its procurement of superior Brazilian green coffee from smallholders by investing significantly in quality assurance training and market information for smallholders. The company has won competitions and awards for best growers and for commanding above-market prices for the product (Onumah et al. 2007).

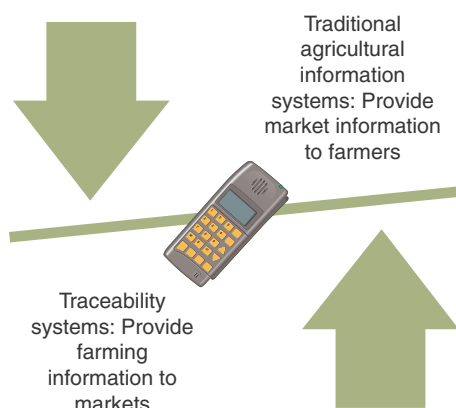
Fresh Produce Traceability for Quality Control

Fresh produce must move quickly through the supply chain to avoid spoilage. After harvest, fresh produce is handled and packed by a shipper or by a grower-shipper and exported or sold directly or through wholesalers and brokers to consumers, retailers, and food service establishments. Traceability systems track fresh produce along the supply chain to identify sources of contamination, monitor cold chain logistics, and enhance quality assurance.

A good example is the use of RFID technology by an avocado producer in Rio Blanco, Chile, for temperature and cold chain monitoring. RFID tags called “paltags” (*palta* is the Chilean word for “avocado”) are attached to the fruit on the tree, and after harvest, the fruit and tags are sorted, washed, waxed, and transported on pallets. The pallets are tagged to monitor temperature during transport, and should the temperature rise above standard levels, the pallets are put back into cold storage by quality inspectors at the harbor. Once the pallets arrive at the port in California, the temperature is read by handheld readers to ascertain whether the temperature has risen above acceptable levels, thus checking quality and safety before shipping the avocados to marketers (Swedborg 2010; “Awards Honor RFID Innovators,” *RFID Update*, 2007).

Fresh produce exporters may also be offered centralized cooling and shipping services. The Fresh Produce Terminal in South Africa tracks fruit into the warehouse and onto shipping vessels, deploying 250 vehicle-mounted computers and 100 mobile computers from Symbol Technologies (Parikh, Patel, and Schwartzman 2009).

FIGURE 11.2. Mobile Technology as a Key Enabler of Information Counterflow from Farmers to Markets



Source: Tina George Karippacheril.

6 This research project is implemented through the International Federation of Agricultural Producers, European Consortium for Agricultural Research, and International Fund for Agricultural Development (IFAD).

Bulk Produce Traceability for Product Authenticity

Bulk produce is more challenging to trace than fresh produce. Products such as grain, coffee, olive oil, rice, and milk from multiple farms are combined in silos and storage tanks, making it difficult to trace them back to their sources (IFT 2009).

Yet traceability systems for bulk products have been implemented in developing countries, even among smallholders. For example, the National Federation of Coffee Growers in Colombia, a nonprofit organization for 500,000 small farmers, identifies and markets high-quality Colombian coffee from unique regions or with exceptional characteristics ("Finalists Unveiled for the Fourth Annual RFID Journal Awards," *RFID Journal*, 2010). The federation commands a 200 percent premium transferred entirely to its growers. Its subsidiary, Almacafe—which handles warehousing, quality control, and logistics—implemented a traceability system using RFID tags in 2007 for specialty coffee for its internal supply chain, from farms to warehouses and during processing, bagging, roasting, and trading for export. Although barcodes were considered first, RFID tags were eventually used because barcodes require line of sight and clear labels to be read, which might have been a problem, considering that coffee sacks weigh more than 40 kilograms and tend to be thrown around.

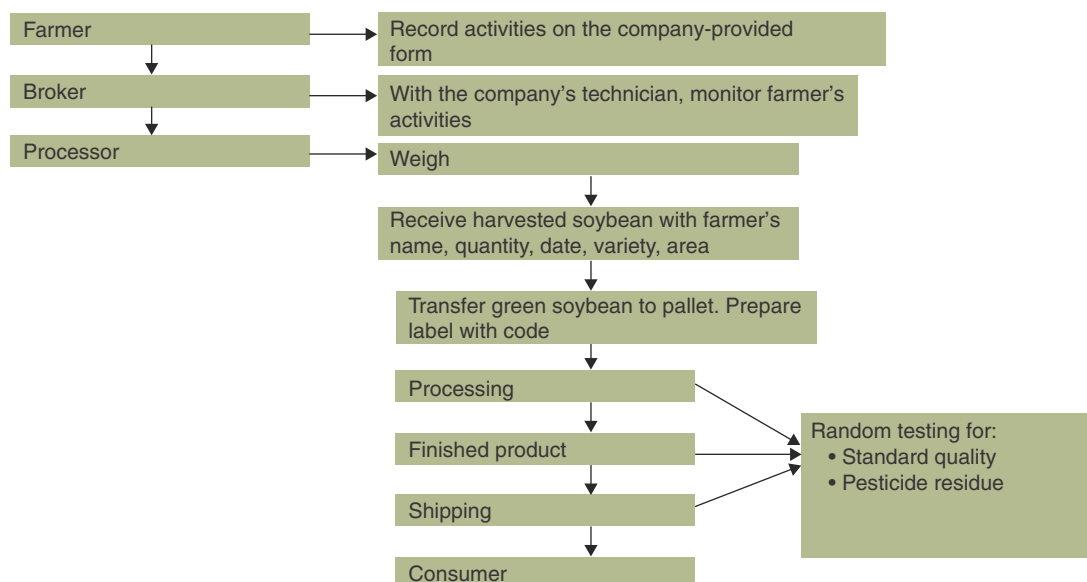
The RFID tags each cost about US\$0.25 (paid by the federation), are encased in a wear-resistant capsule, and are

distributed to farmers with a farm identification number and a specialty coffee program code. The coffee is sold to one of 35 cooperatives and transported to one of 15 warehouses, where tags are read by two RFID antennas on either side of a conveyor belt with 99.9 percent accuracy for data and delivery time. Tags are read at each step of the process, and if the coffee does not meet quality standards, it is rejected and the database is updated. In 2008, the federation extended its program with a pilot to help adapt its traceability model to the Tanzanian coffee supply chain.

Consumers may demand systems to trace fertilizer and pesticide in bulk products. In Thailand, for example, exporters require farmers to provide product information regarding the farm, crop varieties, planting, irrigation, fertilizer application, insect or disease emergence, pesticides or chemicals used, harvest date, costs incurred, problems, and selling price (Manarungsan, Naewbanij, and Rerngjakrabhet 2005). Figure 11.3 shows traceability activities carried out along the supply chain for green soybeans, from farmer to broker to processor.

Traceability systems for bulk goods are also implemented for chain of custody monitoring and quality assurance based on consumer demand. Olive oil, a high-value food, is sometimes blended and sold by distributors and marketers, and traceability helps identify the source, method, variety, and farm where the crop was harvested, so it becomes easier for consumers to determine if the olive oil they are buying

FIGURE 11.3. Soybean Traceability System in Thailand



Source: Manarungsan, Naewbanij, and Rerngjakrabhet 2005.

is genuine. In North Africa, a combination of GPS, mobile devices, electronic security bolts, and sensors are used for end-to-end, real-time monitoring of perishable olive oil shipments from Spain and Morocco by Transmed Foods, Inc., the United States distribution arm of Crespo Foods, and Savi Technologies (Savi Technology 2009). In another example, an IFC project to improve the competitiveness and export prospects for West Bank olive oil assists small and medium-sized enterprises in implementing a basic traceability program to maintain quality, including managing data related to the sources of oil, pressing, handling, storage, and packing operations.

Seafood Traceability for Safety and Sustainability

Seafood traceability enhances the value of suppliers' brands and consumers' confidence in those brands. For traceability, monitoring, and control, data about the farm of origin, processing plant, current location, and temperature are collected and made available to participants in the supply chain, including wholesalers, shippers, and retailers. If a problem arises, this information enables a targeted market recall and limits the impact on consumers. Seafood traceability is implemented to comply with the EU's zero tolerance of residues of banned antibiotics (chloramphenicol and nitrofurans). Thailand, one of the world's largest shrimp exporters, saw exports drop steeply to US\$1.72 billion in 2002 from average annual revenue of US\$2.3 billion between 1998 and 2001 (Manarungsan, Naewbanij, and Rerngjakrabhet 2005). The decline caused the Thai private and public sectors to tighten sanitary measures on chemical antibiotic residues in shrimp and adopt probiotic farming techniques, disease-resistant shrimp, and laboratory diagnostics and testing. Farmers and cooperatives must register to facilitate traceability, and quality management systems have been implemented to isolate quality and safety issues along the value chain. The Department of Fisheries has been working with farmers to introduce GAP (Good Agricultural Practice), a code of conduct for sustainable shrimp aquaculture, and HACCP standards and to improve product documentation and traceability.

The department requires farmers to fill out a "shrimp catching form," which includes the catch date, total shrimp weight, name of the farmer, and ID number. Some central markets also require suppliers and buyers to complete this form to enhance traceability. Registering for traceability gives cooperative members access to laboratory test services, training, and information and experience sharing through networking. They also receive funding of US\$1,160 and kits to perform their own diagnostic tests. Marine Stewardship

Council certification⁷ requires shrimp farmers to notify the Department of Fisheries five days before harvesting, to facilitate tracing shrimp back to their origin (Manarungsan, Naewbanij, and Rerngjakrabhet 2005).

The Vietnamese State Agency for Technological Innovation has collaborated with the Vietnamese Association of Seafood Exporters and Producers and private firms (IBM and FXA Group) to implement a seafood traceability system. The system is based on RFID technology ("Vietnamese Agency Seeks Seafood Traceability," *RFID News*, 2009).

Livestock Traceability for Disease Control and Product Safety

Unlike other food industries, the livestock industry has a long history of implementing animal identification and traceability systems to control disease and ensure the safety of meat and dairy products. Lessons from livestock traceability systems may apply to other areas of food safety.

Namibia was an early adopter of such systems in 2004. Botswana maintains one of the world's largest livestock identification systems and had tagged 3 million cattle by 2008. Botswana's livestock identification and trace-back system uses RFID technology to uniquely identify livestock throughout the country. The system enables access to lucrative markets in the European Union, where traceability is a requirement for beef from birth to slaughter. A bolus inserted into the animal's rumen contains a passive RFID (it has no battery or moving parts) microchip with a very hard ceramic coating, which does not interact with stomach enzymes or acids. Fixed readers placed at 300 locations scan the bolus of every animal in the herd to obtain identification numbers, information on new registrations, and the status of disease treatments in the herd. The information is relayed to a central database and on to 46 district offices. Aside from traceability, the tagging system enables weight and feed to be monitored, yield to be managed, breeding history to be tracked, and animals to be selected for breeding (Burger 2003).

Animal identification and traceability systems have numerous applications, such as tracking animal movement, monitoring health, controlling disease, and managing nutrition and yield. RFID tagging systems for livestock contain unique identification data and information on the animal's location, sex, name of breeder, origin of livestock, and dates of movement. Handheld readers are used to register vaccination information and dates; the data are relayed to a central database.

7 The Marine Stewardship Council develops standards for sustainable fishing and seafood traceability.

The Malaysian Ministry of Agriculture’s Veterinary Department has introduced a government-run system to control disease outbreaks among 80,000 cattle. The system was implemented to increase the competitiveness of Malaysia’s livestock industry by meeting international import standards and domestic halal market standards (“Malaysia Begins RFID-Enabled Livestock Tracking Program,” *RFID News*, 2009). China has a pilot RFID program for 1,000 pigs in Sichuan Chunyung to track epidemics and enable traceability from birth to slaughter for consumers (“China Fixes RFID Tags on Pigs to Track Epidemics,” *ICT Update*, 2003). In South Africa, the Klein Karoo Cooperative tagged 100,000 ostriches to comply with traceability requirements for meat exports to the EU (“Project Klein Karoo Cooperative in South Africa,” *ICT Update*, 2003).

Korea was another early adopter of animal identification techniques and technologies, using general ear tags from 1978 to 1994, barcodes in 1995, and RFID since 2004. Korea introduced a full beef traceability system in 2008, in the wake of the BSE scare, to promptly identify food safety problems and ensure end-to-end traceability. Korea also uses DNA markers to trace components of carcasses. Markers recommended by the International Society for Animal Genetics are used for verification (Bowling et al. 2008).

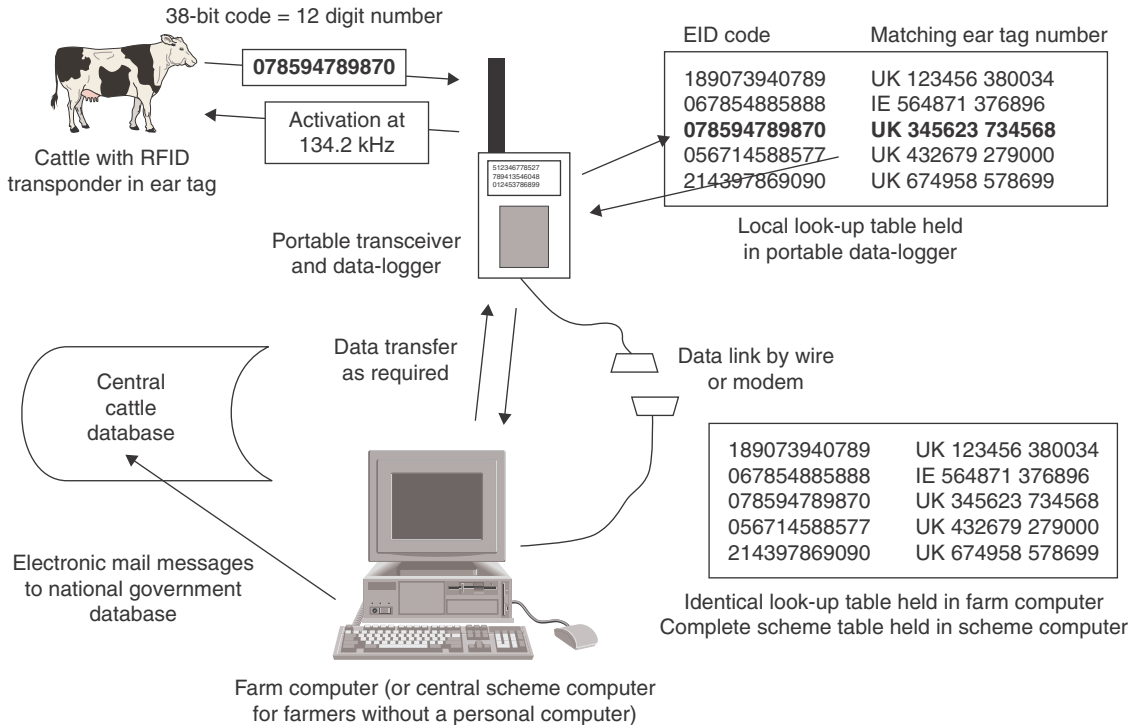
Figure 11.4 illustrates the 2001 Scottish Borders full traceability system for cattle. The system uses RFID ear tags for unique identification and a portable transceiver and data logger that transfers data to a farm computer or a central computer for farmers who do not have a personal computer.

In dairy farming, RFID technology enables unique identification and monitoring of cattle, their feeding habits, health issues, and breeding history to improve yield management. The technology is integrated with feeding machines to determine the correct amount of nutrition for individual animals. The RFID chip sends data about the animal’s feeding habits, dietary needs, and other information to a sensor on the farm. The data are stored in central databases and analyzed by farm managers and supervisors to monitor the animals’ health and nutritional mix.

India has introduced cattle tagging for dairy farming in the states of Tamil Nadu and Maharashtra. The BG Chitale Dairy in Maharashtra has tagged 7,000 cows and buffalo and plans to extend tagging to about 50,000 animals (“Milk Tastes Better with RFID,” *RFID News*, 2010). (See IPS “RFID Facilitates Insurance Credit for India’s Livestock Producers,” in Module 7.)

Traceability systems may be implemented to improve the global competitiveness of livestock and meat exports, the

FIGURE 11.4. Scottish BordersTAG Cattle Tracing System



Source: From Pettitt 2001, *World Organisation for Animal Health (OIE) Scientific and Technical Review*.
Note: EID = electronic identification; RFID = radio-frequency identification.

quality of meat, and the chain of custody traceability. Beef is placed in refrigerated trucks and containers and sealed with a sensor bolt and a tag for identification. Shipments are tracked to ensure that they do not remain in one place for too long. At key points in the supply chain, such as when the beef is unloaded after it has been shipped from the port, the tag is read with a mobile reader to check for evidence of tampering prior to unloading, and tag data are stored in supply chain databases.

Namibia, which started tracking beef in 2004, was one of the earliest emerging market adopters of advanced technologies to ensure quality and traceability (Collins 2004). A pilot program executed through a public-private partnership with Savi Technology involved the application of RFIDs and sensor bolts to containers of chilled and frozen beef shipped from Namibia to the UK as part of the Smart and Secure Tradelanes initiative extended to African ports. In March 2009, Namibia issued new animal identification regulations, which required livestock producers to identify cattle with one visual ear tag and one RFID ear tag. Cattle must be individually registered in the Namibian Livestock Identification and Traceability System. Namibia has also set up a veterinary fence to avoid contamination: Cattle from northern Namibia cannot be exported and must be consumed locally, and cattle from southern Namibia are protected from diseases and exported to Europe. Namibia also sources non-genetically modified (GM) maize from South Africa at a premium to ensure that beef sold in Europe is considered non-GM.

Basic technologies for animal identification and traceability have applications other than food safety and food security. Cattle rustling threatens human security in East Africa, a region characterized by nomadic movements of people with livestock over vast and hostile terrain. The Mifugo Project (*mifugo* is Swahili for “livestock”)—ratified by Ethiopia, Kenya, Sudan, Tanzania, and Uganda—seeks to prevent, combat, and eradicate cattle rustling in East Africa (Siror et al. 2009). Traditional methods of identifying cattle are harmonized with technologically advanced approaches for unique identification, tracking, and recovery of stolen animals. Livestock tags may be queried remotely using the Internet, SMS, and wireless communication through mobile phones to track and monitor animals.

KEY CHALLENGES AND ENABLERS

Implementing traceability technologies for food safety and other purposes does not come without its challenges. Broadly speaking, the main challenges lie in data collection, processes, technological solutions, business models, costs, and learning. Some of these challenges are discussed in more depth in the topic notes.

In traditional societies, traceability is inherent, because production and consumption occur in the same place, but complying with modern traceability requirements for faraway global markets poses a challenge for small-scale producers with few resources. For example, complying with recordkeeping arrangements associated with food safety assurance through HACCP-based systems, with their detailed traceability systems, requires widespread education and cooperation throughout the supply chain (Unnevehr and Jensen 1999). To understand traceability applications for fresh produce and horticultural products, bulk produce, seafood, and livestock, small-scale producers will need to master a considerable range of skills and information.

Although traceability capacity might have some positive effects on domestic markets in developing countries, by and large traceability systems are unidirectional—they track the chain of custody of food exported from developing countries to developed countries. Developing-country farmers who are unable to meet traceability requirements run the risk of being marginalized. Jaffee and Masakure (2005) found that produce export markets in Kenya relied on the exporters’ own farms for products that required traceability; products demanding less traceability came from small-scale outgrowers.

Some evidence indicates that the global movement toward stricter food safety and traceability requirements has translated into stricter demands in domestic markets in developing countries. For example, the rise of supermarkets in Latin America, with their quality and safety procurement standards and associated recordkeeping requirements, had a negative impact on smallholder participation, although some cases of success were noted where there was public or private technical assistance (Reardon and Berdegue 2002).

The costs associated with implementing traceability systems include investments in capital and infrastructure, recordkeeping, and improvements in harvesting and processing. Unlike small-scale producers, large-scale producers and industry associations are better equipped to upgrade their operations in compliance with traceability standards; the added cost of recordkeeping is small compared with the potential financial damages of a product recall (Spencer 2010). The questions that remain, then, are who pays for the cost of implementing food traceability systems, particularly in the case of smallholders, and how sustainable those systems can be in the long run.

With respect to business processes, an important challenge involves the poor integration of organizations in the value chain. Proprietary tracking systems allow tracing one step forward or back, but they rarely allow traceability through the full life cycle of a product. Organizations in a value chain may

be reluctant to share proprietary commercial data about a product, with the exception of requirements for recalls.

Studies from the industrial sector, where traceability systems and techniques originated, emphasize that the main difficulties lie in the design of an internal traceability system for a given, complex production process (Moe 1998; Wall 1994). A study of traceability in the United States, undertaken by the International Institute of Food Technologies (IFT), found that challenges are related to both external and internal traceability. External traceability requires accurate recording and storage of information on products and ingredients coming into a facility and information on products leaving a facility. This requirement frequently proves problematic, because industry partners in a food supply chain may not consistently record and store the lot number of the incoming product or case. For internal traceability, data on ingredients and products that may undergo transformation within a facility must be tracked. In some cases, there may be confusion in the assignment of new lot numbers for products that do not match the incoming lot number for products that enter a facility and undergo transformation. Industry practices on data capture, recording, storage, and sharing also vary widely. Paperwork is often inconsistent or incomplete, individual products or lots may not be labeled with unique identifiers, and standardized definitions for data elements may be lacking (IFT 2009).

For small-scale producers, group systems development and certification may ease some of the constraints in implementing traceability systems. The GlobalGAP standard (www.globalgap.org), for example, allows group certification for smallholders to facilitate their access to markets. Small-scale farmers and producers may also benefit from capacity strengthening in assessing and selecting appropriate technologies for traceability; building networks and partnerships with public, private, or nonprofit organizations that can help finance and build traceability systems; and traceability schemes facilitated through smallholder cooperatives or the public or private sector. Finally, traceability technologies implemented specifically for high-value crops may also expand smallholders' ability to reach key markets.

Golan, Krisoff, and Kuchler (2004) have argued that mandatory traceability requirements that allow for variations in traceability or target specific traceability gaps may be more efficient than systemwide requirements. They may be better suited to varying levels of breadth, depth, and precision of traceability in different firms. Developed countries' experiences with traceability may in some cases be useful for building similar capacity in other countries. Japanese farms, unlike those

in most developed countries, are small but advanced with respect to traceability, a situation that could lend itself well to sharing experiences with small-scale farmers in developing countries (Setboonsarng, Sakai, and Vancura 2009). It could provide insights into the most effective ways to implement traceability systems and the internal and external capacities and resources needed for smallholders to upgrade successfully and comply with safety and traceability requirements.

Incentives to invest in traceability systems also act as key enablers for their development and use. Investments are often driven by regulation and access to markets, the long-term costs associated with public product recalls, the proliferation of certification systems and standards (Heyder, Hollmann-Hespos, and Theuvsen 2009), and pressure from influential external stakeholders such as retailers, consumers, lenders, and NGOs.

Yet investments in traceability systems offer viable benefits and incentives for actors in the supply chain, including swift and precise recalls of unsafe food; premium pricing for safe, sustainable, and traceable food; cost savings and business process efficiencies; and greater consumer confidence, among others (figure 11.5). It is worth exploring some of these incentives in detail, because they offer potential

FIGURE 11.5. Incentives for Investment in Traceability Systems



Source: Tina George Karippacheril.

insights for preventing the adoption of systems that exclude smallholders. Among smallholders, clearly the benefits of establishing or investing in traceability systems should be balanced in relation to the associated costs, with considerations for the long-term sustainability of those investments.

Preventing Recalls of Unsafe Food

Food traceability systems make it possible to take a proactive approach to food safety and prevent the reputational and economic damage—to producers, products, firms, and nations—inflicted by product recalls. For example, the complex recall of contaminated peanut products in the United States is estimated to have been one of the most expensive in that country (figure 11.6).

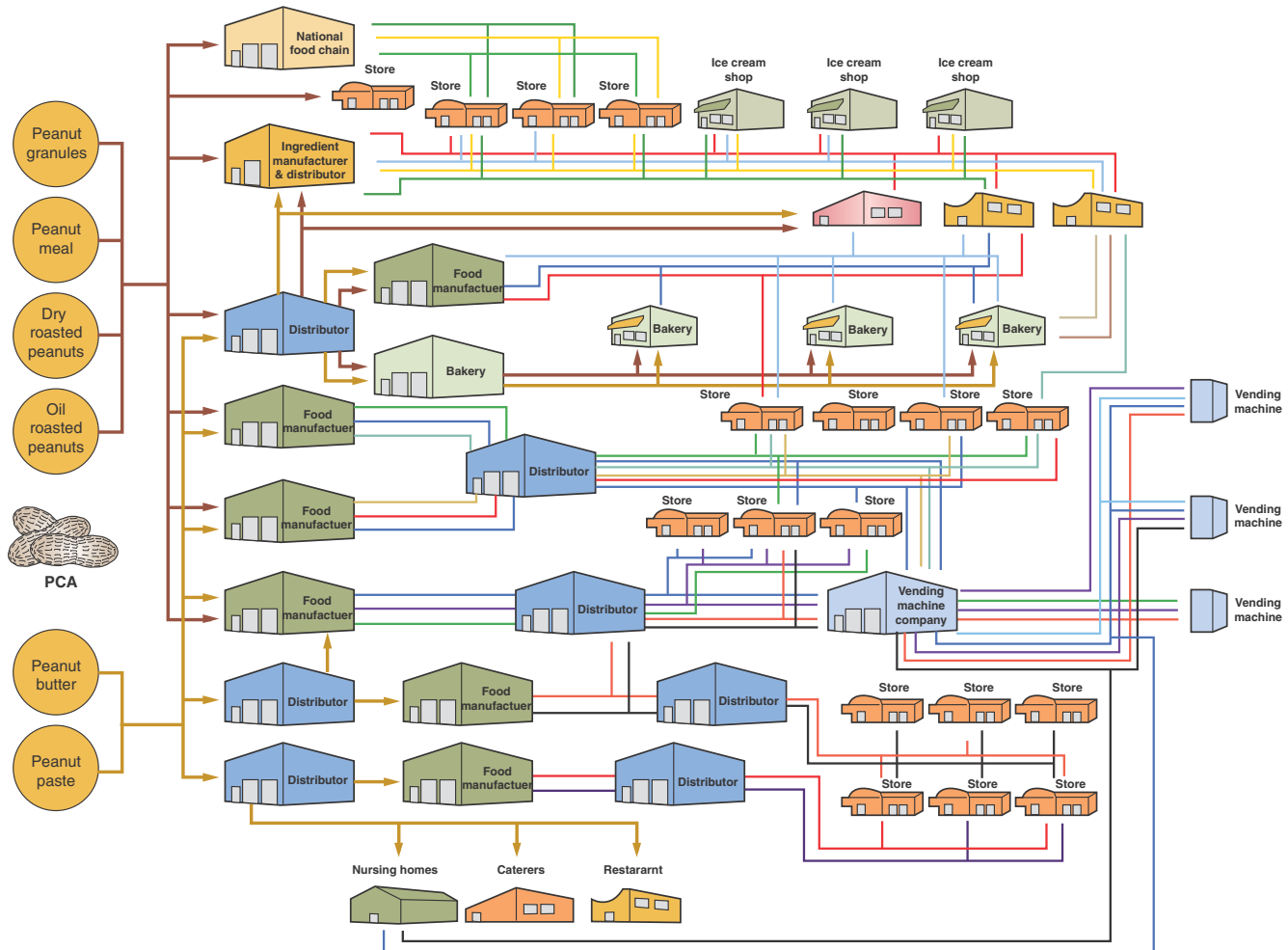
A well-known case of the potential damage of a recall for a young industry in a developing country occurred with raspberries in Guatemala. Following reports of a *Cyclospora*

outbreak, and in the absence of traceability capabilities, the United States Food and Drug Administration issued an import alert, denying all Guatemalan raspberries entry into the United States. The number of raspberry growers declined dramatically, from 85 in 1996 to 3 in 2001. Producers around the world noted the devastating effects of the ensuing trade restrictions on the entire industry and the role traceability systems could have played in reassuring the public and containing the problem to a few growers (Calvin, Flores, and Foster 2003).

Gaining Premium Prices for Safe, Traceable Food

As noted, traceability systems and technologies are also used to certify geographical origin, certify sustainable production processes, monitor the chain of custody, facilitate identity preservation and product marketing, and manage supply chains. Some of these applications enable producers to earn price premiums for sustainable, certifiable, and identifiable specialty

FIGURE 11.6. Peanut Corporation of America Recall



Source: Adapted from U.S. Food and Drug Administration.

food products. The Almacafe model, discussed earlier, enables smallholders to command a 200 percent premium for specialty coffee from unique regions in Colombia—strong motivation for farmers to adopt traceability technologies.

In Honduras, the ECOM Agroindustrial Corporation, whose customers are willing to pay high prices for high-quality, traceable products, supports farmers through technical assistance and training (Pfizer and Krishnaswamy 2007). With initial technical support, women belonging to a shea butter cooperative in Burkina Faso learned to use GPS to document the source of the shea fruit they processed and gain certification under Bio-Ecocert and Bio-NOP, which guarantee that a product is 100 percent natural and has been manufactured under conditions that respect human and environmental health. Certification enabled them to enter more lucrative export markets—despite the fact they are small-scale, predominantly illiterate producers. (See Module 8 for details.)

Building Consumer Confidence

Traceability not only ensures food quality but also builds consumers' trust by making the supply chain more transparent (Bertolini, Bevilacqua, and Massini 2006). Consumer confidence builds demand for products. Studies suggest that consumers in developed countries may be willing to pay more for safe and traceable food. A study in Korea (Choe et al. 2008) found that consumers were willing to pay a premium for traceable food and to purchase it in greater quantities. A consumer preferences study of traceability, transparency, and assurances for red meat in the United States suggests that consumers are willing to pay for traceability and that the market there for traceable food may be profitable (Dickinson and Bailey 2002). Although traceability systems tend to be unidirectional, consumers in domestic markets in the developing world may also benefit from their countries' adoption of traceability techniques and systems.

Topic Note 11.1: THE IMPORTANCE OF STANDARD SETTING AND COMPLIANCE

TRENDS AND ISSUES

Increasing concerns about global food safety have positioned traceability as an important component of food safety and quality regulations, management systems, and certification processes. Stringent food safety and traceability requirements trigger a new set of transaction costs for small-scale producers without adequate capital investment and public infrastructure (Pingali, Khwaja, and Meijer 2007; McCullough, Pingali, and Stamoulis 2008). As a result, one of the main challenges in designing food traceability systems—and ensuring smallholder participation—is the development of fair, adequate, and broad food safety standards. Some studies have found that the introduction of safety standards associated with traceability requirements may lead smallholder farmers to switch to products with fewer transaction costs. It has also been argued that stringent safety standards introduced in Kenya's fresh green bean industry were responsible for smallholders' decision to switch to processed green beans (Narrod et al. 2008).⁸

An additional issue is data standardization. Although traceability implies an end-to-end process in the supply chain, only a few links in supply chains actually use software for traceability. Many organizations exchange data manually

(Senneset, Forås, and Fremme 2007), especially smaller-scale operations, which tend to record traceability data on paper. Data standardization is vital for end-to-end traceability. There are multiple, globally recognized standards but no standard nomenclature to describe how the data should look or be organized, and software applications vary. Many parts of the food supply chain do not use standardized formats for data. The variety of traceability software in use makes data integration difficult (Bechini et al. 2005). A unified approach to traceability across supply chains would promote rapid and seamless traceability, including Web-based, open, and interoperable standards for end-to-end tracking systems.

Public Standards

Public sector interventions in food safety view it as a public good. Regulatory (mandatory) or nonregulatory (voluntary) public interventions are designed to provide consumers with basic food safety and provide information about the nature of the food. Public sector interventions usually take the form of product or process standards but also comprise analytical procedures, inspection and certification systems, and the provision of public information. Food safety standards cover a wide range of parameters, including harmful substances in food (additives, pesticide residues, veterinary drug residues, and other contaminants) and residues in animal feed. Process standards—establishing how food is produced, prepared,

⁸ More recent work has found mixed effects on stricter food safety and traceability requirements in this industry (Jaffee, Henson, and Diaz Rios forthcoming).

treated, and sold—include standards for genetically modified organisms (GMOs), food hygiene, labeling, packaging, and requirements on traceability.

Private Standards

In recent years, stricter public standards and regulations for food safety have been accompanied by a growing set of standards developed by the private sector. Private food safety standards, frequently characterized as surpassing requirements imposed through public standards, have emerged as a strategy to assure consumers that products meet a high level of regulatory compliance.

For example, private standards for particular attributes of food products might be higher and therefore perceived as more stringent or more extensive than public standards. Some private voluntary standards incorporate requirements related to traceability. Examples include standards dealing with social and environmental goals (fair trade, sustainably harvested products), as well as geographical indications and certification marks, which are generally applied to differentiate products (often as part of a marketing, branding strategy, or sustainable development strategy). These standards are not discussed in detail here.

Domestic and International Standards

Although food safety standards may be set nationally, World Trade Organization agreements on technical barriers to trade for testing, inspection and certification, and sanitary and phytosanitary matters form an international framework of

agreements to prevent misuse of standards as barriers to trade. Private food safety standards do not fall under harmonized World Trade Organization guidelines. Their legitimacy and transparency are the subject of intense debate owing to their proliferation, prescriptive nature, potential to undermine public food safety, and potential economic development impacts, particularly for small-scale producers in developing countries. Many of the difficulties that small-scale producers reportedly encounter in applying private food safety standards relate to traceability, which is an area in which private food safety standards exceed Codex recommendations (CAC 2010).

As mentioned, traceability is mandated by law in the EU and Japan (for specific commodities). Until recently, extensive traceability was stipulated in the United States by the private sector for reasons including improved supply chain management, differentiation of products in the market, and product recall (Golan et al. 2003). With the passage of food safety regulations HR2749 and S.510, the United States has strengthened recordkeeping and traceability requirements.

The participation of developing countries in setting standards and assistance from developed countries in implementing them are particularly important. Traceability systems are by and large unidirectional, and exporting countries must accommodate different systems for verification and control from major importing countries. This situation increases the administrative burden and costs of compliance (CAC 2009). Table 11.3 lists examples of food traceability requirements related to food safety and/or security.

TABLE 11.3. Examples of Food Traceability–Related Regulations and Standards, with Particular Application in Food Safety and Security

CLASSIFICATION	ORGANIZATION	DEFINITION OF STANDARD AND REQUIREMENTS
International agreement	Codex Alimentarius Commission	Codex defines traceability as “the ability to follow the movement of a food through specified stage(s) of production, processing, and distribution.” Movement can relate to the origin of the materials, processing history, or distribution of feed or food, forward or backward. Traceability is referenced in several Codex texts, such as the Codes of Practice on good animal feeding and Codes of Practice for fish and fish products.
Domestic regulation	Food Safety Act, 1990 (UK)	The law radically transformed food safety management in the UK and provided a strong stimulus for private sector management of food safety by including “due diligence” requirements, making firms responsible for the safety and quality of food inputs, the conduct of suppliers, and the safety of consumers.
Domestic regulation	EU General Food Law, Article 18 of Regulation (EC) No. 178/2002	“The ability to track food, feed, food-producing animal or substance intended to be, or expected to be used for these products at all of the stages of production, processing and distribution.”
Domestic regulation	Bioterrorism Preparedness Act, 2002 (United States)	Requires the maintenance of records of manufacture, processing, packing, transportation, distribution, receiving, holding, and importation of food to allow identification of immediate previous sources and immediate subsequent recipients of food, including its packaging, to address threats of adverse health consequences or death of humans or animals. ^a

(continued)

TABLE 11.3. *continued*

CLASSIFICATION	ORGANIZATION	DEFINITION OF STANDARD AND REQUIREMENTS
Domestic regulation	Food Sanitation Law, 2003 (Japan)	The 2003 law requires full traceability for beef. A recent bill (2010) requires traceability for rice and rice products.
Domestic standard	French National Organization for Standardization (AFNOR, Association Française de Normalisation)	“Traceability in agriculture and the food industry sector is applied mainly to two combinations, i.e., product/process (progress), and product/localization (location). Traceability can be described, as it were, as a combination of the flow of substances and that of information.” ^b
Domestic regulation	Food Safety Enhancement Act, HR 2749, 2009; S.510, 2010 (United States)	The act, which passed the House in 2009 and the Senate in 2010, gives the Food and Drug Administration greater regulatory powers to ensure food safety, including establishing a national food traceability system, and imposes specific requirements on foreign suppliers. Each person who produces, receives, manufactures, processes, packs, transports, distributes, or holds such food would be required to maintain records to identify the immediate previous sources of such food and its ingredients and the immediate subsequent recipients of such food. Restaurants, grocery stores, and farms would also be required to keep records, with some exemptions as provided by the act. ^c
International standard	ISO 22000:2005	Establishes requirements for food safety management systems based on HACCP principles, as well as traceability requirements.
International standard	ISO 22000:2007	International standard for traceability in the food and feed sectors. Complementary to ISO 22000:2005.
Private standard	Produce Traceability Initiative*	Produces a common framework and standards to help the fresh fruit and vegetable industry maximize the effectiveness of trace-back procedures through consistent nomenclature and protocols for end-to-end connectivity and traceability. ^d
Private standard	GS1 Global Traceability Standard (GTS) and Programme (GTC)	Supports implementation of traceability systems across the supply chain both locally and globally, including the requirements of ISO 9001, ISO 22005, HACCP, British Retail Consortium Global Standard, International Food Standard, and GlobalGAP.
Private standard for primary production	GlobalGAP (Formerly EurepGAP) [†]	HACCP-based reference standard for good agricultural practices, with traceability as a key obligation. “A traceability system is referred to as the totality of data and operations that is capable of maintaining desired information about a product and its components through all or part of its production and utilization chain. Traceability systems contribute to the search for the cause of nonconformity and the ability to withdraw and/or recall products if necessary. The objective of these requirements is to ensure that any product sold as certified is produced from material that originates from certified farms.”
Global Food Safety Initiative (GFSI) benchmarked standards (private initiative) [‡]	Includes: British Retail Consortium Global Standard, International Food Standard, Dutch HACCP, Safe Quality Food (SQF) 1000 and 2000 Codes, FS22000	Standards or schemes benchmarked by GFSI must comply with the “GFSI Guidance Document” (GFSI 2007), which contains commonly agreed-on criteria for food safety standards against which any food or farm assurance standard can be benchmarked. With respect to traceability, the GFSI guidance document indicates in 6.1.17 that the standard shall require the supplier to develop and maintain appropriate procedures and systems to ensure: identification of any outsourced product, ingredient, or service; complete records of batches of in-process or final product and packaging throughout the production process; and a record of purchaser and delivery destination for all products supplied.

Source: Tina George Karippacheril and Luz Diaz Rios with information from (a) FDA 2009, (b) FMRIC 2007, (c) Johnson et al. 2010, and (d) Produce Traceability Initiative 2010.

* Sponsored by the Canadian Produce Marketing Association, GS1 US, Produce Marketing Association, and United Fresh Produce Association.

† Standard benchmarked by GFSI.

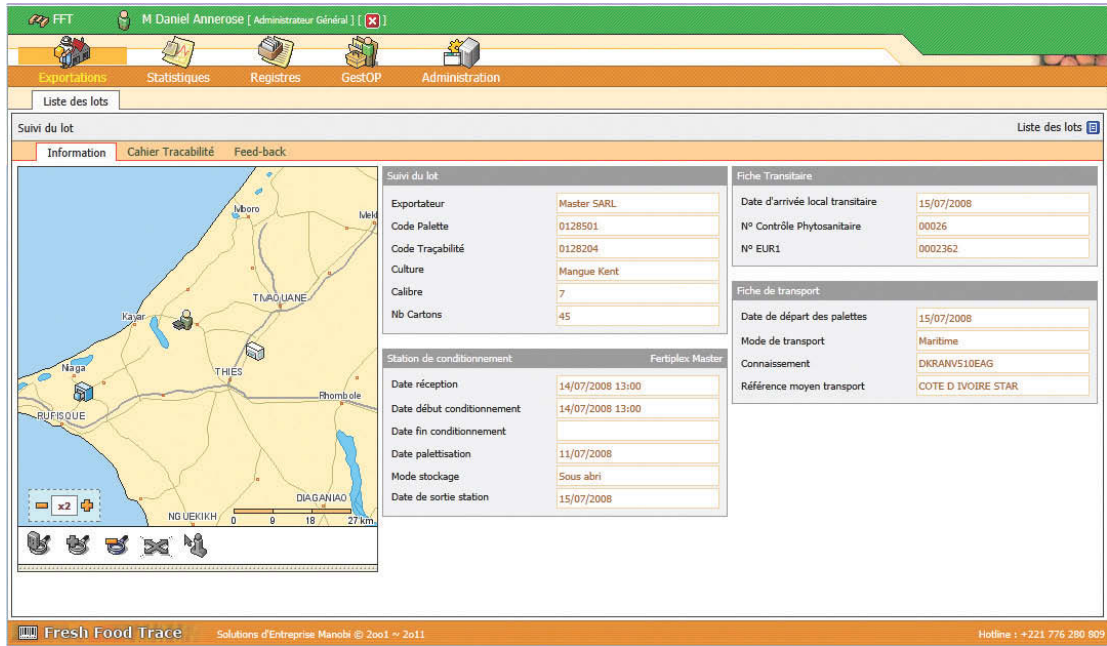
‡ GFSI was launched by the Consumer Goods Forum in 2000. GFSI brings together the chief executive officers and senior management of around 650 retailers, manufacturers, service providers, and other stakeholders across 70 countries. One of the GFSI's objectives is “convergence between food safety standards through maintaining a benchmarking process for food safety management schemes.” GFSI (2007) contains commonly agreed-on criteria for food safety standards, against which any food or farm assurance standard can be benchmarked. According to the CAC (2010), as of June 2010, 13 schemes were recognized by GFSI.

Data Standards

As discussed, data standardization is vital for end-to-end traceability. A key player in data standardization and open systems for product traceability is GS1, a global nonprofit organization with more than 1 million member organizations in 108 countries. The GS1 Global Trade Item Number (GTIN) and Global Location Number (GLN) are assigned to identify the product and location. The GTIN has two components—a

product identification code and a company prefix, assigned by GS1. GLNs usually are assigned to a company, which then assigns a unique GLN for each of its facilities. A GLN is typically associated with GPS coordinates for the facility or plant. RFID applications use the serialized GTIN standard, sGTIN, developed by EPCglobal. The United Nations Standard Product and Services Code (UNSPSC) is a global classification system for information on products and services, including

FIGURE 11.7. Fresh FoodTrace Web Platform



Source: Annerose 2010.

food products. Access to UNSPSC is free and included as a classification option in ERP systems such as SAP and Oracle.

INNOVATIVE PRACTICE SUMMARY
Mango Traceability System Links Malian Smallholders and Exporters to Global Consumers

A produce traceability initiative is helping mango growers and exporters in Mali enhance traceability and comply with GlobalGAP standards, connecting smallholder trade to global markets. Previously, Malian mango growers relied on importers in global markets who did not bear the risk associated with transporting perishable produce, and the market system had not yet earned a reputation for high-quality produce in export markets. The partners in the initiative included Manobi (<http://www.manobi.net/worldwide/>, the mobile data services operator), Fruiléma (<http://www.fruilema.com/>, an association of fruit and vegetable producers and exporters in Mali), and IICD (<http://www.iicd.org/>, a nonprofit that specializes in ICT for development).

The partners developed the Fresh Food Trace Web platform (figure 11.7), which automates and visualizes data for tracking mango production, conditioning, transportation, and export (IICD 2008). Growers log traceability data and product

information on mangoes on mobile devices at every step (image 11.1), thereby offering complete traceability to end markets. Importers, retailers, and customers are willing to pay US\$0.09 more per pound for individual farm sourcing and compliance with food safety standards (Annerose 2010). The traceability system also serves to enhance the market's reputation for supplying safe and traceable Malian mangoes sourced directly from smallholders.

IMAGE 11.1. Mango Growers in Mali Use Mobile Devices to Log Traceability Data



Source: Annerose 2010.

Topic Note 11.2: TRACEABILITY TECHNOLOGIES, SOLUTIONS, AND APPLICATIONS

TRENDS AND ISSUES

Systems for tracking products through supply chains range from paper-based records maintained by producers, processors, and suppliers to sophisticated ICT-based solutions. In addition to supporting product traceability, ICT may also support data capture, recording, storage, and sharing of traceability attributes on processing, genetics, inputs, disease/pest tracking, and measurement of environmental variables. Table 11.4 describes some aspects of how traceability is used in agricultural and agrifood systems.

The costs associated with putting traceability systems into place are seen as barriers even among established actors and appear even more daunting to small-scale producers from less developed countries. Paper is still used as a cheaper option for traceability, although it limits the ability to record data accurately, store it, and query it to identify and trace products. Digital databases for traceability are seen as more expensive to implement, operate, and maintain, requiring investments in hardware and software, skilled human resources, training, and certification.

RFID tags are still relatively expensive for widespread adoption in the supply chain compared with the much cheaper and more widely available barcodes (Sarma 2004). Tags priced at less than US\$0.01 apiece could offer lower-cost mass market options for the technology. Commercialization of advances such as those driven by nanotechnology may also push prices down by enabling RFID tags to be printed on paper or labels (Harrop 2008). RFID in its current form is a microchip and

could prove cheaper (and easier to use) in nano form. The following sections review the technologies that may be used in a variety of contexts in developing countries, depending on the associated costs and business models employed.

Document-Based Solutions (Paper/Electronic Documents)

Smaller organizations and producers constrained for resources typically use pen and paper to record, store, and communicate data to partners in the supply chain. Paper invoices, purchase orders, and bills of lading, as well as electronic file formats (MS Word, PDFs, or others), may be used to store alphanumeric codes and other data on product lot number, harvest date, product receipt/shipping date, quantity, or ingredients. Document-based systems, whether physical or electronic, store data in an unstructured form. Searching through paper records is done by physically browsing through papers that are at best categorized and filed in shelving space. Searching through electronic documents requires users to locate the document and then perform full text or metadata searches within it.

Because document-based systems take time and effort to query, they increase the time needed to locate the precise source, location, or details of a suspected contaminated product. Data recorded on paper cannot be exchanged easily among partners in the food supply chain. They also have drawbacks related to illegible handwriting and human transcription errors when data are transferred from manual to database systems. Data may be inaccurate and quite difficult to verify through cross-checking.

TABLE 11.4. Traceability Applications in Agriculture and Agrifood Systems

APPLICATIONS	DESCRIPTIONS
Product	Tracking the physical location of a product for supply chain management and to facilitate recall—e.g., through barcode labeling, RFID tags and readers, mobile devices, GIS, GPS, and remote sensing systems.
Process	Determining the types and sequencing of activities affecting the product during cultivation and after harvest, such as mechanical, chemical, environmental, and atmospheric factors, and the absence or presence of contaminants—e.g., through sensors and instrumentation devices that transmit and store information to RFID tags.
Genetic	Determining the types, source, and origin of GM ingredients and planting materials affecting a product—e.g., through DNA testing and nuclear medicine.
Inputs	Determining the types and origin of inputs such as fertilizer, chemicals, irrigation water, livestock, feed, and additives involved in the processing of raw materials into a food product—e.g., through instrumentation devices, nanotechnology, sensors, electronic tags, and handheld devices for data collection, storage, and transfer.
Disease and pests	Tracking the epidemiology of pests, bacteria, viruses, pathogens, and zoonosis in raw materials—e.g., through GIS, GPS, and mobile devices.
Measurement	Tracking and calibrating product data against national or international standards throughout the supply chain—e.g., through measurement and instrumentation systems, sensors, and laboratory equipment for analysis of chemical and physical attributes.

Source: Opara 2003.

Structured Database Solutions

Some organizations capture and store traceability data in their management information systems and other databases, such as ERP systems for inventory control, warehouse management, accounting, and asset management. They may also rely on homegrown custom solutions and legacy information systems. The advantage of capturing product traceability data in structured database systems is the ability to rapidly and precisely query data elements to isolate the source and location of products that may be contaminated. ERP systems such as SAP can read standardized data from barcodes and RFIDs, including GTINs and GLNs.

Electronic data interchange systems allow vendors and business partners to exchange data such as GTINs and GLNs. Businesses may also exchange information via ebXML (extensible markup language), which defines the structure of data and security for the transfer. Database solutions such as ERPs may be supplemented by Web-based portals for data input and data exchange with business partners in the supply chain. In legacy systems and custom solutions, data used to identify products may not follow traceability data standards such as product lot number. Multiple data standards cause errors and confusion and impede accurate product tracing.

Emerging trends in ICT, such as the use of cloud computing and SaaS (software as a service) solutions, have reduced the cost of owning ERP and database management solutions to capture, record, store, and share traceability data.

Barcode Technologies

Conventional methods of traceability through a chain of custody involve the use of barcodes and labels. Barcodes are commonly and recognizably used for inventory control management and global logistics of people and goods, such as air travel tickets or parcel shipping and delivery. Barcodes represent data to uniquely identify a product. Barcodes can be scanned by an electronic reader to identify and interpret key data elements stored in the barcode. The data can be used to trace the product forward and backward through the supply chain.

Barcode solutions require a printing component to print barcodes on labels or products and a scanning technology to read barcoded information. Barcode labels may also contain some information below the barcode to allow for human verification and cross-checking of data. Storage of data elements on a barcode depend on the type of barcode technology used. The GTIN uses a 14-digit barcode with information about companies, products, and product attributes worldwide,

which can be read upstream and downstream through a supply chain.

An even more precise system of barcode traceability is reduced space symbology. This system uses 14-digit GTIN barcodes on individual items, boxes, and pallets, which can all be linked by product and producer or distributor codes, allowing trace-back from the level of an individual item (Golan, Krisoff, and Kuchler 2004).

The Produce Traceability Initiative requires produce tracking via barcoded case labels with traceability information such as the GTIN and lot/batch number. The European Article Numbering–Uniform Code Council standard has a set of 62 product attributes for barcodes to track input, production, and inventory along the supply chain, permitting open real-time updates of information to all systems in the network when producers enter new information in the system.

RFID-Based Solutions

RFIDs offer promising capabilities for traceability in the developing and the developed world and are seen as an alternative to older barcode systems. Passive RFID tags use an initial signal from an RFID reader to scavenge power and store data on an event at a specific point in time. Passive RFID tags do not use a power source and are less expensive than active RFID tags. Grain-sized RFID tags or transponders incorporated as particles or attached as labels to food products can identify the food item and become connected to the Internet as uniquely identified nodes.

Products tagged with RFID may also be fed with data through an interface with wireless sensor networks. Sensors, also called motes, may transmit data on motion, temperature, spoilage, density, light, and other environmental variables sliced by time to the RFID tag (“Organic RFID to Cut Waste on Produce,” *RFID News*, 2009). GPS, low Earth orbit satellites (Bacheldor 2009), and motion sensors may interface with RFID tags to communicate variables on location and position coordinates (latitude/longitude). RFID readers to read data from RFID tags may be integrated as an application on a mobile device. Thus an “ecosystem”⁹ built by combining RFIDs, wireless sensor networks, GPS, mobile devices, and applications can make it possible to manage traceability across the supply chain. Product traceability recorded through such an ecosystem-based solution may range from data on logistics and postharvest practices surrounding the trees of the small-scale producer right up to the table of the

9 Also described as the “Internet of Things” (ITU 2005).

end consumer (Ampatzidis et al. 2007). Lower costs per device, nanotechnology advances that permit greater storage and smaller size, increased ruggedness in extreme temperatures and moisture, and rapid growth in wireless cellular network and device availability have led smaller producers in developing countries to use RFIDs, GPS, GIS, wireless sensor networks, and mobile phones to implement traceability systems, paving the way for connectivity to global markets.

RFIDs have been used for unique animal identification, storage of data on breeding history, animal health, disease tracking, animal movement, and nutrient and yield management. RFID-tagged animals are tracked from birth through slaughter to check and monitor disease, to meet the needs of global markets for safe meat, and to enable product recall.

The advantage of electronic traceability systems based on RFID is their staggering capacity to store data on product attributes. Barcodes permit only limited data storage. Unlike barcode systems, which are read-only, RFID systems possess read/write capability. Barcodes require the item and the scanner to be in the direct line of sight, and items must be physically moved to collect data on the product, whereas data are automatically collected via RFID without line of sight (Cronin 2008; Nambiar 2009; Sarma 2004; Stokes 2010).

The disadvantages of RFID solutions include their cost, complexity, and environmental sustainability (IFT 2009). RFID signals are affected by environmental conditions such as moisture, which absorbs electromagnetic waves; metal packaging, which scatters waves; and physical damage to the chipset in harsh conditions. Studies of RFID applications summarized by Nambiar (2009) identify challenges such as a lack of expertise, resistance to change, lack of systems integration (Attaran 2009), inconsistent information, lack of supporting tools for implementation (Battini et al. 2009), and integration difficulties as a result of the proliferation of RFID readers (Floerkemeier and Fleisch 2008). In practice, the implementation of RFID technologies is hampered by problems with tag detection, tag coverage, and reader collision (Carbunar et al. 2009). Other technological hurdles include protecting the privacy and security of data stored on the RFID tag from unauthorized access and tampering (Langheinrich et al. 2009).

Nano Solutions for Traceability and Precision Farming

Transformative technologies such as nano solutions are creating new pathways for food security and precision agriculture. “Nanotechnology” is “the ability to engineer new attributes through controlling features at a very small scale—at or around

the scale of a nanometer. One nanometer is one-billionth of a meter, or about 1/80,000 the width of human hair.”¹⁰ Nano solutions can help food security by decreasing input costs, increasing yields, and decreasing postharvest loss.

In the field of traceability, nano solutions enable food safety and food preservation. Nano materials may be used in smart packaging and in food handling to detect pathogens, gases, spoilage, and changing temperature and moisture. Traceability requirements for food safety may present a lower-risk, higher-benefit area for the application of nano solutions. (Froggett 2009, 2010). Current technologies to detect pathogens in food require considerable time, money, and effort. Nano solutions can detect contamination in real time. *Azonano*, an online journal of nanotechnology, reported in 2005 that researchers at Kraft Foods, Rutgers University, and the University of Connecticut were developing a nano solution called an “electronic tongue.” (“Food Packaging Using Nanotechnology Methods,” *Azonano*, 2005). An array of embedded nanosensors in the electronic tongue detect the presence of pathogens in packaged food and change the color of the tongue to signal spoilage to consumers. The EU Good Food Project has developed a portable nanosensor to detect chemicals, pathogens, and toxins in food at the farm and slaughterhouse and during transportation, processing, and packaging. Nanotechnologies are also enabling the production of cheaper and more efficient nanoscale RFIDs for tracking and monitoring food through the supply chain for traceability (Joseph and Morrison 2006).

Nano solutions can help increase farm sustainability while decreasing environmental impact. Nanoscale sensors in fields enable targeted minimal application of nutrients, water, and/or pesticides (Froggett 2009). Encapsulation and controlled-release methods are used to deliver doses of pesticide and herbicide. Particle farming yields nanoparticles for industrial use by growing plants in specific types of soil (one example is the harvesting of gold particles from alfalfa plants grown in gold-rich soil). Nano solutions such as NanoCeram (2-nanometer-diameter aluminum oxide nanofibers developed by Argonide in the United States) filter viruses, bacteria, and protozoan cysts from groundwater. Altairnano is working on Nanocheck (which contains lanthanum nanoparticles) to absorb phosphates from aqueous environments such as fish ponds. Research at the Center for Biological and Environmental Nanotechnology shows that nanoscale iron oxide particles are effective at binding with and removing arsenic from groundwater (Joseph and

10 “The A to Z of Nanotechnology,” Institute of Nanotechnology, March 19, 2004, <http://www.azonano.com/Details.asp?ArticleID=631>, accessed February 2011.

Morrison 2006). An emerging trend in agriculture and food security is the convergence of nanotechnology, biotechnology, information technology, and cognitive science, referred to by the United States government as “NBIC.”

The potential impact of nano solutions on smallholder farmers and agricultural producers is beyond the scope of this module but merits research and discussion. Investments in nano research and approaches to regulation continue in OECD countries such as Australia, Canada, EU member countries, Japan, Korea, New Zealand, and the United States, as well as non-OECD countries such as Brazil, China, India, the Russian Federation, and South Africa. Figure 11.8 depicts the use and convergence of information, communication, electronics, and nanotechnologies to enable information to flow from farmers to markets.

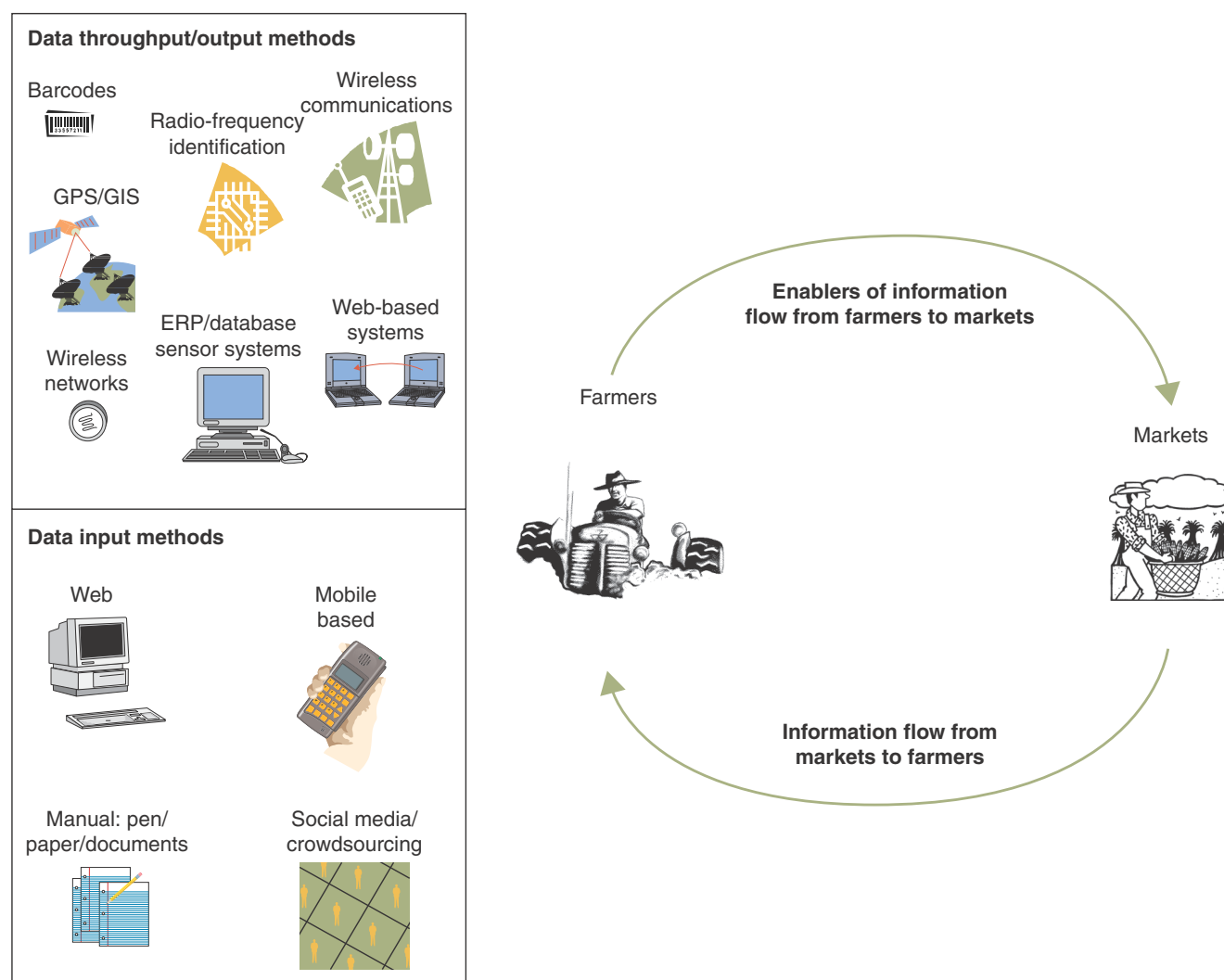
DNA Techniques

While conventional methods of traceability work for labeling and tagging food products that are not genetically modified or engineered, DNA traceability offers a more precise form of traceability for animals and animal by-products derived through biotechnology. DNA traceability works on the principle that each animal is genetically unique, and thus by-products of the animal can be traced to its source by identifying its DNA (Loftus 2005).

Nuclear Techniques for Traceability

A joint research project of the Food and Agriculture Organization and the International Atomic Energy Agency (Cannavan n.d.) seeks to establish analytical techniques to determine the provenance of food by assessing its isotopic

FIGURE 11.8. ICT Enables Information Flow from Farmers to Markets



Source: Tina George Karippacheril.

and elemental fingerprints.¹¹ These techniques are also used to identify the geographical origin of food and to identify sources of contamination.

INNOVATIVE PRACTICE SUMMARY

ShellCatch in Chile Guarantees Origin of the Catch from Artisanal Fishers and Divers

In Chile, ShellCatch (<http://www.shellcatch.com/english/index.htm>) allows buyers to pinpoint the origin of shellfish and the condition of catchment areas in the Tubul, Arauco Gulf, and Bio-Bio regions. ShellCatch shifts the responsibility for daily monitoring of catch origin, including detection of extraction from legal catchment areas, from processing plants to harvesters—that is, artisanal fishers and divers.

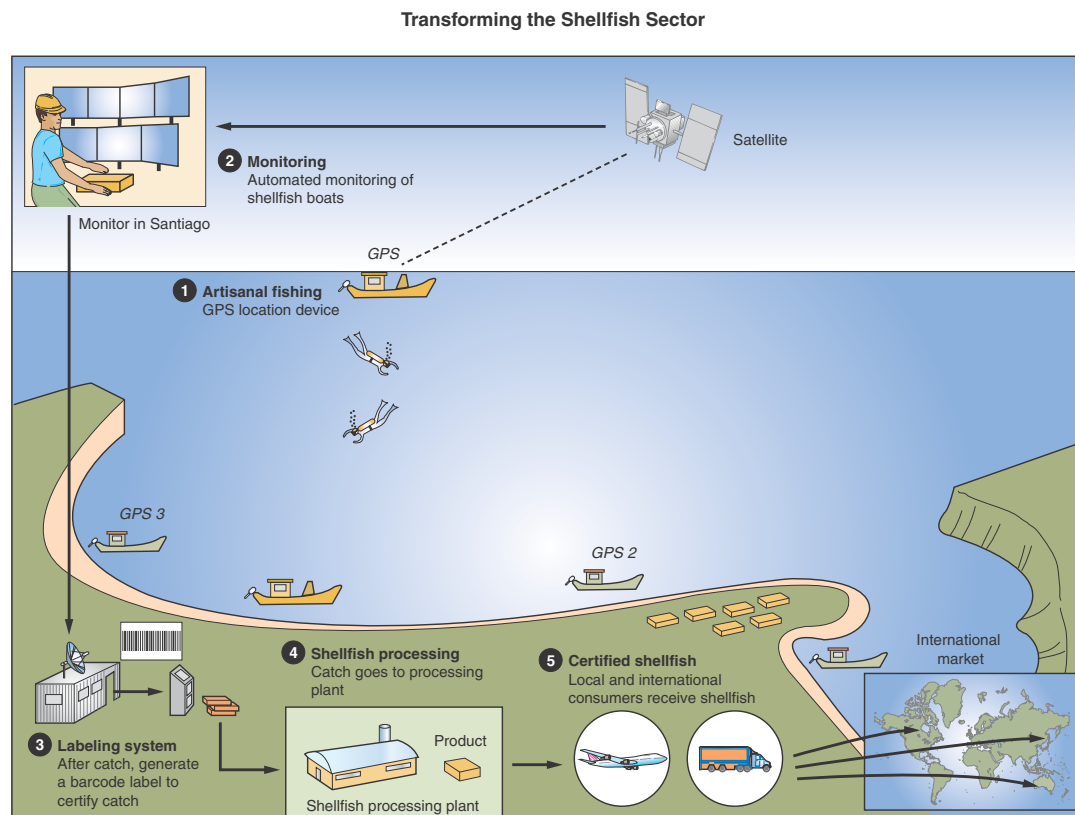
11 Joint FAO/IAEA Program, 2010, "Implementation of Nuclear Techniques to Improve Food Traceability," <http://www.naweb.iaea.org/nafa/fep/crp/fep-improve-traceability.html>, accessed February 2011.

GPS-equipped fishing boats transmit data on origin of catch to a Transdata center in Santiago to monitor fishing from legal fishing areas. When the catch is brought to port, a ticketing system cross-checks the origin of the catch via GPS data transmitted from the boats, then weighs, certifies, and labels bags of catch with traceability data in a barcode label. After ticketing, the certified catch is sent to processing plants and on to domestic and international markets for consumption. Figure 11.9 illustrates this process.

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FIGURE 11.9. Embayment Management and Shellfish Traceability in Chile



Source: "Transforming the Shellfish Sector, Appropriate Technology for Coastal Management," Shellcatch, <http://www.shellcatch.com/english/index.htm>, accessed February 2011.

REFERENCES AND FURTHER READING

- Ampatzidis, Y. G., S. G. Vougioukas, D. D. Bochtis, and C. A. Tsatsarelis. 2007. "A Yield Mapping System for Hand-Harvested Fruits Based on RFID and GPS Location Technologies: Field Testing." *Precision Agriculture* 10 (1): 63–72.
- Annerose, D. 2010. "Manobi: ICT for Social and Economic Development." Presentation to World Bank, August 12, Washington, DC.
- Attaran, M. 2009. "Keeping the Promise of Efficiency." *Industrial Engineer* 41 (3): 45–49.
- Bacheldor, B. 2009. "Hybrid Tag Includes Active RFID, GPS, Satellite and Sensors." *RFID Journal*. <http://www.rfidjournal.com/article/view/4635>, accessed April 2010.
- Battini, D., M. Faccio, A. Persona, and F. Sgarbossa. 2009. "A New Methodological Framework to Implement an RFID Project and Its Application." *International Journal of RF Technologies: Research and Applications* 1 (1): 77–94.
- Bechini, A., M. G. C. A. Cimino, B. Lazzerini, F. Marcelloni, and A. Tomasi. 2005. "A General Framework for Food Traceability." Proceedings of the 2005 Symposium on Applications and the Internet Workshop, Trento, January 31–February 4.
- Bertolini, M., M. Bevilacqua, and R. Massini. 2006. "FMECA Approach to Product Traceability in the Food Industry." *Food Control* 17 (2): 137–45.
- Bowling, M. B., D. L. Pendell, D. L. Morris, Y. Yoon, K. Katoh, K. E. Belk, and G. C. Smith. 2008. "Review: Identification and Traceability of Cattle in Selected Countries Outside of North America." *Professional Animal Scientist* 24: 287–94. <http://pas.fass.org/content/24/4/287.abstract>, accessed May 2011.
- Buhr, B. 2002. "Electronic Traceability in European and U.S. Meat Supply Chains (2002)." Presentation at the National Pork Industry Forum, Denver, February 28.
- Burger, T. 2003. "Africa: Livestock Identification and Traceback System (LITS)." *ICT Update* No. 15. <http://ictupdate.cta.int/en/Feature-Articles/LITS-tracking-Botswana-s-livestock-using-radio-waves>, accessed May 2011.
- CAC (Codex Alimentarius Commission). 2006. "Principles for Traceability/Product Tracing as a Tool within a Food Inspection and Certification System." CAC/GL 60-2006. Rome. http://www.codexalimentarius.net/web/more_info.jsp?id_sta=10603, accessed May 2011.
- . 2009. Report CAC/32 INF/14. "International Seminar on Setting Food Safety Standards, Effects on International Trade, Particularly for Developing Countries: The Hague, The Netherlands, June 9–12, 2008." CAC, Rome. http://www.fs.is.usda.gov/PDF/codex_if32_14e.pdf, accessed May 2011.
- . 2010. "Considerations of the Impact of Private Standards." 33rd Session of the Codex Alimentarius Commission, Geneva, July 5–9.
- Calvin, L., L. Flores, and W. Foster. 2003. "Food Safety in Food Security and Food Trade. Case Study: Guatemalan Raspberries and *Cyclospora*." International Food Policy Research Institute (IFPRI) Washington, DC. http://www.ifpri.org/sites/default/files/publications/focus10_07.pdf, accessed May 2011.
- Campden BRI. 2009. *Traceability in Food and Feed Chain: General Principles and Basic System Requirements*. Guideline No. G60. Chipping Campden, UK: Campden BRI.
- Cannavan, A. n.d. "Food Traceability and Authenticity: Global Issues." Presentation to Queen's University, Belfast. <http://www.qub.ac.uk/research-centres/ASSET/FileStore/Fileupload,170711,en.pdf> accessed July 2010.
- Carbunar, B., M. K. Ramanathan, M. Koyuturk, S. Jagannathan, and A. Grama. 2009. "Efficient Tag Detection in RFID Systems." *Journal of Parallel and Distributed Computing* 69 (2): 180–96.
- "China Fixes RFID Tags on Pigs to Track Epidemics." *ICT Update* No. 32 (2003). <http://ictupdate.cta.int/en/content/search?SearchText=RFID&x=0&y=0>, accessed May 2011.
- Choe, Y. C., J. Park, M. Chung, and J. Moon. 2009. "Effect of the Food Traceability System for Building Trust: Price Premium and Buying Behavior." *Information Systems Frontiers* 11 (2): 167–79.
- Collins, J. 2004. "African Beef Gets Tracked: Namibia Beef Tracking by Savi Technologies." *RFID Journal*, December 10. <http://www.rfidjournal.com/article/articleprint/1281-1/1/>, accessed May 2011.
- Cronin, R. 2008. "RFID versus Barcode." *Pharmaceutical Technology* 32 (11): 177–78.
- Dickinson, D. L., and D. Bailey. 2002. "Meat Traceability: Are U.S. Consumers Willing to Pay for It?" *Journal of Agricultural and Resource Economics* 27 (2): 348–64. <http://ageconsearch.umn.edu/bitstream/31128/1/27020348.pdf>, accessed May 2011.
- Disney, W. T., J. W. Green, K. W. Forsythe, J. F. Wiemers, and S. Weber. 2001. "Benefit-Cost Analysis of Animal Identification for Disease Prevention and Control." *Scientific and Technical Review* (Office International des Epizooties) 20: 385–405.
- "Finalists Unveiled for the Fourth Annual RFID Journal Awards." 2010. *RFID Journal*, March 18. <http://www.rfidjournal.com/article/view/7467>, accessed May 2011.
- Fletcher, A. 2004. "Coke Recall Highlights Need for Complete Traceability." Food Quality News.com, March 23. <http://www.foodqualitynews.com/Innovation/Coke-recall-highlights-need-for-complete-traceability>, accessed May 2011.
- Floerkemeier, C., and E. Fleisch. 2008. "RFID Applications: Interfacing with Readers." *IEEE Software* 25 (3): 67–70.
- FMRIC (Food Marketing Research and Information Center). 2007. *Handbook for Introduction of Food Traceability Systems (Guidelines for Food Traceability)*. 2nd edition. Tokyo: FMRIC. http://166.119.78.61/j/syouan/seisaku/trace/pdf/handbook_en.pdf, accessed May 2011.
- Folinas, D., I. Manikas, and B. Manos. 2006. "Traceability Data Management for Food Chains." *British Food Journal* 108 (8): 622–33.
- Food and Drug Administration (United States). 2009. "Title III—Protecting Safety and Security of Food and Drug Supply." <http://www.fda.gov/RegulatoryInformation/Legislation/ucm155769.htm>, accessed May 2011.
- "Food Packaging Using Nanotechnology Methods: An Overview of 'Smart Packaging' and 'Active Packaging.'" 2005. *Azonano*, July 25.

- <http://www.azonano.com/article.aspx?ArticleID=1317>, accessed May 2011.
- Froggett, S. 2009. "Nanotechnology and Agricultural Trade." OECD Conference on the Potential Environmental Benefits of Nanotechnology: Fostering Safe Innovation-Led Growth, U.S. Department of Agriculture, July 17, Washington, DC.
- . 2010. "Nanotechnology in Agriculture." Presentation to the World Bank, Washington, DC, October.
- GFSI (Global Food Safety Initiative). 2007. "GFSI Guidance Document." 5th edition. GFSI, Paris. http://www.ciesnet.com/pfiles/programmes/foodsafety/GFSI_Guidance_Document_5th%20Edition%20_September%202007.pdf, accessed May 2011.
- Golan, E., B. Krissoff, and F. Kuchler. 2004. "Food Traceability: One Ingredient in a Safe and Efficient Food Supply." *Amber Waves* (April). Economic Research Service, <http://www.ers.usda.gov/AmberWaves/April04/Features/FoodTraceability.htm>, accessed May 2011.
- Golan, E., B. Krissoff, F. Kuchler, L. Calvin, K. Nelson, and G. Price. 2004. "Traceability in the U.S. Food Supply: Economic Theory and Industry Studies." Agricultural Economic Report No. 830. Economic Research Service, United States Department of Agriculture, Washington, DC. <http://www.ers.usda.gov/publications/aer830/>, accessed May 2011.
- Golan, E., B. Krissoff, F. Kuchler, K. Nelson, G. Price, and L. Calvin. 2003. "Traceability in the US Food Supply: Dead End or Superhighway?" *Choices*, Second Quarter. Farmdoc, <http://www.farmdoc.illinois.edu/policy/choices/20032/2003-2-04.pdf>, accessed May 2011.
- Gruère, G., and D. Sengupta. 2009. "Biosafety Decisions and Perceived Commercial Risks: The Role of GM-Free Private Standards." IFPRI Discussion Paper No. 00847. International Food Policy Research Institute (IFPRI), Washington, DC. <http://www.ifpri.org/sites/default/files/publications/ifpridp00847.pdf>, accessed May 2011.
- Harrop, P. 2008. "Printing Electronics on Food Packaging," *Asian Food Journal*, October 1. <http://www.asiafoodjournal.com/article-5609-printingelectronicsonfoodpackaging-Asia.html>, accessed May 2011.
- Hashemite Kingdom of Jordan. 2004. "Strengthening Official Food Safety Control Services: Risk Management Approach—Imported Food Control—A Success Story." Paper presented at the FAO/WHO Second Global Forum for Food Safety Regulators, Bangkok, October 12–14. <http://www.fao.org/docrep/meeting/008/AD875E.htm>, accessed May 2011.
- Hazell, P., C. Poulton, S. Wiggins, and A. Dorward. 2006. "The Future of Small Farms." Synthesis paper prepared as background for *World Development Report 2008* by Rimisp—Latin American Center for Rural Development, Santiago. <http://www.rimisp.org/getdoc.php?docid=6444>, accessed May 2011.
- Heyder, M., T. Hollmann-Hespos, and L. Theuvsen. 2009. "Agribusiness Firm Reactions to Regulations: The Case of Investments in Traceability Systems." Proceedings of the 3rd International European Forum on System Dynamics and Innovation in Food Networks, organized by the International Center for Food Chain and Network Research of the University of Bonn, Innsbruck-Igls, February 16–20. <http://ageconsearch.umn.edu/bitstream/59118/2/Heyder.pdf>, accessed May 2011.
- IFT (Institute for Food Technologists). 2009. "Traceability (Product Tracing) in Food Systems: An IFT Report Submitted to the FDA, Volume 1: Technical Aspects and Recommendations/Food and Drug Administration." *Comprehensive Reviews in Food Science and Food Safety* 9(1): 92–158. <http://onlinelibrary.wiley.com/doi/10.1111/j.1541-4337.2009.00097.x/pdf>, accessed May 2011.
- IICD (International Institute for Communications and Development). 2008. "ICTs Help to Boost Mali Mango Exports." March 17. <http://www.iicd.org/articles/icts-help-to-boost-malis-mango-exports/>, accessed February 26, 2011.
- Ingelfinger, M. D. 2008. "Melamine and the Global Implications of Food Contamination." *New England Journal of Medicine* 359: 2745–48. <http://www.nejm.org/doi/full/10.1056/NEJMp0808410>, accessed May 2011.
- ITU (International Telecommunication Union). 2005. *ITU Internet Reports 2005: The Internet of Things*. Geneva.
- Jack, D., T. Pardoe, and C. Ritchie. 1998. "Scottish Quality Cereals and Coastal Grains: Combinable Crop Assurance in Action." *Supply Chain Management* 3: 134–38.
- Jaffee, S., and S. Henson. 2004a. "Food Exports from Developing Countries: The Challenges Posed by Standards." In *Global Agricultural Trade and Developing Countries*, edited by M. A. Aksoy and J. C. Beghin. Oxford: Oxford University Press.
- . 2004b. "Standards and Agro-Food Exports from Developing Countries: Rebalancing the Debate." Policy Research Working Paper No. 3348. Washington, DC: World Bank. <http://elibrary.worldbank.org/content/workingpaper/10.1596/1813-9450-3348>, accessed May 2011.
- Jaffee, S., S. Henson, and L. Diaz Rios. Forthcoming. *Making the Grade: African Smallholder Farmers, Emerging Standards, and Development Assistance Programs in Africa*. Washington, DC: World Bank.
- Jaffee, S., and O. Masakure. 2005. "Strategic Use of Private Standards to Enhance International Competitiveness: Vegetable Exports from Kenya and Elsewhere." *Food Policy* 30: 316–33.
- Johnson, R., S. A. Lister, E. D. Williams, V. K. Burrows, H. F. Upton, and J. Monke. 2010. "Food Safety in the 111th Congress: H.R. 2749 and S. 510." Washington, DC: Congressional Research Service. Foreign Agricultural Service, <http://www.fas.org/sgp/crs/misc/R40443.pdf>, accessed May 2011.
- Joseph, T., and M. Morrison. 2006. "Nanotechnology in Agriculture and Food." Report. Nanoforum.org European Nanotechnology Gateway. May. <http://www.nanoforum.org/dateien/temp/nanotechnology%20in%20agriculture%20and%20food.pdf>, accessed May 2011.
- Kuchenmüller T., S. Hird, C. Stein, P. Kramarz, A. Nanda, and A. H. Havelaar. 2009. "Estimating the Global Burden of Foodborne Diseases—A Collaborative Effort." *Eurosurveillance* 14 (18): 191–95. <http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=19195>, accessed May 2011.
- Langheinrich, M. 2009. "A Survey of RFID Privacy Approaches." *Personal and Ubiquitous Computing* 13 (6): 413–21.

- Loftus, R. 2005. "Traceability of Biotech Derived Animals: Application of DNA." *Scientific and Technical Review* (OIE), 24 (1): 231–42.
- "Malaysia Begins RFID-Enabled Livestock Tracking Program." 2009. *RFID News*, April 6. http://www.rfidnews.org/2009/04/06/malaysia-begins-rfid-enabled-livestock-tracking-program?tag=Animal_Tagging, accessed May 2011.
- Manarungsan, S., J. O. Naewbanij, and T. Rerngjakrabhet. 2005. "Shrimp, Fresh Asparagus, and Frozen Green Soybeans in Thailand." Discussion Paper No. 16. Washington, DC: Agriculture and Rural Development, World Bank. http://siteresources.worldbank.org/INTARD/Resources/ThailandCountrySurveyF_final.pdf, accessed May 2011.
- McCullough, E. B., P. L. Pingali, and K. G. Stamoulis, eds. 2008. *The Transformation of Agri-Food Systems: Globalization, Supply Chains, and Smallholder Farmers*. London: Earthscan.
- McKean, J. D. 2001. "The Importance of Traceability for Public Health and Consumer Protection." *Scientific and Technical Review* (OIE) 20: 363–71.
- "Milk Tastes Better with RFID." 2010. *RFID News*, April 1. <http://www.rfidnews.org/2010/04/01/milk-tastes-better-with-rfid>, accessed May 2011.
- Moe, T. 1998. "Perspectives on Traceability in Food Manufacture." *Trends in Food Science and Technology* 9: 211–14.
- Muto, M., and T. Yamano. 2009. "The Impact of Mobile Phone Coverage Expansion on Market Participation: Panel Data Evidence from Uganda." *World Development* 37 (12): 1887–96.
- Nambiar, A. N. 2009. "RFID Technology: A Review of Its Applications." Proceedings of the World Congress on Engineering and Computer Science 2009 Vol. II, 1253–1259, International Association of Engineers San Francisco, August. http://www.iaeng.org/publication/WCECS2009/WCECS2009_pp1253-1259.pdf, accessed May 2011.
- Narro, C., D. Roy, B. Avendaño, and J. Okello. 2008. "Impact of International Food Safety Standards on Smallholders: Evidence from Three Cases." In *The Transformation of Agri-Food Systems: Globalization, Supply Chains and Smallholder Farmers*, edited by E. B. McCullough, P. L. Pingali, and K. G. Stamoulis, 355–72. London: Earthscan.
- Onumah, G. E., J. R. Davis, U. Kleih, and F. J. Proctor. 2007. "Empowering Smallholder Farmers in Markets: Changing Agricultural Marketing Systems and Innovative Responses by Producer Organizations." ESFIM Working Paper 2. Empowering Smallholder Farmers in Markets (ESFIM). http://www.esfim.org/wp-content/uploads/ESFIM_Working_Paper_2.pdf, accessed May 2011.
- Opara, L. U. 2003. "Traceability in Agriculture and Food Supply Chain: A Review of Basic Concepts, Technological Implications, and Future Prospects." *Journal of Food, Agriculture, and Environment* 1 (1): 101–06.
- Overby, C. S., with C. P. Wilson and J. Walker. 2004. "Retailers Need an RFID Code of Conduct." Forrester Research, March 31. http://www.forrester.com/rb/Research/retailers_need_rfid_code_of_conduct/qid/34185/t/2, accessed May 2011.
- Parikh, T. S., N. Patel, and Y. Schwartzman. 2007. "A Survey of Information Systems Reaching Small Producers in Global Agricultural Value Chains." Paper presented at the International Conference on Information and Communication Technologies and Development, Bangalore, December 15–16, <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.113.4811&rep=rep1&type=pdf>, accessed May 2011.
- Pettitt, R. G. 2001. "Traceability in the Food Animal Industry and Supermarket Chains: Traceability of Animals and Animal Products (H. A. MacDaniel & M. K. Sheridan, eds)." *Revue scientifique et technique (International Office of Epizootics)*, 20 (2): 584–97. http://web.oie.int/boutique/index.php?page=ficprod&id_produit=77&fichrech=1&lang=en.
- Pfitzer M., and R. Krishnaswamy. 2007. "Role of the Food & Beverage Sector in Expanding Economic Opportunity." *Corporate Social Responsibility Initiative Report* 20, 33–35, Kennedy School of Government, Harvard University, Cambridge MA.
- Pingali, P., Y. Khwaja, and M. Meijer. 2007. "The Role of the Public and Private Sectors in Commercializing Small Farms and Reducing Transaction Costs." In *Global Supply Chains, Standards, and the Poor*, edited by J. F. M. Swinnen. Wallingford, UK: CABI International.
- Produce Traceability Initiative (PTI). 2010. "PTI Action Plan Implementation Toolkit." <http://www.producetraceability.org>, accessed May 2011.
- "Project Klein Karoo Cooperative in South Africa." 2003. *ICT Update* 32. <http://ictupdate.cta.int/en/content/search?SearchText=RFID&x=0&y=0>, accessed May 2011.
- Reardon, T., and J. A. Berdegue. 2002. "The Rapid Rise of Supermarkets in Latin America: Challenges and Opportunities for Development." *Development Policy Review* 20 (4): 317–34.
- RFID News. 2009a. "Organic RFID to Cut Waste on Produce." December 16. <http://www.rfidnews.org/2009/12/16/organic-rfid-to-cut-waste-on-produce?tag=Sensors>, accessed April 2010.
- . 2009b. "Vietnamese Agency Seeks Seafood Traceability." May 18. <http://www.rfidnews.org/2009/05/18/vietnamese-agency-works-toward-seafood-traceability>, accessed May 2011.
- RFID Update. 2007. "Awards Honor RFID Innovators." March 27. <http://www.rfidjournal.com/article/view/6702>, accessed May 2011.
- Roberts, M. T. 2004. "Mandatory Recall Authority: A Sensible and Minimalist Approach to Improving Food Safety." *Food and Drug Law Journal* 59: 563–84.
- Safe Food International. 2005. *Global and Local: Food Safety around the World*. Washington, DC: Center for Science in the Public Interest. http://safefoodinternational.org/local_global.pdf, accessed May 2011.
- Sarma, S. 2004. "Integrating RFID." *Queue* 2 (7): 50–57.
- Savi Technology. 2009. "Savi Networks' Wireless Tracking Service to Help Transmed Cut 'Total Landed Cost' of Food Inventory Shipped from Africa to U.S." Press release, October 21. <http://www.savi.com/about/press-releases/2009-10-21.php>, accessed May 2011.
- Schulze, H., F. Albersmeier, J.-C. Gawron, A. Spiller, and L. Theuvsen. 2008. "Heterogeneity in the Evaluation of Quality Assurance Systems: The International Food Standard

- (IFS) in European Agribusiness." *International Food and Agribusiness Management Review* 11 (3): 99–139. http://ageconsearch.umn.edu/bitstream/53727/2/20081010_Formatted.pdf, accessed May 2011.
- Senneset, G., E. Forås, and K. M. Fremme. 2007. "Challenges Regarding Implementation of Electronic Chain Traceability." *British Food Journal* 109 (10): 805–18.
- Setboonsarng, S., J. Sakai, and L. Vancura. 2009. "Food Safety and ICT Traceability Systems: Lessons from Japan for Developing Countries." ADBI Working Paper 139, Asian Development Bank Institute (ADBI), Tokyo. <http://www.adbi.org/working-paper/2009/05/28/3012.ict.food.traceability.system/traceability.systems.in.japan/>, accessed May 2011.
- Siror, J. K., S. Huanye, D. Wang, and W. Jie. 2009. "Use of RFID Technologies to Combat Cattle Rustling in the East Africa." Paper presented at the Fifth International Joint Conference on Networked Computing, Shanghai, August 25–27.
- Smyth, S., and P. W. B. Phillips. 2002. "Product Differentiation Alternatives: Identity Preservation, Segregation, and Traceability." *AgBioForum* 5 (2): 30–42. <http://www.agbioforum.org/v5n2/v5n2a01-smyth.htm>, accessed May 2011.
- Spencer, J. 2010. "Small Farms Balk at Food Safety Bill." *Wall Street Journal*, April 9. http://online.wsj.com/article/SB10001424052702304172404575168232140548698.html?mod=WSJ_newsreel_us, accessed May 2011.
- Stokes, T. 2010. "Revealing the Food Identification Code." *FoodInfo Online Features* April 30. <http://www.foodsciencecentral.com/fsc/fixid15885>, accessed May 2011.
- Sugahara, K. 2009. "Traceability Systems for Agricultural Products Based on RFID and Mobile Technology." *Computer and Computing Technologies in Agriculture II*, Volume 3. *IFIP Advances in Information and Communication Technology* 295: 2293–301.
- Swedberg, C. 2007. "RFID Keeps Avocados Fresh." *RFID Journal*, April 2. [http://www.evidencia.biz/RFID_Journal_-_Evidencia_RFID_Helps_Keeps_Avocados_Cold_Chain_Fresh_\(Radio_Frequency_Identification\).htm](http://www.evidencia.biz/RFID_Journal_-_Evidencia_RFID_Helps_Keeps_Avocados_Cold_Chain_Fresh_(Radio_Frequency_Identification).htm), accessed May 2011.
- Timon, D., and S. O'Reilly. 1998. "An Evaluation of Traceability Systems along the Irish Beef Chain." In *Long-Term Prospects for the Beef Industry*, edited by C. Viau, 219–25. Paris: Institut National de la Recherche Agronomique (INRA).
- Unnevehr, L. J. 2000. "Food Safety Issues for Fresh Food Product Exports from LDCs." *Agricultural Economics* 23: 231–40.
- Unnevehr, L. J., and H. H. Jensen. 1999. "The Economic Implications of Using HACCP as a Food Safety Regulatory Standard." Staff General Research Paper 1631. Iowa State University, Ames.
- Unnevehr, L., and T. Roberts. 2002. "Food Safety Incentives in a Changing World Food System." *Journal of Food Control* 13: 73–76.
- Wall, B. 1994. "Quality Management at Golden Wonder." *Industrial Management and Data Systems* 94 (7): 24–28.
- Weinberger, K., and T. A. Lumpkin. 2005. "High-Value Agricultural Products in Asia and the Pacific for Small-Holder Farmers: Trends, Opportunities, and Research Priorities." Paper presented at the workshop, How Can the Poor Benefit from the Growing Markets for High Value Agricultural Products? Cali, October 3–5. http://www.zef.de/module/register/media/3ced_weinberger_lumpkin_2006.pdf, accessed May 2011.
- WHO (World Health Organization). 1999. *Weekly Epidemiological Record* 74 (43): 357–364. <http://www.who.int/docstore/wer/pdf/1999/wer7443.pdf>, accessed May 2011.
- . 2000. *Weekly Epidemiological Record* 75(33):268. <http://www.who.int/docstore/wer/pdf/2000/wer7533.pdf>, accessed May 2011.
- . 2001. *Weekly Epidemiological Record* 76 (50): 398. <http://www.who.int/docstore/wer/pdf/2001/wer7650.pdf>, accessed May 2011.
- . 2002. *Global Strategy for Food Safety: Safer Food for Better Health*. Geneva: WHO. http://www.who.int/foodsafety/publications/general/global_strategy/en/, accessed May 2011.
- . 2007a. "Food Safety and Foodborne Illness." WHO Fact Sheet 237. <http://www.who.int/mediacentre/factsheets/fs237/en/>, accessed May 2011.
- . 2007b. *The World Health Report 2007: A Safer Future*. Geneva: WHO. <http://www.who.int/whr/2007/en/index.html>, accessed May 2011.
- . 2008. *Terrorist Threats to Food: Guidance for Establishing and Strengthening Prevention Response Systems*. Geneva: WHO. <http://www.who.int/foodsafety/publications/general/en/terrorist.pdf>, accessed May 2011.
- Wilson, N., and W. Clarke. 1998. "Food Safety and Traceability in the Agricultural Supply Chain: Using the Internet to Deliver Traceability." *Supply Chain Management* 3: 127–33.

SECTION 4

Improving Public Service Provision

Module 12 **STRENGTHENING RURAL GOVERNANCE, INSTITUTIONS, AND CITIZEN PARTICIPATION USING ICT**

CORY BELDEN (World Bank) and REGINA BIRNER (University of Hohenheim)

IN THIS MODULE

Overview. Well-functioning public institutions in rural areas are critical to agricultural development and sustainability. However, these public institutions are often neglected as a result of underfinancing, isolation, a lack of technical support, and low levels of human capital. This module focuses on how information and communication technology (ICT) can help governments, line departments, and civil society groups provide public services to the agriculture sector.

Topic Note 12.1: Public Agencies and the Provision of E-government. ICT helps governments decrease bureaucracy, cut transaction costs, and spread information to other stakeholders. While improving service provision and rural livelihoods, these technologies also form more efficient relationships between the government and citizens, producers, private enterprise, civil society, employees, and other public agencies.

- **Building Public Service Provision through Internet Applications**
- **Agricultural and Rural Information through Ministerial Websites**
- **Using Biometrics to Provide and Target Rural Services**
- **E-Government to Business**
- **E-Government to Government**

Topic Note 12.2: Civil Society and the Provision of E-Services. Civil society organizations provide many digitized services similar to those of public agencies. Yet they also perform the important function of using ICT in more sensitive activities such as publishing information on political figures, political parties, or new legislation. They can more easily direct their efforts to more specific groups or needs and fill voids in public agriculture services.

- **Providing ‘Hubs’ for ICT Innovation**
- **E-Learning through the Web and SMS**
- **Collecting Data to Protect Local Knowledge and Ecosystems**

Topic Note 12.3: Increasing Citizen Participation through E-Democracy. Citizen participation and demand for public goods is incredibly important in the agriculture sector: Because so few resources are available in remote locations, the quality of governance often depends on citizen involvement. ICT holds great promise for enhancing democracy in rural areas, providing people with faster, real-time capacity to involve themselves in democratic initiatives, meaning that more stakeholders can affect local governance processes.

- **Information Kiosks in India**
- **Virtual Communities**
- **Government Responsiveness through Citizen Participation in Digitized Political Processes**
- **Digital Media Forums in Developing Countries**

OVERVIEW

The widespread use of ICT in developing countries arrives at a critical time. Food insecurity, poverty, malnutrition, environmental degradation, and state failure are daunting trends that need to be slowed and quickly reversed. One of the foremost ways to reverse these trends is enlarging and improving the agricultural sector. Already, using ICT, the sector has reduced transaction costs, increased rural participation in the value chain, and raised producer incomes. Seeing the widespread benefits of ICT, development institutions and governments are now investing heavily in ICT opportunities, expanding the possibilities and scalability of interventions.

Like ICT for agriculture, ICT for governance holds incredible potential and has already proved successful in many countries. Governance—defined by the World Bank as the “traditions and institutions by which authority in a country are exercised for the common good” (World Bank n.d.)—is a vital component of rural development. How governments, civil society groups, and nongovernmental organizations (NGOs) offer their services in rural areas determines the quality of life for community members, including the extent to which improvements in agriculture raise farmers’ incomes and reduce poverty. “Good governance”—which is participatory, consensus-oriented, effective and efficient, accountable and responsive, transparent, inclusive, and follows the rule of law (ESCAP 2011)—is most difficult to provide in unconnected and remote areas. It requires active citizen participation, government attentiveness, functioning accountability mechanisms, and the financial means to fulfill public demands. Yet the expansive reach of ICT has made the provision of good governance more possible.

Some of the earliest e-governance (electronic governance) initiatives began around the mid-1990s. With the Internet as the principal device (in which information would eventually be disseminated through other mobile tools), governments in developed countries began establishing technological windows of information and public services. As broadband Internet service became more affordable and widespread, poorer countries tapped into this type of electronic government. Innovative approaches to offering electronic services both in the agricultural and public service sectors as well as for the private sector are on the rise in Asia, Latin America, and even Africa. Mobile phones, radio, geographic information systems (GIS), and other ICT applications expand government capacity to reach out, target, and provide appropriate services to rural communities. Beyond service provision, governments, civil society groups, and development institutions are now increasing rural public participation through electronic means.

Electronic voting, online complaint lines, and mobile legislative consultation are some of the most innovative forms of democratic participation occurring around the world.

Because less than 25 percent of the population living in developing countries is online, the benefits of using the Internet as the only tool for e-governance are limited. Initial investment costs pose the most significant challenge to increasing broadband accessibility: In 2009, an entry-level fixed broadband connection cost on average US\$190 purchasing power parity per month in developing countries compared to only US\$28 per month in developed countries (International Telecommunication Union 2010). Yet given that broadband Internet networks will continue to expand into rural areas, this module discusses public service provision using the Internet alongside mobile phones, the radio, and other devices. It aims to highlight and describe the most promising examples (both in developed and developing countries) of ICT for governance and institutions as infrastructure catches up, with a specific focus on rural and agriculture issues.

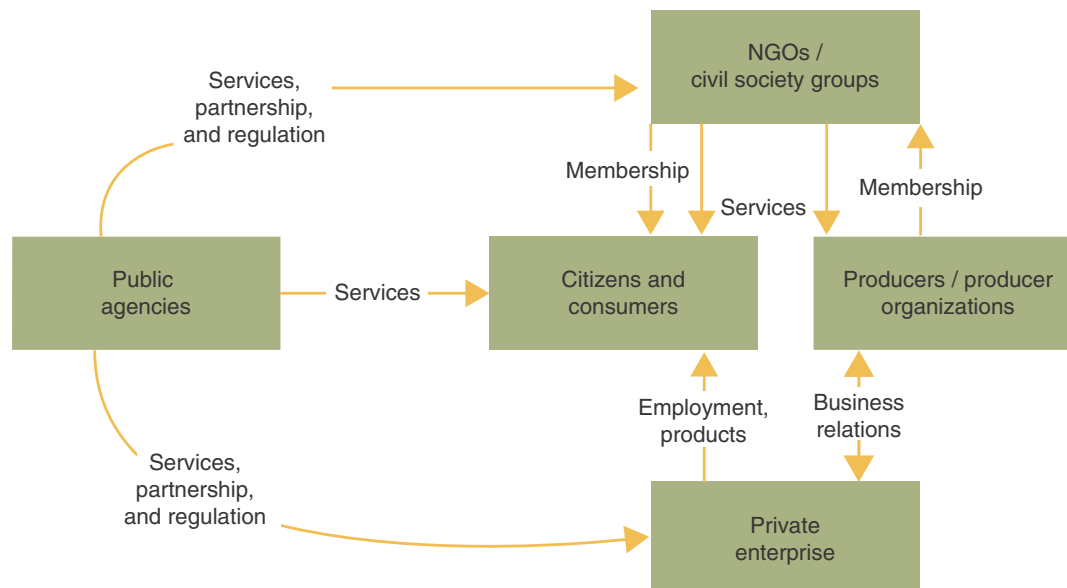
Framing the Governance and Accountability Challenge

Figure 12.1 illustrates the services that public agencies, nongovernmental organizations (NGOs), and civil society groups, as well as private enterprise, offer citizens, producers, or producers’ organizations. The relationships that define these stakeholders are those that can be enhanced through ICT. Services, partnership, regulations, and membership characterize these relationships and define how rural institutions function in remote communities.

For citizens and producers, public agencies provide services such as agricultural extension, land administration, and infrastructure; for civil society groups and NGOs, they provide services such as legal frameworks. For private enterprises, public agencies provide regulation services such as business registration. Civil society groups, NGOs, and private enterprise can provide similar services to rural farmers. Because of distance, limited resources, low human capacity, and widespread poverty, however, providing these services to rural citizens is not easy in developing countries. As the gap between public agencies and the agrarian sector continues, service provision and good governance risk deterioration. Four main governance challenges, most strongly felt in rural government offices, are briefly described below. These challenges are addressed most effectively through the use of ICT.

Human resource management challenges:

- **Human capacity:** Limited education results in restricted human capital in public agencies.

FIGURE 12.1. Relationships Between Key Stakeholders in the Agrarian Sector

Source: Authors.

- **Low performance:** Incentives like good wages are minimal in poorly resourced governments.
- **Poor supervision:** Limited resources and staff reduce employee oversight.

Corruption and procurement challenges:

- **Corruption:** Loopholes and poor enforcement create spaces for unwarranted financial gain.
- **Poor procurement:** Unqualified staff and paper accounting result in poor transactions.
- **Rent seeking:** Funds obtained unfairly by government through private assets.
- **Bribery:** Lack of legal mechanisms motivates political and financial cheating.

Targeting challenges:

- **Elite capture:** Better-off and politically connected farmers capture public programs.
- **Assessment:** Low capacity to assess whether targets are met.
- **Research:** Low capacity to identify the most vulnerable or their needs.

Bureaucratic procedures:

- **High transaction costs for clients:** Resources needed to travel to, wait for, and pay for services.
- **High transaction costs for government:** Resources needed for logistics and travel to remote places.

By digitizing its services, the public sector improves its ability to address the governance challenges listed above through the mechanisms for transparency and accountability that ICT devices automatically invoke. For example, financial transactions through mobile phones or computerized systems discourage bribery and corruption because of their built-in traceability. Similarly, putting information online in a central location ensures accurate and more equal knowledge transfer to all citizens, not just to those who are politically connected. Using biometric data to transfer inputs or services to beneficiaries ensures that the targeted individuals are the intended recipients. Short messaging service (SMS) messages containing prices for certain crops reduce intermediaries' interference. As this module intends to demonstrate, ICT applications adopted to improve only farm practices and producers' situations actually increase transparency in government processes, hold elected officials more accountable, reduce corruption, and boost citizen participation in the agrarian sector (Katz, Rice, and Aspden 2001; Mercer 2004; Selwyn 2004). Table 12.1 summarizes the applications described in this module.

This module follows the outline in table 12.1, splitting the discussion into three themes, with the most attention focused on the first: (1) how the public sector can use ICT to improve services and policies, (2) how civil society groups and NGOs can use ICT to reach beneficiaries, and (3) how democracy and citizen participation can be improved through ICT. Each thematic section presents current trends, lessons learned,

TABLE 12.1. Examples of ICT in E-Governance

E-GOVERNANCE		
Organization	E-services (examples)	E-democracy
Public agencies	<i>E-government to citizens:</i> Tax payment, biometric identification cards, government websites, irrigation management, digitized land administration, SMS extension services, mobile or radio pricing information	Citizen report cards, complaint lines, discussion forums, virtual communities, participatory budgeting, chat rooms, mailing lists, opinion polls, citizen juries, online focus groups, petitions, blogs, online media, social networks, online video or news broadcasts
	<i>E-government to business:</i> Regulatory information, procurement, automated tax payments, electronic toll collection	
	<i>E-government to employees or government:</i> Knowledge management systems, intranets, financial management systems, automated payroll, online timesheets	
Civil society and NGOs	<i>E-services to citizens:</i> Agriculture websites, e-learning, radio broadcasts, online petitions, video-based information dissemination, SMS alerts, innovation hubs	

Source: Authors.

and benefits of using ICT, followed by summaries of innovative practices from countries at a variety of electronic readiness levels.

KEY CHALLENGES AND ENABLERS

The following sections highlight key challenges related to using ICT in efforts to improve the efficiency and overall functioning of governance. They also discuss the enablers that can help to ease these challenges as interventions are designed and implemented.

Internal e-readiness: Human resources pose challenges to e-government success. Staff and bureaucrats in public agencies often resist e-government development because they see it as a threat to job security (Jiang, Muhanna, and Klein 2000). Internal e-readiness helps calm employees' fears and prepares them for ICT interventions. The number of full-time IT employees and a firmly established IT department appear to be robust indicators of successful e-government adoption (Norris and Kraemer 1996; Schweser 2009). To ensure internal e-readiness, countries introducing e-government should try to condition staff through training and conferences.

Interoperability: The ability of a government website to connect people to information or to other websites is important to e-government development. As well as frequently updating their Web pages, government agencies must provide clear, functioning links to other relevant information. Interoperability can extend to culture relevancy and content. Language is a major challenge. Providing government information in only one language, or even two, may not suffice to reach citizens in the most rural and poor areas. Finally,

interoperability is critical in infrastructure development. India's choice to pursue a government-wide centralized administrative system reduces financial burdens over the long term and ensures that data and management systems are integrated over multiple departments. However, implementing a centralized system is much more difficult than implementing singular systems. Oversight and technical support across diverse departments is a prerequisite, as are staff support, national leadership, and ample financial resources (Reidl 2001).

Education and training: Computer literacy, outside of literacy itself, is one of the biggest challenges to ICT development in rural areas. Countries implementing ICT for poor communities must remember that training and education are likely to be a necessity in the initial stages. Without them, users may struggle to use the Internet or other ICT applications. The resulting frustration and reduced enthusiasm about new technologies can spread quickly. For new users, education increases both accessibility and confidence. Public extension services can help meet the need for education and training in the use of ICT.

Privacy and security: Privacy and security are also major challenges to e-government development (OECD 2003; Schweser 2009). Even in developed countries, securing citizens' profiles, credit information, addresses, and preferences becomes a critical issue. Before implementing an e-government initiative, practitioners should consider privacy protection programs and inform the public about the risks and safety concerns related to using ICT. Leaks in personal information and increases in identity fraud are serious threats to e-government success.

Matching e-government projects to local infrastructure:

Investing in an e-government website when Internet access is limited for most households and businesses may not be a smart financial commitment. E-government projects should match the infrastructure capacity of the country or region. A project aimed at connecting rural farmers to buyers through the Web is ineffective if the rural communities do not regularly have electricity. A kiosk, perhaps powered by a generator, or SMS alerts may be more appropriate. The Kosovo case demonstrates that ICT for governance does not have to be an all-or-nothing proposition. Building ICT requires creative solutions and gradual progress. Developing e-government in step with expanding technology capacities will sustain the effectiveness of the ICT.

Sustained leadership: Strong leaders are crucial for consistent e-government development. Public officials or leaders that are frequently “seen” are most effective in mobilizing citizen support for ICT. Increased and active leadership could help institutionalize the ICT in business development. Yet this type of “campaign support” for e-government initiatives is not the only important leadership role. Country leaders must also consistently and strategically prioritize ICT ahead of other development needs so that e-government attempts are not “stop-and-go” (InfoDev 2002).

Investment and public-private partnerships: Financial planning and long-term revenue inflows are important to e-government as they develop (OECD 2003; Relani 2004; Schwester 2009). Generating revenue is crucial to sustainable ICT and public-private partnerships should be pursued in order to maintain long-term growth and expansion. Governments can charge small fees to private enterprises or citizens who use their services, yet modicum fees require many years to pass before returns on investment are significant.

Interorganizational collaboration and coordination: A major challenge to e-government success is coordination between multiple public agencies. Almost all e-government services require interagency collaboration, particularly for financial management. Yet this collaboration is difficult to encourage and facilitate. Simply computerizing internal processes will not result in integration and flow if government agencies have a history of performing their duties in “rigid silos of departments” (Fuchs and Horak 2008). Haphazard computerization can actually worsen government effectiveness. Shared infrastructure like the same intranet or knowledge management system may ease the ICT transition.

Social access: Creating access for women (and other vulnerable groups) is usually the most difficult social task in ICT development. Democratic forms of participation like blogging often are unavailable to females who do not have the time or cultural access to participate. If kiosks are intended to reach women, they should be placed in women-centric locations like weekly markets or hospitals. Similarly, broadcasts for farmers should be run late in the evening when farmers have returned from their activities. Even more important is that leaders and donors must reflect on their intended objective. Is the ICT truly reaching disadvantaged groups? Do observations prove that the ICT contributes to a wide range of smallholder productivity? If not, strategy, targets, and objectives should be reconsidered.

Content analysis: Content analysis is another crucial element of successful delivery of e-services by government and civil society. The Internet, SMS alerts, newsletters, and other ICT applications must be relevant to the user. Content that may seem relevant may in fact not be relevant, depending on the need. Technologies, climate change, and markets constantly shift the importance of messages. During a drought, radio broadcasts on collecting water for irrigation might be more appropriate than others. These analysis activities are particularly important in e-government because the information provided by governments (such as market price information) is not often up to date. Private sector initiatives offer more accurate and timely agriculture information compared to the public sector. Thus one of the first steps in improving e-government services should be enhancing the quality of the information provided. Routine checks for information accuracy are also critical.

Usability: Usability is user-friendliness. Text options and clear links to other sites create this friendliness. The Cereal Knowledge Bank does an excellent job of fostering usability. Buttons like “home” and “back” make it easy for people of all ages and skill sets to access information. The site offers downloadable printable information as well. Users can click on “small,” “medium,” or “large” text options, providing reading material for a variety of eyesight capacities. Giving the user options is also part of usability. Lack of options and links to nonexistent websites frustrate users.

Active participants and institutionalization: Participants matter in ICT development for governance. Just because an organization delivers an e-government website, virtual community, or radio broadcast does not mean citizens will

actually use it, so community involvement and buy-in are critical to success. For example, while a virtual community or extension service may have hundreds of members, only a few of those members may contribute to the knowledge base or discussion (Kim n. d.). Requiring participation in messaging, radio programs, and virtual communities in order to maintain membership, or rewarding contributions, may incentivize participants to comment, respond to queries, and add value to the community or cooperative. To further activate wide participation, practitioners must obtain community acceptance and buy-in, secure links to sustainable revenue flows, and maintain government support (Madon 2004). Stimulating valuable social interaction and interest with relevant groups and leaders will increase the prospects of successful ICT integration.

Political and cultural environment: Institutions introducing an ICT should consider the political and cultural environment during design and implementation. This consideration is particularly important in e-democracy projects. For example, if women do not normally participate or have a voice in government issues or politics, introducing an ICT for women without proper preparation, like training and community meetings, may have minimal positive effect. Saxena (2005) puts it well, stating that “while e-government is an automated government, the reverse does not inevitably hold true. Introduction of automation into the public sector will not automatically create better or more open governance unless it is based on open and democratizing principles.” In other words, simply computerizing government or services is not the same as improving e-governance (Fuchs and Horak 2008).

Topic Note 12.1: PUBLIC AGENCIES AND THE PROVISION OF E-GOVERNMENT

TRENDS AND ISSUES

Public agencies need to provide a wide array of public services to rural producers and citizens. However, providing agricultural services like irrigation and drainage systems, market assistance, extension and advisory services, or other services like health and education is extremely complicated due to poor roads, few human resources, and corruption in rural areas. The public sector must also create a friendly business environment for small and medium-sized businesses, foreign investors, and innovative producers seeking to capitalize on a business idea.

Through ICT, government agencies can provide services to producers and private enterprise while enhancing the quality of governance. E-government, or a government’s use of ICT to enhance public services, initially began as an intragovernmental communications tool (Moon 2002). Administrative ICT applications—like knowledge management systems, financial decision support systems, and intranets—were and are still used to improve the internal workings of public agencies. As technologies developed, the boundaries of ICT in government expanded. Governments found that they could decrease bureaucracy, cut transaction costs, and spread information to other stakeholders like citizens and businesses by digitizing public services. These advantages are quite pronounced in the rural sector. For example, sending real-time price information through SMS increases producers’ bargaining power with traders, and tracking cattle through sensor technologies traces the health of the animals, opening doors

to export markets. While improving service provision and rural livelihoods, these technologies also form more efficient relationships between the government and citizens, producers, private enterprise, civil society, employees, and other public agencies.

One way to clarify the opportunities and steps in an e-government project is through the stages of e-government. The simple framework outlined below shows how the public sector can improve its digitized services over time. The stages in this e-government framework—publish, interact, and transact—are as follows (InfoDev 2002):

- **In the publish stage**, a government might start with a website or two offering static information regarding public services. Hours of operation, addresses of public agencies, and basic regulations or laws might be posted online.
- **In the interact stage**, interests groups and citizens can interact online with government officials, receive market information via SMS, and assist in irrigation projects through ICT.
- **In the transact stage**, producers can make financial transactions through point-of-sale terminals, businesses can obtain licenses online, and citizens can buy or sell land through digital land administration.

Table 12.2 provides examples of e-government ICT with reference to the publish, interact, and transact stages. Country examples are also included.

TABLE 12.2. E-Government Stages

STAGE	TYPE OF ICT	COUNTRY EXAMPLE
Publish	Website with ministry information	Nigeria http://www.nigeria.gov.ng/
	Market information systems	India http://agmarknet.nic.in/
	Databases and resources	Brazil, EMBRAPA http://www.embrapa.br/english
Interact	Irrigation management	Afghanistan (See Module 5, page 107)
	Email communication with government	Singapore http://ele.ecitizen.gov.sg/news.htm
Transact	Rural finance system	M-PESA, Kenya (See Module 7)
	Digital land administration	Indonesia (See Module 13)

Source: Authors.

The e-government sector has continued to grow with the expansion of ICT and infrastructure. A number of key trends should be noted:

- **A major trend toward a central interministerial committee.** These committees, often housed by the head of state or in the cabinet, lead and create national e-government policies and strategies. E-government committees at the national level help generate significant visibility, funding opportunities, and push both public and governmental digital transformation. Designating an ICT national leader also helps ease state and local governments into the national strategy and is now occurring more broadly in developing countries. However, these committees have a tendency to stagnate, existing more for show rather than progressive ICT action.
- **A shift from a computerized, technological approach to a more service-driven approach.** Governments are now looking into how technologies can integrate with public services and institution building, rather than the opposite. The service-driven approach is much more effective than the technological approach, because it taps into public demand, which is often latent owing to limited access to new technologies and education about them.
- **An increase in private-public partnerships.** Private firms are increasingly involved in e-government projects due to the technical features involved as well as the profitability of some services. This participation is critical to financing infrastructure that the government cannot afford, as well as to refining the public

sector's sources of information, efficiency, and scaling opportunities.

- **A change in legacy.** Governments and development institutions are recognizing that electronic public services are not improved through ICT if they support rather than redesign dysfunctional policies and procedures. E-government is being viewed as a more complex overhaul in public service provision and government function rather than as a series of individual departmental projects (Hafkin 2009).

Finally, it is important to note that ICT projects specifically purported to resolve agriculture development also address governance challenges. Rather than repeat the examples covered in other areas of the Sourcebook, table 12.3 cross-references ICT interventions from the public, private, and development sectors that are described in other modules. Their components are highlighted to demonstrate the positive effects that ICT-enabled agriculture has on rural governance even, when the intended objectives are strictly agricultural.

LESSONS LEARNED

Public service providers and development institutions assisting in the development of government-sponsored ICT projects should be aware of the challenges associated with them. Though impact studies are limited, there is some evidence of the difficulties that may present themselves during or after implementation. These effects can weaken the relationship between the rural sector and the government,

TABLE 12.3. ICT-Enabled Agriculture Interventions and Their Impact on Rural Governance

	INTERVENTION	BUREAUCRATIC CHALLENGES	HUMAN RESOURCE CHALLENGES	TARGETING CHALLENGES	CORRUPTION AND PROCUREMENT CHALLENGES
Risk Management Module 10	ILRI created index-based livestock insurance to provide insurance to 3 million pastoralist households in northern Kenya. Satellite images that captured the amount of vegetation on the ground were used to assess damages. Premiums and payments are collected by a rural agent through point-of-sale systems.	For private firms and government alike, it is too costly to assess the damages and collect premiums in remote areas. Administrative and logistical costs are minimized by satellite imagery and point-of-sale systems as government workers no longer have to travel to remote locations.	Human discretion, which is often used for assessing damages, is highly fallible. Satellite images improve the capacity to analyze and accurately assess damages. It also creates opportunities for long-term data collection, which could improve environmental or production projections.	A lack of data reduces the chances of targeting the right farmers during a disaster. To ensure the insurance was priced fairly and would reach the most vulnerable, analysts created an index that predicted livestock mortality based on the amount of vegetation on the ground. This was used in tandem with the satellite images to ensure fairness.	When government agents collect premiums or pay indemnities without a digital system, opportunities for bribery or theft increase significantly. Using point-of-sale systems not only reduces the logistical costs of providing insurance but also monitors financial transactions, preventing both government and producer losses.
Market Information Module 9	Esoko is a market information service in Africa set up through mobile phones that (1) delivers a wide range of market information and (2) serves as a platform for buying and selling agricultural commodities.	Providing market information through bulletins and other conventional means takes considerable financial resources and time and is often unreliable. Esoko.com allows any farmer with an Internet connection to register for a free account and access 800,000 prices from a diverse set of markets. Users can also connect with buyers and advertise their products.	Incentivizing the private sector to advertise through mobile telephones and Internet significantly increased the sharing of information on prices, market preferences, supply, and demand. The burden of sending trained government staff to collect this information is lightened; more resources and staff time can be allocated to other needs.	Users have the option of customizing the technology to meet their needs. By tracking harvest activities or selecting market information for certain products, farmers are finding relevant information faster than a traditional extension service could provide. Governments can use data on farmers' digital interests to target individuals or areas for specific types of training or input programs.	Through mobile applications, farmers can observe price fluctuations and financial transactions. Even without a subscription, farmers can request market data for the cost of one SMS message. Removing intermediaries' opportunities to take advantage of uninformed farmers drastically reduces the need for government intervention.
Land Administration Module 13	The Indonesian National Land Agency has created an SMS-based property inquiry service and a remote land titling program called the People's Land Title Service (LARASITA). The service, which uses a vehicle and a laptop with wireless connectivity, has brought land services to five rural provinces that would otherwise not have access to them.	Land titling, an often centralized service in developing countries, is not accessible for citizens living in the periphery. Insecure land rights are problematic in rural locations, resulting in lower yields and poor farming practices. Mobile land titling allows citizens do not have to spend unnecessary time and financial resources to travel to the main city to register their property.	Using computers and laptops reduces paperwork burdens for staff. Entering data directly into an electronic system connected to the central database also reduces the time it takes to complete these service-related tasks. Data entries should also reflect the rural situation accurately.	Digitizing the land system allows more people to access land and make transfers, even in remote locations. Agencies can ascertain which properties are not included in the land system and go about reaching them. Using the mobile system also improves targeting, particularly because rural inhabitants are most prone to exclusion in land titling systems.	Digital systems raise red flags when companies or persons obtain land without going through proper legal channels. It is also easier to prevent discrimination against certain groups as rural awareness of rights increases. Web portals and digital land systems provide tighter accountability mechanisms that prevent corruption, which also enhances citizen trust.
Irrigation Management Module 5	The Program for the Management of Irrigation Systems by Water Users, in collaborations with others, used digital orthophoto quads (DOQs) to help the government and local communities manage address problems of maintenance, drainage, canal structuring, system monitoring, and payment in the Dominican Republic.	Digitized irrigation management systems reduce the time spent in the field for M&E. DOQs capture information to help public agencies plan and implement better-functioning irrigation systems. Where GPS cameras and mobile phones are used, water users can send pictures of maintenance issues or system breakdowns, also reducing staff travel.	DOQs can be used over time to anticipate water challenges like increasing salinity. Creating a database with these images allows users to be more active in the irrigation network. Active participation usually increases public demand for good services, and it may lead to better staff performance and oversight.	Using ICT in irrigation systems improves public agencies' ability to target. Satellite images such as DOQs can distinguish land plots, water sources, and which producers have the most or least access to water from the system. With this information, public agencies can adjust water subsidies and infrastructure to better target those farmers with the fewest water resources.	Local users, who are active in monitoring the irrigation networks, can hold contractors accountable and reduce waste in financial resources. In addition, water fees are easier to assign if there is a more accurate picture of the water situation in rural areas. DOQs can prevent public agency discrimination in prices and water access.

worsen situations for farmers, and reverse positive trends in the development of sound governance.

Because ICT applications are “disruptive technologies” that restructure bureaucracies, redistribute power, and alter the confidentiality of information (Hanna 2009), practitioners should be wary of political apprehension. ICT is not a panacea for development challenges, especially those relating to good governance. In fact, studies assert that the introduction of digital services into certain bureaucracies is prone to overlooking manifestations of “neopatrimonial” behavior (patronage taking place behind the facade of a modern state) that could render ICT ineffective in improving governance (Berman and Tettey 2001).

Strained resources and an unstable state or emerging democracy can make the productivity of ICT even more difficult to achieve. For example, because the results are not immediate, politicians do not always support e-government projects: Incentives to develop and begin implementing ICT are sometimes limited in terms of reelection or political clout. Using ICT in societies with thin models of citizen participation may produce minimal change (Dahlberg 2001). As a result, e-government projects should be dependent on the institutional, political, and administrative capacity of the country.

The use of ICT can also increase class divisions (Selwyn 2004). The “digital divide” is a global, national, and local phenomenon, even in developed countries (Jung, Qui, and Kim 2001; Loges and Jung 2001; Bonfadelli 2002). This divide is most clearly visible between the wealthy and poor. For example, traders or wealthy farmers, who typically have higher incomes compared to producers, also have more access to mobile phones, which can put poorer producers at an even greater disadvantage. Recent studies show that where citizens with higher levels of education and income use employment-related ICT like databases and bookkeeping, those with lower education and less income use ICT for games and entertainment (van Dijk 2006). As a result of these social challenges and others, institutions evaluating ICT for governance should examine “effective access,” or the users’ “actual engagement with, or use of, the technology” (Selwyn 2004).

Gender disparities in levels of ICT adoption are an additional social and economic concern (see Module 4 for more details on gender issues). Evidence shows that women in rural

areas are much less likely to have access to mobile phones or computers than men. In general, this disparity occurs because women do not have the income (often controlled by men in the household) to purchase mobile phones or gain the education to use them effectively. Contributing to the challenge are social norms in rural communities. One study found that men put restrictions on how women use mobile phones, further decreasing women’s freedom to use phones economically. Women’s incomplete understanding of how phones and even radio broadcasts could be used for agricultural and innovative purposes is a chief barrier to integrating women as users of ICTs. Most women see phones as security measures, not ways to access public services or improve livelihoods (E-Agriculture 2010). Evidence suggests that the gender disparity in ICT access decreases when women and men have similar educational backgrounds and incomes. Projects focused on increasing women’s primary education and basic computer skills should thus increase their effective use of ICT (Gillwald, Milek, and Stork 2010).

Beyond these challenges are others related to infrastructure and cost. As noted, initial costs for mobile and broadband Internet networks are so high that the public sector cannot extend them to rural areas. Incentivizing the private sector to finance infrastructure can reduce this burden. In addition, public agencies might want to further consider how to link mobile phone applications into online service systems, as many development institutions and private firms have done. Increasing the number of applications that can be used through mobiles may improve rural access, as most rural producers do not have access to the Internet. (See Module 2 on affordability and accessibility for more information on these connectivity issues.)

INNOVATIVE PRACTICE SUMMARY **Building Public Service Provision through** **Internet Applications**

Government portals are one of the most prominent forms of e-public services that agencies provide. Most government agencies begin their ICT development with these websites and, over time, develop their capacity to provide more services electronically or simultaneously through SMS. Some initiatives are designed and implemented in all ministries at once; others are designed and implemented one by one. At first, government websites may provide only bits of

information, but after years of sustained investment (including adequate investment in rural infrastructure), these portals can offer hundreds of transaction services.

Website development is a continuous process in all countries, developing and developed. Those involved in e-government initiatives in countries with few resources and low capacity can look to other public agency websites for ideas on how to improve or enhance their own efforts to reach citizens through ICT. Both <http://www.regulations.gov/> in the United States and <http://ec.europa.eu/> in the European Union are good references for governments trying to disseminate information on policy and law in their countries.

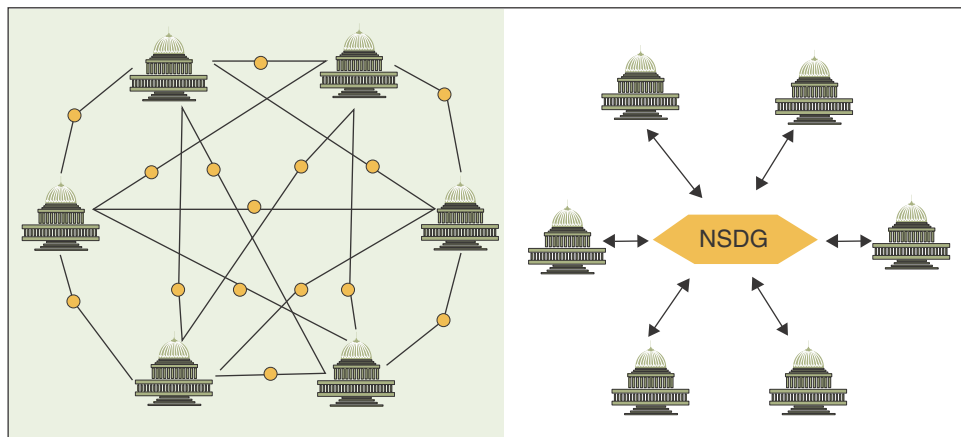
India's E-Governance Initiative

India, revered as one of the most progressive countries in e-government, began the National e-Governance Plan (NeGP) in 2006. In the past five years, the project has seen substantial national growth in providing electronic information and services online. The NeGP includes both telecommunication and internal government systems infrastructure development, simultaneously building electronic public service delivery and strengthening rural access to the Internet. NeGP is composed of almost 50 projects, spread out over all ministries and line departments at the federal, state, and local levels. Each state also has the ability to select five e-government projects, which are dependent on and tailored to the state's economic and social development needs. These services are being generated through public (51 percent) and private funds (49 percent) funds (see <http://www.nisg.org/index.php>).

The National e-Governance Service Delivery Gateway (<http://www.nsdg.gov.in/administration/index.jsp>), which serves as a data exchange board between all government agencies, will help the Indian government track, monitor, store, and quickly reply to citizen inquiries. Whereas many government portals develop with singular infrastructure, India chose an infrastructure system that would allow for standards-based interoperability between agencies (see figure 12.2). A central system that acts like a behind-the-scenes routing service eases the transition from paper to electronic services, reduces the amount of overlap in agency efforts, minimizes costs, and improves information sharing between departments. Of particular importance, integrated infrastructure benefits the citizen: services should look similar and follow the same types of procedures in all government agencies.

As NeGP moves forward, citizens will be able to access public services from each relevant ministry through departmental websites with the gateway portal. Grievance redress, online permits and applications, and other relevant services are currently being implemented, along with programs that allow people to track the status of their submission and protect their privacy. The project has also made substantial efforts to reach out to the large rural populations. E-District is a service that allows rural citizens without computers or Internet to access services through community centers. In addition, the Department of Agriculture and Cooperation and the Directorate of Marketing and Inspection (<http://agricoop.nic.in/> and <http://agmarknet.nic.in/>) have developed impressive agricultural public services, including a market information system, pages with technical advice, and even a public grievance program dealing with agricultural issues.

FIGURE 12.2. Singular Infrastructure versus Centralized Infrastructure in India



Source: <http://www.nsdg.gov.in/administration/>.

Finally, mobile government through SMS is an additional e-government initiative.

Success in Singapore

Singapore's e-government portal provides another useful example of e-government development. Now in the transact stage, the country's e-government program is among the best in the world. Government workers were trained in ICT as early as 1981, starting with a civil service portal through IBM. By 2006, data were shared across 13 ministries that were connected through an integrated central service system. Internet technology and penetration increased rapidly in Singapore. Even 10 years ago, 90 percent of the population already had Internet access. The expansion of government-sponsored "Citizen Connect" centers—placed in multiple strategic rural locations around the country—are partly responsible for this broad access. Singapore, through its efforts to connect all citizens to the Internet, even despite resource and infrastructure constraints, has experienced impressive ICT gains. For example, it only takes 20 minutes to register a business online, and the government offers almost all of its 2,600 public services online, making government interaction easier and possible in remote locations.

The 2,600 services range widely in scope and subject. Rather than printing documents to turn in to public agencies, people can complete most services fully through the Web. For example, they can apply for maternity leave, pay taxes, register for university, make appointments with doctors, and search for information regarding housing (Hachigian and Wu 2003; Riley 2003). Citizens can also apply for passports, change addresses, and even register small court claims online (see <http://www.smallclaims.gov.sg>).

BiblioRedes in Chile

Because of literacy and limited computer education, programs that help educate farmers and other citizens are crucial once network connections are available. Chile's Digital Equity Fund subsidizes broadband infrastructure in remote areas and funds a project called BiblioRedes. A product of the Digital Literacy Campaign, the BiblioRedes project connected 101 of 121 public libraries in municipal districts with low connectivity rates to the Internet. With this connection, even in isolated regions, a 14-hour "Digital Literacy" training program is available for new users to learn basic computer skills. A complementary course allows users to learn about other IT applications. Chilean libraries are used often, and as a result, these

systems—both the Internet availability and computer training programs—benefit over 3 million people. Women and young adults with low incomes have preferential access to the services. In fact, over 50 percent of the users are female (United Nations Department of Economic and Social Affairs 2009).

INNOVATIVE PRACTICE SUMMARY

Agricultural and Rural Information through Ministerial Websites

Making It Work in Malaysia

Government websites can be specifically related to agriculture as well. The Malaysian Ministry of Agriculture's Third National Agricultural Policy for 1998–2010 was formed to improve agricultural productivity and competitiveness following price increases in imported commodities. The use of ICT was a major aspect of the 12-year plan (Mathison 2002), which has made substantial progress over the last decade. In one of its major projects, the Ministry of Agriculture, along with farmers' organizations, developed a portal that allowed agriculturalists to share information. The website (now at <http://www.doa.gov.my/web/guest/home>) provides a wide array of services, including technical information on Malaysian agriculture, registered agriculture service providers (like fumigators), pricing information for producers, open forums through Agribazaar, permits, and archives. It also provides a bulletin service for advertisements and events. All of the information can also be accessed by listening to a voice recorder easily visible on the website. Farmers can also contact officials to locate experts for technical assistance. Through SMS or through the website, farmers can also contact extension agents and report paddy pest outbreaks to the ministry.

The development of the now quite advanced Web (and SMS) portal was done carefully. The ministry did a baseline survey in certain rural areas before implementation. This survey included questions on farmers' economic status, electronic education, literacy, and agricultural challenges. Upon collecting the data, the leaders of the project found that 30 percent of respondents felt that they did not receive adequate agricultural information (through media, television, radio, and other types of ICT). They also found that only 15 percent of respondents owned a computer and 20 percent were computer literate. Not only did this survey help shape the website and its services, but it also confirmed that farmers would need additional support. The ministry

continues to survey farmers, which helps to update Web designers, experts, and the ministry on agricultural issues in rural areas.

Aggregating Research Information in Ghana

Making research results available to the public is also essential to fostering innovative solutions to poverty and economic growth. Much internal research done in developing countries sits in an office, restricting dissemination. Some countries are now actively posting data and country analysis on their websites and open access software (See Topic Note 6.1 in Module 6 for more discussion on the dissemination of research results.) For example, the Ghana Statistical Service, which is closely linked with the Ministry of Finance and Economic Planning, created a website for in-country research and data. The website offers aggregate information on macroeconomic variables, national surveys, and downloadable publications like the Ghana Living Standards Surveys (<http://www.statsghana.gov.gh/Publications.html>) (image 12.1). Many of these survey results focus specifically on rural demographics, such as households engaged in agriculture, household income, assets, credit, expenditure, seasonal patterns, and home processing of agricultural products. The data serve as a resource for development partners and universities trying to address rural challenges. They also inform local governments and actors, as well as donors looking for new areas for investment.

It should be noted that Web portals specifically purposed to help rural farmers are often largely ineffective due to lack of access and regularly updated information. This is even more pronounced for government websites attempting to provide market and price information (more information on these government challenges can be found in Module 9). Rather than abandon Internet portals that do provide worthwhile and open-access information to some farmers, governments should pursue SMS dissemination through Web-to-phone software, while continuing to build regularly updated and reliable content.

INNOVATIVE PRACTICE SUMMARY Using Biometrics to Provide Rural Services

Websites offering research, services, and information are not the only type of ICT that government can use to improve the provision of public services in rural areas. Biometric cards are up-and-coming examples of government-sponsored ICT tools in developing countries. Fingerprints, iris scans, and electronic passports are all useful applications for accurate

IMAGE 12.1. Online Access to Public Data, Such as the Ghana Living Standards Surveys, Can Stimulate Research and Development



Source: Ghana Statistical Service (<http://www.statsghana.gov.gh/Publications.html>).

identification. Identity theft or fraud is a common problem in all countries and poses many challenges to providing public services. For example, a sick person might try to access health care under a relative's plans by using the relative's identification, or a farmer who takes a loan one year might try to pass as another person to receive another loan the following year. Today, credit markets, voting, and targeting public service delivery are prominent identity challenges in agriculture development.

Bangladesh Takes on Biometrics

Biometric ID cards, which are like laminated identification cards but with a microchip or barcode, are being used in developing countries like Brazil, the Republic of Korea, India, Senegal, and Bangladesh for public services like voting and employment programs (image 12.2). In Bangladesh, the Bangladesh Election Commission, the Bangladesh Army, and international organizations took part in designing, funding, and implementing a biometric identification system for 80 million Bangladeshi voters in just three years. During this time, huge training activities took place to build capacity in election workers, and more than 15,000 computers were delivered to voting registration centers. The Bangladesh project had 14 stages, including but not limited to form distribution and data collection, data verification, data export to server, proofreading/editing, preparation of proof voter list and verification, card preparation and handing over for distribution, card distribution, correcting mistakes in cards, and data safeguarding

and distribution (Islam and Grönlund 2010). The project used an Automated Fingerprint Identification System, as well as a multi-biometrics Face-Fingerprint Recognition System that has proven to be very effective in capturing human traits (Jain and Ross 2006). The combined software package produced a two-dimensional barcode with fingerprint templates, along with a card including the person's name, gender, birth date, photo, and signature.

While the project had no shortages of trials, overall, the biometric card initiative in Bangladesh was considered a success. Strategic planning and innovative methodologies helped the project deal with challenges like geography. Enumerators reached even the most rural areas using various types of transportation, including walking, human haulers, speedboats, and helicopters (Islam and Grönlund 2010). The UN stated that the biometric project produced the most credible election in the history of Bangladesh (UNDP 2008), maintaining a 98 percent accuracy rate (UNDP 2009). The success of these biometric identification cards has also generated discussion about future uses. Although use of the cards is now limited to conventional means (e.g., matching a person's card to his or her features through physical examinations), the World Bank is exploring new and cost-effective ways to use the cards for broader purposes, like agriculture or rural public services, through electronic means.

Biometric Innovation in India

Over the next few years, over 1.2 billion people will be issued personal biometric cards that include simple data like birth dates and sex; and in the future, more complex data like criminal records, credit histories in India (image 12.2) (see <http://uidai.gov.in/> for more information). Called "Aadhaar," the unique 12-digit identification numbers, which cost around US\$3 each, will allow all citizens to gain access to public services like banking and education anywhere in the country through the biometric data and online verification systems. Already, 30 million people have been given a number (Polgreen 2011).

IMAGE 12.2. Biometric Identification Can Replace Traditional Forms of Identification



Source: Simone D. McCourtie, World Bank.

The use of these cards is expected to extend (and has already, in some pilot areas) and improve agricultural and rural employment programs. An example of this is the National Rural Employment Guarantee Act (NREGA), established in 2006, which guarantees 100 days of annual employment at minimum wage rates to all rural adults who are willing to perform unskilled manual work. The act involves all levels of government, including the local (*panchayat*) institutions that are primarily responsible for registering households, issuing and distributing job cards, allocating employment, and monitoring the job sites. Applicants to the program must be issued a job card: Once it is issued, recipients can seek employment from a local NREGA program officer (Raabe et al. 2010) (<http://nrega.nic.in>).

Despite the benefits resulting from the program (including the fact that more than half of the program's beneficiaries belong to Scheduled Castes and Tribes, and more than half are women), it has also had its fair share of challenges. Corruption by job card issuers, electoral politics that limit citizens' ability to get access, misappropriations in payment, and substantial delays in issuing cards are only some of the problems experienced. In the last four years, more than 1,200 complaints regarding program irregularities have come to the Ministry of Rural Development ("Biometric Cards to NREGA Workers on Anvil," 2010). However, biometric cards and devices provide opportunities to address these challenges. Biometric cards, instead of job cards, are

being piloted in Andhra Pradesh and Bihar to better identify and ensure payments and accessibility. Wage dispersion will also improve through the use of biometric ATMs (Patowary 2009). These ATMs require fingerprint authentication so rural employees can receive wages by way of a thumbprint scanner instead of a personal identification number. This procedure will help to reduce delays, improve transparency, and reduce irregularities.

Some issues in using biometric data should be noted. Aging or accidents that cause burning or deformities reduce the biometric software's ability to accurately capture all citizen groups (Giné, Goldberg, and Yang 2010). Costs can also be underestimated. The London School of Economics found that in India, the government grossly underestimated the 10-year rollout costs (Giné, Goldberg, and Yang 2010). Also, some societies do not support the use of biometrics. A survey in the United Kingdom concerning biometrics found that 55 percent of respondents felt that biometrics infringed on civil liberties (Giné 2010). Another problem is rollout costs. For just this fiscal year alone, Aadhaar will cost around US\$326 million (Polgreen 2011).

INNOVATIVE PRACTICE SUMMARY

E-Government to Business

E-government to business is also important to ICT development and economic growth. Public agencies can use ICT to bring foreign investment, expand small businesses, and link farmers to buyers. Financial transactions like paying taxes can be carried out online. Electronic markets can facilitate sales and purchases. Businesses can also obtain regulatory information and permits or licenses through government-sponsored ICT. Often, businesses already conduct online transactions (e-commerce) with other firms. If the government also provides online services to businesses, many of the same benefits are gained. E-government services for firms diminish red tape and improve regulatory clarity. As a result, businesses are more competitive and efficient—qualities that are particularly important to the agricultural sector.

Providing Regulatory Information to Small and Medium-Sized Enterprises

Between 2003 and 2008, 24 governments created websites dedicated to serving private enterprises, which use these “one-stop shops” to register, pay taxes, obtain licenses, and complete other business processes (today, there are even more). The service is often very efficient, cutting delays in bureaucratic procedures like registration by 50 percent (Djankov 2008).

Many one-stop shops facilitate business start-ups. Business start-up involves numerous formalities—registration for taxes, pensions, and insurances, screening procedures, opening bank accounts, and obtaining environmental certificates (de Sa 2005). Even in developed countries, these formalities take time.

One-stop shops are most effective online, but some countries can provide only start-up information and documents online; entrepreneurs must travel to a city to complete their business registration. In 2005, Kosovo provided e-government services in this manner. Forms could be downloaded from an e-government website that also specified the sequence of procedures and costs, but the transactions had to be completed at a central location in the capital. Now the Kosovo government is establishing completion locations in each of the municipalities. Reform efforts like these, along with others aiming to expand business capacity, led to a 47 percent increase in registered businesses from 2005 to 2009 (World Bank 2009).

Vietnam has worked for many years to develop quality e-commerce systems. In 2000, the Ministry of Planning and Investment began building a useful website for businesses, particularly foreign investors. The first experiments with e-commerce technology occurred in Ho Chi Minh City and Hanoi (Desai and de Magalhães 2001). Working to simplify administrative procedures, the government created an online, one-stop shop for private enterprise (Vasavakul 2002). This website (in English and Vietnamese) now includes license and permit applications as well as standardized forms for the various departments with which firms must interact during or after registration (Wescott 2003) (For one-stop shop information, see <http://www.dpi.hochiminhcity.gov.vn/invest/index.html> and <http://www.business.gov.vn/mastertop.aspx?LangType=1033>.)

While this one-stop shop certainly expanded capacity for foreign investors, small businesses in rural locations struggled to access similar e-government services. A survey conducted in 2006 (five years after the one-stop shop was implemented) showed that most users living outside of the main cities had poor telecommunications services; one interviewee stated that the “connection in the rural Internet shop is very slow. Many times I wanted to send a message but had to drop since waiting so long” (Nguyen and Nguyen 2006). This rural/urban and domestic/foreign disparity increases the digital divide and reduces the participation of rural smallholders. Though foreign firms have access to one-stop shops, rural owners of small and medium-sized enterprises must resort to slow, costly,

IMAGE 12.3. One-Stop Shops Using ICT Can Increase Efficiencies in SME Start-Ups

Source: Tran Thi Hoa, World Bank.

bureaucratic procedures. Development partners like the World Bank have been working to expand the one-stop shop service to Vietnam's small and medium-sized enterprises by providing specific electronic and physical contact sites (image 12.3). (See <http://www.business.gov.vn/index.aspx> for government efforts to help small and medium-sized enterprises and IPS "Vietnam's One-Stop Shop for e-Government Services," in Module 13 for application to land administration.)

Securing Efficient Payment Systems and Tax Services

Automated payment software systems are very useful e-government technologies. In 2000, the Contribution Network Project (<http://mns.mu/index.php>) was implemented as a public-private partnership between the Mauritian Government, Bank of Mauritius, and the World Bank. As an e-government to business service, the Contribution Network Project provides one channel for all payments that Mauritian firms need to make to a variety of departments (Heeks 2002). A decade later, the Mauritius Revenue Authority (<http://www.gov.mu/portal/sites/mra/index.htm>), a product of the Contribution Network Project, in collaboration with the Companies Division (<http://www.gov.mu/portal/site/compdivsite/menuitem.e24cd2cc6b820a052eada810f6b521ca/>), collects revenue from both business and citizens electronically.

Businesses small and large can set up an account to automatically pay a variety of government-required expenses, including

but not limited to corporate income tax, value-added tax (VAT), national pension scheme, and company registrations. The automated payment software facilitates a computerized relationship between the banks, business, and government.¹ Mauritius uses a Value-Added Network, which is a secured private network between banks and the government, operated by a trusted domestic service provider. When a firm registers for the service, the bank will remove cash from the businesses and send it to the government. The government will then send an email receipt to the business. Identity management software is also used, offering syntax checks,

user validation, and integrity checks, all of which are important to building user confidence.

This transaction scheme has a number of outstanding benefits. Taxes and business fees are crucial to economic development; in fact, in Mauritius "income taxes and VAT constitute around 34 percent of government recurrent revenue" (Lollbearree and Unuth 2001). The benefits of this faster electronic process include:

- Easing pressure on government during busy times like tax periods.
- Reducing employee numbers on government payrolls and preventing staff from making multiple data entries for records (even in developing countries, paper tax forms typically enter a computer system at some point).
- Speeding up cash flow.
- Generating revenue for sustainability.

Initial investment costs can be quite high for automated payment systems like these, but the returns on the investment can surpass them. Setting up the main facility for the Contribution Network Project required a capital investment of around US\$250,000. Employers then bear the costs for hardware, connection to the network, and training (this totals around

¹ For more on automated payment systems, see Sumanjeet (2009) and Frederick (2009).

US\$1,410). There are communications fees based on the volume of data transmitted—currently, employers are charged about US\$0.18 per kilobyte (Lollbearree and Unuth 2001).

Increasing Efficiency in Transportation and Logistics

Businesses, particularly agribusinesses, face major challenges in transportation infrastructure. Poor road conditions like potholes and soft shoulders cause terrible accidents and traffic. The resulting high transaction costs reduce firms' and growers' international competitiveness (Sriraman 2009). Import costs rise and trade declines when road infrastructure is poor; studies have shown that a 10 percent increase in transportation costs lead to a 20 percent decrease in trade volumes (Limao and Venables 2000). Transportation costs can reduce the market value of rural producers' goods to such an extent that it is not cost-effective for businesses to purchase them for export. Similarly, transportation costs for imported commodities can double shipping charges and make them unaffordable for rural citizens. In both cases, private enterprises are deterred from reaching out to rural locations.

Developing countries have adopted toll roads to overcome some of these challenges. Toll roads provide funding to maintain and expand roads, but collecting tolls and fines is quite difficult. Toll operators can pocket fees and bribe drivers for still more cash. Drivers can refuse to pay, and without strong vehicle identification schemes, governments cannot ensure that they are properly fined. Electronic toll collection is a more efficient way of collecting road fees. It reduces the scope for bribery and loss of revenue by tracking cash and vehicle flow, decreases waiting times, and

monitors traffic volumes, which help to predict potential maintenance needs.

Indian businesses face serious obstacles to smooth transportation. The logistics of getting people and goods from Point A to Point B constitute almost 10 percent of the country's GNP, out of which almost 40 percent is transportation (Sriraman 2009). Moreover, the use of vehicles to transport goods has grown in past decades. Road quality and accessibility are important factors in transportation development, but another challenge is the speed of transport. Truck drivers carrying goods, especially over state lines, are stopped and checked, fined, taxed, and questioned. These activities slow traffic and increase transaction costs for both the government and the agribusiness.

India is one of the first developing countries to implement electronic tolling systems. The National Highways Development Project, chiefly funded by toll fees, began a long-term investment in improving road conditions on the country's National Highway Network. The primary initiative of the project was to expand automated tollbooths. The government chose radio-frequency identification (RFID) technology, which uses electromagnetic waves to exchange data between a terminal and an object, like a vehicle, and costs less than other options (table 12.4). (For more information on RFID, see Shepard 2005 and Banks et al. 2007.) A number of activities can be tracked with RFID, such as activities involved in supply chain management, passport or other identification control, and animal identification. For India's toll roads, RFID is coupled with a national, unified, central management system; a legal framework to handle violators; vehicle classifications; and a prepaid system for interested users (Nilekani 2010). Users

TABLE 12.4. Comparing Costs for Electronic Toll Collection, India

	ETC TECHNOLOGY	COST	SUPPLIERS	IN USE	COMMENTS
DSRC	Active Microwave 5.8 GHz	About Rs 2,000 per OBU About Rs 5 Lac per Reader	Limited	Yes (Japan)	Due to higher bandwidth and data speed, supports many ITS applications
	Passive Microwave 5.8 GHz	Rs 1,000 for OBU • Rs 2L for Reader	Multiple	Yes (Europe)	Very Simple OBU
	Infrared ISO-CALM	Rs 1,000 for OBU • Rs 2L for Reader	Limited	Yes (Austria and Malaysia)	Can be easily extended to a contactless card and useful for other ITS applications
RFID	Passive RFID	About Rs 100 per Tag About Rs 2 Lac per Reader	Multiple	Yes (South America, Georgia, U.S.)	Allows tamper resistant "stickers" Small, light, very cheap, almost unlimited life
	Active RFID	About Rs 1,000 per On Board Unit (OBU)	Limited	Yes (Florida)	On-board transmitter, higher range, expensive Finite life, as the battery has to be replaced
	GNSS/CN	About Rs 2 Lac per Reader About Rs 2000 per OBU	Limited	Yes (in Germany)	Too sophisticated and due to absence of toll plazas, enforcement on violations is very difficult in India.

Source: Nilekani 2010.

Note: ETC = electronic toll collection; OBU = on-board unit; DSRC = dedicated short-range communication; GNSS/CN = global navigation satellite system and cellular network; Rs = rupees; 1 lac = 0.1 million; ITS = intelligent transportation systems.

can also pay their bill through mobile phones and credit cards. Technologies like RFID are not limited to the federal government. In India, for example, Gujarat State has computerized its 10 internal checkpoints, a step that dramatically increased state tax revenue and reduced corruption (ADB 2003).

Not only do technologies like RFID dramatically reduce transaction costs for travel; they also create more opportunities to extend e-government to businesses and citizens. Once RFID is established, it can be applied for tracking stolen vehicles, paying vehicle taxes, and paying driving or parking fines (Nilekani 2010).

Even more important, these technologies benefit rural sectors. If businesses have smoother transportation facilities and reduced road costs, they are more likely to travel further to buy or sell agricultural products. Similarly, the revenues gained from toll collection can be applied to infrastructure for rural feeder roads.

INNOVATIVE PRACTICE SUMMARY

E-Government to Government

This section discusses internal e-operations concerning government-to-government interactions. These ICT initiatives are equally important to e-government–citizen and e-government–business relationships, because public agencies that use ICT to service other organizations or people usually are required to use it themselves to make the ICT effective. E-government to government involves “agency to agency” interactions mentioned briefly in the NeGP example. E-government to government or employees is essentially an advancement of human resource and administration capabilities. For employees within a government agency, ICT projects can include human or knowledge management systems, purchasing requisitions, payroll processing, position applications, and department transfers (Fang 2002). It is vital that internal e-government projects integrate service delivery channels and common interministerial infrastructure and do not continue to reinforce fragmented ones (OECD 2003).

Improving Internal Public Financial Systems

Integrated financial management information systems (IFMIS), or the computerization of public expenditure management, are designed to support and track budget decisions and execution, fiduciary responsibilities, and financial reports in various government bodies (USAID 2008). They help lock agencies into a single, common platform for data storage and sharing. IFMIS involves standard data classification, internal controls over data entry and reporting, and common processes for

transactions like procurement. In the long run, the systems should be able to interface with other financial software like payroll. Financial systems have extensive applications—they track incoming revenue, monitor debt, and enable resource management and audit operations (USAID 2008). An important feature is that they can also help federal agencies integrate with local ones to monitor financial flows.

A recent in-depth, qualitative study (Ezz, Papazafeiropoulou, and Serrano 2009) conducted on an IFMIS in Bezuck² illustrates the challenges in implementing integrated financial systems. The IFMIS included a variety of public agencies—the Central Bank, a number of ministries, and the Bezuck Information Support Center (ISC), a prominent think tank that guides cabinet leaders on economic, social, and political decisions. In the early 2000s, these agencies were mandated to interact and collaborate with the ISC to improve financial decision making. The ISC introduced an IT system to facilitate this process by tracking and documenting the various agencies’ transactions. As financial processes became digitized, the historical challenges to collaboration became more apparent. Roles of certain ministries were not clear, and many employees did not understand the new system’s capabilities. Some traditional decision-making processes were interactive, some were sequential, and others depended on another person’s completed tasks. Because of this complexity, ministries struggled to use the new ICT to make financial decisions. Another challenge was overlap in IT support. Ministries have their own IT departments with their own procedures to deal with technology troubleshooting (Ezz, Papazafeiropoulou, and Serrano 2009). Despite these difficulties, the agencies’ attempt at financial integration led to training for over 50,000 government employees (United Nations Department of Economic and Social Affairs 2009).

Decentralizing E-Government to Local Levels

Established in 2005, the Ministry of Local Government in Uganda, in collaboration with DFID and the International Institute for Communication and Development, began to pilot e-government at district headquarters and subcounties. Called DistrictNet, the digital system aimed to improve data and voice communications between district-level officials and the sublocal government actors below them. The system was implemented in 76 districts in all regions, initially focusing on 11 subcounties. Before the ICT was introduced, subcounties collected data through hard-copy forms in the

2 Bezuck is a name invented to preserve the country’s anonymity, because of the challenges in implementing ICT.

communities and sent the forms to district headquarters. This process yielded little data, caused backlogs of three to six months in paperwork, and caused data to be lost during paper shuffles (United Nations Department of Economic and Social Affairs 2009).

The objectives of digitizing some of these processes included increased coordination between district headquarters and subcounties, reduced travel between these locations, improved technical skills, and increased availability of information. To meet these goals, voice and data links were established between district headquarters and subcounty governments. Because many subcounties lacked electricity, other energy sources were used to create the links. A valuable aspect of the project was that it measured the initial results through a variety of indicators, such as the time it took subcounty officials to respond to district queries, the

volume of data exchanges, use of IT systems, and information requests by citizens (United Nations Department of Economic and Social Affairs 2009).

Data are still collected on paper at the community level, but they are digitized by the subcounty and electronically forwarded to district planners, who analyze them and provide feedback to their local government counterparts. Impact studies show that feedback is better and timelier, owing to more accurate, digital data transmission. Because the Ministry of Local Government is no longer involved in the district analysis, staff can focus their energy elsewhere. Significant challenges to implementing the system included low levels of professional technical knowledge and low computer literacy within the local government (Jager and Reijswoud 2003).

Topic Note 12.2: CIVIL SOCIETY AND THE PROVISION OF E-SERVICES

TRENDS AND ISSUES

Civil society organizes in groups that are not part of the local, state, or federal government. These groups include a wide range of institutions, such as unions, trade associations, self-help groups, and NGOs. They can operate on a local, grassroots scale with a small, restricted membership or have a presence in multiple countries and communities. Their serious involvement in economic, social, and political development makes them important participants in the rural governance discussion. Moreover, ICT tools are important to their efficiency and ability to contribute to growth.

Civil society groups can use ICT tools to improve the lives of beneficiaries and internal management, especially given that these tools are widely recognized for their role in promoting democracy, fostering compliance with human rights accords, and improving livelihoods (Ganie-Rochman 2002; Hadiwinata 2003). They provide many digitized services similar to those of public agencies. Civil society groups can facilitate the interactions between producers and extension agents or traders. They can partner with government and contribute to electronic voting and toll collection systems, or they can independently broadcast radio programs on agricultural technology or business. Yet civil society also has the opportunity to use ICT in more sensitive activities. These organizations can publish information on political figures, political parties, or new legislation. They can more easily direct their efforts to

more specific groups or needs and fill voids in public service, whereas government must sometimes function as a public service catchall. The environment, gender, agriculture, and education are all important niches for civil society operations, depending on the context.

Civil society groups are a growing presence in rural areas; of these groups, the most active are domestic and international NGOs. The innovative practice summaries focus on these organizations because they have been so active in rural agriculture. Over the last decade, other civil society organizations—producer groups and self-help groups, particularly in relation to agriculture—have become increasingly involved. Their use of ICT, though related, is addressed in Module 8 on farmers' organizations.

LESSONS LEARNED

Civil society groups can improve rural governance dramatically, especially through ICT. Civil society groups, which are often present in their beneficiaries' communities, have more opportunities to influence cultural and social dynamics than federal or even local government. This role is important, because culture, upbringing, values, and norms influence the extent to which a person or farmer may desire to use ICT. For example, younger people are usually more adept with new computer technologies, the Internet, or SMS applications,

yet in rural societies where senior staff or family members have authority and the most access to information, younger citizens with the ability to learn these new technologies often are not permitted to do so (Mercer 2004). At other times, older people are not confident enough to experiment with new technologies. Civil society groups, especially if they are local organizations, can facilitate the knowledge transfer from youth to senior community members. Again, ICT to enhance governance or even agricultural productivity is not just a matter of physical access and ownership, but also a matter of obtaining social access (Flor 2001; OECD 2003; Madon 2004).

The most positive institutional reforms have grown out of public demand. Limited understanding of ICT applications and their economic usefulness can restrict the demand for and success of these technologies in the agrarian sector. Creating demand for ICT is often easiest when community leaders take a stand and engage both local citizen groups and local politicians. Local civil society organizations can nurture leadership figures and create forums for citizen education and awareness.

INNOVATIVE PRACTICE SUMMARY

Providing 'Hubs' for ICT Innovation

NGOS can offer dynamic services by creating ICT hubs “to channel the information that the farmers need or use to help their work” (Mercer 2004) into one place. When NGOs and development partners offer Internet or ICT support in a central rural location, many people, including farmers, can access e-services more easily. These hubs not only increase farmers’ knowledge communication with others, but they also help the government achieve results. Governments cannot provide overly ambitious public services in developing countries. The participation of development organizations in providing e-services may help to reduce the pressure on underresourced public agencies and promote innovation in rural communities while providing relevant and context-specific information to local people.

InfoDev, in collaboration with a variety of other partners, has very recently developed an innovative hub: the mobile applications lab (or mLabs) (<http://www.infodev.org/en/TopicBackground.34.html>). Considering the rapidly expanding telecommunications infrastructure, mobile applications, and electronic public services, spaces that allow innovation and entrepreneurship to thrive are critical resources. In many developing countries, innovation is thwarted by financial, human, and technological constraints. Even where good

ideas transform into tangible tools, they struggle to gain attention and capital, limiting their viability as a business or service. mLabs seeks to improve this situation. In five different regions (East Africa, Southern Africa, the Caucasus, East Asia, and South Asia), *infoDev* is establishing centers with the tools needed to experiment with and expand innovation, including agriculture innovation.

mLabs (image 12.4) will provide entrepreneurs with high-quality equipment, stable Internet connections, and technical and business training. These services will allow users to test ideas, scale up software capabilities, expand scope, and hone the skills needed to capitalize on their tool or application. Through events, competitions, and business mentoring, innovators will also have easier access to investors. mLabs provides an innovative civil service: a hub that allows creativity, risk, failure, and success, coupled with the necessary tools and support needed to build new instruments that can service the population. This kind of hub is critical to development, particularly because local entrepreneurs know their communities’ needs better than external providers.

mLabs are in incipient stages, starting with an investment of approximately US\$380,000 each. This suggests that mLabs are largely unsustainable without additional and regular financing. While uncertain, mLabs does have a business model that may address common financial constraints. First, depending on the business model used in that location, local programmers, entrepreneurs, developers, or designers can become members of the mLab. Membership is based on the services desired—some memberships are free and others

IMAGE 12.4. mLab in East Africa Assists Agricultural Entrepreneurs



Source: Tim Kelly, World Bank.

are fee based. “Incubatees,” which are at the highest level of membership, are members who are actually pursuing a business idea. Incubatee fees will vary based on location—some will charge a monthly fee, and others will allow free use of the lab under the conditions that the lab receives an equity stake in the company. These incubatees will have full use of the lab and its services; they can also work for a paid salary within the mLab. Without going into great detail on the remaining levels of membership, mLabs expects to collect fees or receive income from companies that land in commercial markets. Additionally, mLabs will reach out to the private and public sectors. Due to their entrepreneurial nature and mobile focus, the mobile applications generated in mLabs are likely to attract seed investment (for more information on mLabs’ business plan and sustainability prospects, see <http://www.infodev.org/en/Article.705.html>).

mLabs East Africa is currently the furthest along in development. The lab has recently selected its first set of incubatees, which includes entrepreneurs focused on agriculture and market information systems (see <http://www.ihub.co.ke/blog/2011/06/first-set-of-incubation-clients-selected-for-mlab-east-africa/> for further information on these start-ups, which include mFarm and Zege Technologies). These start-ups, while receiving the opportunity to gain visibility, capital, and technical assistance, also receive the benefit of contributing to their communities, country, and social and economic development (with the caveat that these hubs and technologies become popular and widely known). mLabs, and the few similar to them (see Grameen AppLabs for innovative approaches on application development: <http://www.grameenfoundation.applab.org/section/index>), have the potential to improve agriculture public services and others by giving underresourced and contextually based entrepreneurs the opportunities to grow.

INNOVATIVE PRACTICE SUMMARY

E-Learning through the Web and SMS

Like government, civil society groups can also provide agriculture information through websites tailored to particular technologies or needs. The Cereal Knowledge Bank is an innovative, interactive website on rice, wheat, maize (corn), and cropping systems (<http://www.knowledgebank.irri.org/>). The International Rice Research Institute and International Maize and Wheat Improvement Center, which launched the website in January 2008, offer useful tools for improving rural agricultural productivity. Users can click on a large button named “Maize Doctor” to receive diagnostic tips. The Cereal Knowledge Bank also offers information on rice evaluation

systems and various cropping methods. Useful for nutrition and crop development, the website contains a glossary on rice as well as downloadable handbooks on disease, hybrid production, rice morphology, and natural disasters. The Cereal Knowledge Bank provides information on extension, such as how to create an extension system, needs and opportunity assessments, and a checklist for extension start-ups.

The site demonstrates a high degree of user-friendliness, or usability, a critical aspect of successful ICT implementation. Text options and clear links to other sites create this friendliness. Useful buttons (“back,” “home,” and “help”) are at the top of each page and clearly marked, making it easy for people of all ages and skill sets to access information. Moreover, the Knowledge Bank maintains information on 13 countries. By clicking on the country flag, users can access the information in the country’s official language. Giving the user options is also part of usability; a lack of options and links to nonexistent websites frustrate users.

Through ICT, development organizations can also provide online networking opportunities to citizens and farmers to increase their learning. Networking leads to empowerment, gives citizens a voice, and makes it easier to disseminate technology in agricultural communities. The Indian Society of Agribusiness Professionals (ISAP) is a civil society institution that was established in 2001. A network of agricultural professionals in India and other developing countries, it now hosts over 15,000 associate members, including 1,500 agri-experts, 525 partner NGOs, 1,050 researchers, and over 824 individual users (according to its website, <http://www.isapindia.org/Default.aspx>). One of the world’s largest agricultural networks, ISAP aims to serve farmers, rural entrepreneurs, and graduate students who do not find appropriate employment (Singh 2006). Its goals, as summarized on its website, include improving the livelihood pattern of smallholders through improving access to affordable technologies and market-related information, extension services and advice, access to market capital and risk management tools, as well as network development.

The network has a number of projects to achieve these goals. It offers training and conferences on commodity futures and trading; to date, ISAP has trained almost 80,000 farmers at 2,064 locations in India. The network also offers programs to upgrade skills. The most innovative aspects of ISAP are its membership program and network solutions. For free, individuals can apply for basic registration, which gives them access to Web sources like “Ask the Expert,” job search engines, an online query redress service, and technology assistance for commercializing products. For Rs 600, an individual can

receive an annual subscription to *Weekly Market Newsletter* in Hindi, access peer-to-peer networks, and obtain a 15 per cent discount on advertisements (posted on the ISAP site) and conference fees. These individuals can also participate in the ISAP consortium for consulting to receive or obtain referrals. For various prices, other development agencies, academic institutions, government agencies, agribusinesses, and overseas organizations can receive the same access.

Finally, the ISAP network connects producers to buyers. The organization involves producers, traders, NGOs, and farmers groups, thus obtaining end-to-end solutions in supply management. Through its networks online and activities on the ground, ISAP provides training on markets and gives technical advice on production and postharvest management to farmers. By tracking these farmers, private enterprises are assured of quality products because they know that the farmer or cooperative in question attended ISAP training.

INNOVATIVE PRACTICE SUMMARY

Collecting Data to Protect Local Knowledge and Ecosystems

Public agencies are limited in their ability to collect relevant data in all rural locations, but new ICT tools make easy data collection possible through civil society groups. CyberTracker (<http://www.cybertracker.org/>), originally created to track animals and plants for conservation, has created opportunities for poor, rural, and illiterate people to collect useful information on a variety of subjects. The technology is open source software developed in South Africa by CyberTracker Conservation in collaboration with the European Commission.

A user interface that uses words and icons (image 12.5) allows nonexpert civil society groups to record a variety of important data. The software can be installed on either a PDA or smartphone to collect large amounts of field observations, with spatial references through a GPS. Using a touch screen, the technology can be customized to fit users' needs and improve efficiency in data collection (for example, users can select which icons or lists they would like shown on the screen). The software can also be customized to local languages. With an icon-based, simple screen, local people can use the technology to collect complex data. When the data are transferred to computers, interactive maps show detailed patterns of ecological features like animal traffic or agricultural areas. Analyzing these patterns has high potential to project future trends, especially if data are collected in a variety of locations (CTA n.d.).

CyberTracker is used all over the world for many purposes. In Africa, it is used primarily to track animals and plants, with the intention of monitoring ecosystem changes caused by climate change. The technology can also be used to monitor crop growth and livestock movement. Local people, even if they have little or no education, can be paid to track ecological change using the technology, because the interface is so user friendly. Aside from creating jobs in the rural sector, the technology captures invaluable local knowledge that is being lost as indigenous populations disperse and new technologies enter rural areas. Rural, indigenous populations gain a more effective position and voice in policy dialogue. Civil society groups working to improve understanding of local needs in agriculture can use CyberTracker to capture relevant data cost-effectively, with few outside resources. They can also use the technology to capture social data through digitized surveys (CTA n.d.).

IMAGE 12.5. CyberTracker Gives Users Icon and Word Options



Source: CyberTracker (<http://www.cybertracker.org/>).

Topic Note 12.3: INCREASING CITIZEN PARTICIPATION THROUGH E-DEMOCRACY

TRENDS AND ISSUES

Waves of new ICT applications have opened opportunities for citizen participation in various types of regimes and locations. In fact, experts feel that one of the most promising digitized applications of ICT is to foster broad participation, local innovation, and social learning (Hanna 2009). This potential, coupled with citizens' recent ability to increase their voice in state affairs and organize more effectively through ICT tools (like those recently witnessed in the Arab Spring), motivates this discussion, as does the fact that citizen participation and demand for public goods is incredibly important in the agrarian sector. The quality of governance in remote locations often depends on citizen involvement, because so few resources are available to reach those locations.

Electronic democratic projects can be designed and implemented by a wide array of institutions. Using ICT to improve democracy is just like using more traditional media to improve democracy. Town hall meetings, complaint call lines, public surveys, petitions, and newspapers are all communications media. Residents of a village facing an economic downturn can meet in a central location to discuss possible community-based options. Political parties can organize a petition, and newspapers can present useful facts on the activities of politicians or proposed legislation. Each of these media has improved its methods through technologies such as the Internet and SMS. Now people around the world have faster, real-time capacity to involve themselves in democratic initiatives, meaning that more stakeholders can affect governance processes (Heeks 2001).

The ICT tools used to foster citizen participation can involve a variety of complex processes. A practical taxonomy of these processes, or what ICT can help to create, is as follows (Macintosh 2004):

- **Information:** One-way relationship; institutions produce and deliver political information to citizens through ICT.
- **Consultation:** Two-way relationship; institutions invite citizens to give feedback on issues; public agencies set the agenda and manage the process through ICT.
- **Active participation:** Partnership relationship; citizens actively engage in setting the agenda and creating content for policy making through ICT.

Digital democracy—a “collection of attempts to practice democracy without the limits of time, space, and other physical conditions, using ICTs” (Nugent 2001, cited in Schweseter 2009)—is not synonymous with electronic voting (as perceived in the past). Considering the taxonomy described earlier, ICT can help citizens influence government decisions in many ways (Macintosh 2004). With ICT, institutions can disseminate information faster through cell phones, radio, or online. To participate in a policy meeting with the Ministry of Agriculture, farmers can use an ICT application like Skype and eliminate typical logistical concerns (such as organizing housing and travel reimbursements for 30 participants). Virtual communities, Web complaint lines, email correspondence between government officials and citizens, participatory budgeting, online media, and Web-based political information sharing are all vectors of digital democracy. Fostering citizen participation through ICT allows citizens to form and find groups that have similar interests; for example, agrarian communities can share information on crop diseases, pests, prices, and technologies. In addition, these communities can discuss and subsequently act on policies that directly affect their activities and livelihoods. Though ICT for citizen participation is most heavily concentrated in wealthier countries, these tools are proliferating to poor countries. Botswana is in the top 25 percent of all countries using electronic means of participation, and five African countries have open Web forums to discuss political topics (Hafkin 2009).

LESSONS LEARNED

The challenges faced by institutions trying to use ICT to improve citizen participation are similar to those faced by public agencies and civil society. Technical and infrastructure challenges are especially strong for voice conversations, because poor network connections hamper effective dialogue.

Unlike e-government and civil society projects intended to improve public services, institutions using ICT to enhance democracy may need to address more serious social and political difficulties. For example, increasing citizen participation shifts the relationship between government and citizens from vertical relationships to horizontal ones (Ndou 2004). Even decentralized and democratic governments have a fairly vertical power hierarchy, or a top-down structure. In many instances, ICT changes this structure rapidly (Fang 2002).

Giving citizens increased access to government information, allowing quick transfer of knowledge through cell phones or email, and providing space for a real-time public forum reduces the vertical structure found in most governments and increases the horizontal one. This horizontal shift can dramatically challenge a societal structure (Saxena 2005). While this shift is generally a positive step toward citizen representation, it may provoke a far-reaching backlash from politicians, policy makers, elitists, traditional authorities, and others, reducing the effectiveness of the ICT for citizen participation. Some of these negative consequences are currently being witnessed in the regime changes occurring in the Middle East and North Africa.

Using ICT for democratic projects also increases the visibility of cultural challenges. Teaching rural citizens how to use ICT is a challenge in itself, as is fostering their understanding of participation. If digital exercises in participation are meant to be inclusive, addressing perceptions of equality within the community is also necessary. Women, youth, and other vulnerable groups are often excluded from political decision making within communities. Extending their participation to higher levels with new technologies is not effective unless root societal dynamics are explored and addressed.

INNOVATIVE PRACTICE SUMMARY

Information Kiosks in India

The Gyandoot project (see <http://www.gyandoot.nic.in/>) in drought-prone, rural Madhya Pradesh in India is a solid example of both e-government services and e-democracy. Thirty-eight government-owned telekiosks were established in central locations like village markets and major roads in Dhar District (Cecchini and Raina 2004), where 60 percent of the population lives below the poverty line (Jafri, Dongre, and Tripathi 2002) (image 12.6). Rather than using expensive local area networks and very small aperture terminal technologies, the kiosks, which each serve approximately 25–30 villages through cybercafés (Meera, Jhamtani, and Rao 2004), operate through a dial-up network with modems from existing telephone lines. E-government services within the cybercafés include regularly updated price information, computer training, application for income and domicile certificates,

IMAGE 12.6. Rural Kiosks Can Lead to Information Sharing Between Agrarian Communities



Source: Ray Witlin, World Bank.

employment news, and a landholder's book of land rights and loans. Yet Gyandoot also provides ICT that enhances democracy, partly because it is an intranet system—all of the kiosks are connected to allow citizens to share information. An online rural newspaper updates citizens with local political information like public expenditures and raises awareness in their villages. Complaint lines, expert opinions on legal matters, and email are also available.

Gyandoot has had its successes and challenges.³ First, providing services like price information and village auctions online and directly to farmers removes the intermediaries who commonly take advantage of rural impoverished citizenry (Meera, Jhamtani, and Rao 2004). Second, kiosk operators performed well. Third, almost 80 percent of users were satisfied with Gyandoot's services. Finally, high rates of satisfaction match the fairly high rates of government action. Sixty percent of complaints put forth through the Gyandoot system were addressed within one week; according to one survey, district administrators felt that officials' performance improved dramatically and immediately because they knew citizens could file complaints (Jafri, Dongre, and Tripathi 2002).

³ Though some of these figures are dated, they are worth including because the real effects of many ICT e-governance initiatives have not been widely studied.

On the other hand, individual access to Gyandoot kiosks is fairly low. One survey showed that many kiosks served only one to four people per day (Cecchini and Raina 2004). Electricity outages and distance to the kiosk often caused this problem. Socioeconomic factors also posed challenges for Gyandoot. All surveys cited here found that most users were wealthier male community members. Start-up and intranet costs of more than Rs 2.5 million (Bhatnagar and Vyas 2001) were also high. Compared to user fees at Rs 5 to Rs 25 per service, incoming revenues could not cover the initial expenses.

INNOVATIVE PRACTICE SUMMARY

Virtual Communities

The proliferation of virtual communities is another result of expanding Internet connectivity. Presently, tens of thousands of virtual communities interact via Web-based technology. Virtual communities are groups of people who join and participate in online organizations, usually for a specific purpose, practice, circumstance, or interest (Kim n.d.). The people in the community may never interact with one another in person, yet with open source technology they can connect, discuss, and act on local, national, and international issues.

Types of virtual communities range widely. People create communities for commerce (such as eBay and Craigslist). Development organizations create databases that members can access for research. Political groups can create websites for activists to sign petitions or receive information on events.

Practitioners can also set up “communities of practice” and organize continuous dialogue on projects or provide useful job-related material. These communities can help sustain conversation. For example, after a conference or workshop, interactions between participants usually cease. Yet some have found that forming an online community of practice after the event helps to retain long-term participation (Kim n.d.). Online communities could have potential for public agencies and civil society groups in developing countries. Often, participants in meetings organized through ministries are required to travel to the capital. After the meeting or workshop adjourns, they return to their rural communities. If ministries could create a portal, or community of practice, for these participants, facilitating future meetings and continuing conversation over a sustained period of time might be easier.

Political virtual communities are also shaping democracy, holding great potential for creating transparency and

generating information on politicians, candidates, and policy. The United States has numerous websites that provide political information and express views on elected representatives. DNet (<http://dnet.org/>) and Project Vote Smart (<http://www.votesmart.org/>) are led by NGOs. DNet provides information about candidates’ positions on election issues. It also gives media reports, and encourages candidates themselves to post statements, biographical data, and endorsements. In some cases, citizens can communicate directly with candidates via email and host live interviews. Discussion boards can also be generated for citizen-to-citizen communication.

In developing countries, political communities like these are slowly coming online and may help generate more public awareness and participation. As early as 2004, the Tanzanian National Assembly introduced a website for parliamentary decisions and data. Called POLIS, the site provides citizens with the proceedings of parliament and other government activities (<http://parliament.go.tz/POLIS/Bunge/Polis.asp?Menu=0>). Full texts of legislation, fact sheets, and information like parliamentarians’ voting records are housed in this portal. Easy navigation tools—including the MP Profile Database, Bill Tracking System, Session Management System, and the Act and Documents Management System—help citizens find information (United Nations Department of Economic and Social Affairs 2009). To achieve further transparency in rural areas and for illiterate citizens, future initiatives could include mobile phone applications or POLIS radio broadcasts.

INNOVATIVE PRACTICE SUMMARY

Government Responsiveness through Citizen Participation in Digitized Political Processes

Government responsiveness is one of the foundations of effective democracy. Innovative ICT tools give governments the opportunity to respond more efficiently and broadly through issue-based and policy-based forums. Participation in political processes ranges from expressing online grievances to electronic consultation to participatory budgeting. This section provides an example for each of these interventions.

The Government Information Agency in Korea is considered the best-practice example for implementing this type of ICT. Even before 1990, Koreans could access a number of online services, including registering births and locating relevant economic statistics (Sang, Tan, and Trimi 2005). In addition to a frequently updated webpage, secure e-signature system, and personnel management system, the website also provides transparent and timely responses to citizens’ inquiries.

(For more information on electronic signatures, see Gupta, Tung, and Mardsen 2004.) If someone requests information related to a specific government policy, public officials collect the applicable information and post results within the week (Holzer and Manoharan 2004), demonstrating fast and reliable government responsiveness.

In addition, Korea has created e-People (see <http://www.epeople.go.kr/jsp/user/on/eng/intro01.jsp>), an anticorruption portal that uses cloud computing, complaint lines, petitions, and discussion forums to reduce corruption and boost citizen engagement in the country. All government ministries and local government departments, along with 448 public sector organizations are on e-People. The site receives over 100,000 hits per day, and over 8,000 complaints were documented in 2010 alone. When a complaint is made, it is categorized and forwarded to the relevant agency, where the agency has an opportunity to respond. Citizens (and foreigners or diasporas, who are also allowed to use the site) can check the status of their complaint and evaluate the response given as well. Users can also view a record of the complaints sent by others, allowing them to choose whether to withdraw or submit a similar complaint. This option reduces the amount of petitions going to the agencies while also helping the government assess the magnitude of the problem.

Participatory budgeting, which is gaining traction around the world, occurs when communities and citizens directly determine how a portion of the public expenditure will be used. The first phase of a pilot project recently completed in the Democratic Republic of Congo has had remarkable success, despite what would appear to be great hurdles. The World Bank, in partnership with the provincial government, forged a partnership with Airtel, the largest cell provider in the Democratic Republic of Congo. Airtel provided geographic information and premium numbers to the team. After districtwide deliberations, where discussants debated and selected five to six main priorities for their district, a short list of numbered priorities was created. Before voting day, SMS messages were sent to the district's Airtel users (almost 300,000 people), directing voters on how to participate. On voting day, users sent a four-digit code that represented their district to the premium number. Once they received the short list of priorities for their district and responded, they received a confirmation of their vote. Their votes were documented in real time in an online database, which was connected to a GPRS modem with a very low bandwidth. Conventional means of voting were also made available for those without cell phones or an Airtel subscription.

Results were promising. After votes were in, public expenditures were allocated from the central government to the provincial government and were then used in local projects determined by the citizens within the given district. In some cases, over US\$80,000 was invested in an intervention such as a school building, health clinic, roads, or irrigation structures. In most cases, this was the first time that any real investment was made in the districts.

Despite the success of the pilot, there are many challenges ahead. Implementing construction efficiently is challenging in rural areas because the work is often done in remote areas with few qualified staff. SMS hotlines or phones with camera capacity could be an option to address this challenge. Scalability is also in question: once initial donor support ends, public and governmental support for the project (which requires time and capital) may fade. SMS messaging is too expensive for citizens to afford, and public subsidization may be necessary for a number of years. (Source for all information: Weber, Maketa, and Tiago 2011).

INNOVATIVE PRACTICE SUMMARY

Digital Media Forums in Developing Countries

Media outlets also provide space for ICT initiatives to enhance good governance. Traditional newspapers that have created online websites generate real-time public participation through comments and letters. Live chat sessions are also possible through online newspapers, and experts or writers can respond to readers' comments to carry on discussions about the topic. These online and interactive news sources and chats are not limited to more technologically capable countries. Zimbabwe, Bolivia, Nicaragua, the Philippines, and Ghana are only a few of the many developing countries providing media online.

Online independent newspapers can be effective in strict political regimes with little freedom of speech. One such newspaper, *Malaysiakini* (<http://malaysiakini.com/>), made an enormous impact on governance in a country where the ruling party dominated the media. The newspaper provides information in four languages. Information includes alternative views on local politics (Pang 2006), and articles explore trade issues, government budgets, mining, foreign direct investment, migration, religion, and agricultural development. New legislation, politics, and corruption are frequently debated. When serious news arises, the online news source also sends subscribers SMS alerts.

In the last few years, the website has received almost 40 million page views and 800,000 video downloads per

month (*Malaysiakini* 2008). Its success stems largely from the fact that it is only online. Online media cost less than print media (Pang 2006), and the site is subscription based. Users pay approximately US\$40 to access the daily content. This fee may be high for rural citizens, yet civil society groups could help to pay this price to make the information available to poorer people through a hub like a telecenter. A significant limitation is that because the newspaper is not produced in a traditional print format, it cannot receive press accreditation, so its journalists cannot enter political spaces and attend potentially important meetings (Pang 2006).

An organization in Tanzania, Daraja (<http://www.daraja.org/>), is also experimenting with ICT and media to achieve improvements in local government and boost citizen inclusion in political processes. The new organization intends to build links between government and communities on critical topics in Tanzania. One such project involves water services: over half of Tanzania's rural water points are malfunctioning despite increases in government funding and population growth. The three-year "Raising the Water Pressure" program uses local populations and the media to place political pressure on government officials in rural areas. Through mobile phones, citizens can send feedback or grievances about their local water supply. This information is forwarded to the appropriate district officials and the local media. Local media can then interact with district officials to determine their plan of action regarding the poor water service (image 12.7).

The use of mobile phones also increases the voice of the common citizen or vulnerable group that may not receive access to the government. Since its inception, 500 texts have been sent to the water database, of which 100 have been forwarded to district officials. Only 100 have been forwarded due to challenges with illegibility; illiteracy is a major barrier to the program's success. However, in the cases where grievances were passed to government officials, reactions have been positive. Daraja also plans to assist local governments in technical capacities, in order to build a positive relationship with local officials (Taylor 2011). (For more information on this project, see <http://www.daraja.org/our-work/rtwp/>.)

Blogging is another innovative and inexpensive form of ICT used internationally

to improve public access to information and opinion. Blogs provide writers a space to express personal views or experiences and give readers the opportunity to learn from first-hand accounts. Most bloggers live in wealthier countries, but blogging is becoming more common in poorer ones.

Global Voices, an international nonprofit, offers a space for bloggers and readers in almost 20 languages. With a community of over 300 bloggers and translators, the organization aims to "aggregate, curate, and amplify the global conversation online" (<http://globalvoicesonline.org>). Global Voices partners with authors to produce relevant, region-specific blogs in countries all over the world. Readers can access blogs written on specific subjects like agriculture. Of course, many bloggers on Global Voices tend to be urban and more educated than rural farmers. As a result, the organization began an outreach project called Rising Voices. Twice a year, the initiative holds a microgrant competition to select new media outreach projects. Recipients of these grants teach ICT techniques to communities that are poorly positioned to take advantage of tools like blogging.

There are certainly constraints to blogging in developing countries, especially rural areas; lack of electricity and low bandwidth are typical challenges. Blog tools are often in English, which limits who can use them, but the number of blog tools is expanding quickly. A number of providers like Wordpress, Google, and Aeonity offer free hosting and troubleshooting help for users. In fact, Weebly has a "drag

IMAGE 12.7. ICT Can Support Well Water Infrastructure Monitoring



Source: Curt Carnemark, World Bank.

and drop” editor, so users can simply drag pictures and text onto their Web pages.

REFERENCES AND FURTHER READING

- ADB (Asian Development Bank). 2003. *Case Studies*. Manila: ADB.
- Banks, J., M. Pachano, L. Thompson, and D. Hanny. 2007. *RFID Applied*. Hoboken, NJ: John Wiley & Sons.
- Becker, T., and T. Ohlin. 2006. “The Improbable Dream: Measuring the Power of Internet Deliberations in Setting Public Agendas and Influencing Public Planning and Policies.” *Journal of Public Deliberation* 2 (1): 1–22.
- Berman, B., and W. J. Tetley. 2001. “African States, Bureaucratic Culture, and Computer Fixes.” *Public Administration and Development* 21 (1): 1–13.
- Bhatnagar, S., and N. Vyas. 2001. “Gyandoot: Community-Owned Rural Internet Kiosks.” World Bank eGovernment website. <http://go.worldbank.org/V5YKYDSRE0>, accessed February 2011.
- Blakely, R. 2009. “India to Issue All 1.2 Billion Citizens with Biometric ID Cards.” *Sunday Times*, July 15. <http://www.timesonline.co.uk/tol/news/world/asia/article6710764.ece>, accessed October 2011.
- Bonfadelli, H. 2002. “The Internet and Knowledge Gaps: A Theoretical and Empirical Investigation.” *European Journal of Communication* 17 (1): 65–84.
- Cecchini, S., and M. Raina. 2004. “Electronic Government and the Rural Poor: The Case of Gyandoot.” *Information Technologies and International Development* 2 (2): 65–75.
- Chantararat, S., A. Mude, C. Barrett, and C. Turvey. 2010. “The Performance of Index Based Livestock Insurance: Ex Ante Assessment in the Presence of a Poverty Trap.” International Livestock Research Institute. http://www.ilri.org/ibli/images/stories/files/IBLI_2_January2010.pdf, accessed November 2010.
- Chapman, R., and T. Slaymaker. 2002. *ICTs and Rural Development: Review of Literature, Current Interventions, and Opportunity for Action*. London: Overseas Development Institute (ODI).
- CTA (Technical Centre for Agricultural and Rural Cooperation). n.d. “Educational video on CyberTracker.” <http://pgis.cta.int/completed-initiatives/73-educational-video-on-cybertracker>, accessed January 2011.
- Dahlberg, L. 2001. “The Internet and Democratic Discourse: Exploring the Prospects of Online Deliberative Forums Extending the Public Sphere.” *Information, Communication, and Society* 4 (4): 615–33.
- de Sa, L. 2005. *Business Registration Start-Up: A Concept Note*. Washington, DC: International Finance Corporation (IFC), World Bank.
- Desai, M., and N. de Magalhaes. 2001. “Vietnam’s Tale of Two Cities.” World Bank, accessed February 2011. <http://go.worldbank.org/ANV1MDO1C0>.
- Diamond, J., and P. Khemani. 2005. “Introducing Financial Management Systems in Developing Countries.” IMF Working Paper 05/196, International Monetary Fund, Washington, DC.
- Djankov, S. 2008. “A Response to ‘Is Doing Business Damaging Business?’” World Bank, Washington, DC.
- Doctor, S., and W. Dutton. 1999. “The Social Shaping of the Democracy Network (DNet).” In *Digital Democracy: Discourse and Decision Making in the Information Age*, edited by B. Hague and B. Loader, 222–42. London: Routledge.
- Donner, J. 2009. “Mobile-Based Livelihood Services in Africa: Pilots and Early Deployments.” In *Communication Technologies in Latin America and Africa: A Multidisciplinary Perspective*, edited by M. Fernandez-Ardevol and A. Ros Hijar, 37–58. Barcelona: IN3.
- E-Agriculture. 2010. “Gender, Information, and Communication.” www.e-agriculture.org, accessed January 2011.
- ECA (Economic Commission for Africa). 2004. *Economic Report on Africa 2004: Unlocking Africa’s Trade Potential*. Addis Ababa: ECA.
- Economic Times. 2010. “Biometric Cards to NREGA Workers on Anvil.” May 30. Accessed February 2011, <http://economictimes.indiatimes.com/news/economy/policy/Biometric-cards-to-NREGA-workers-on-anvil/articleshow/5990480.cms>.
- ESCAP (United Nations Economic and Social Commission for Asia and the Pacific). 2011. “What Is Good Governance?” <http://www.unescap.org/pdd/prs/ProjectActivities/Ongoing/gg/governance.asp>, accessed February 2011.
- Ezz, I., A. Papazafeiropoulou, and A. Serrano. 2009. “Challenges of Interorganizational Collaboration for Information Technology Adoption.” *Information Technology for Development* 15 (3): 209–23.
- Fang, Z. 2002. “E-government in Digital Era: Concept, Practice, and Development.” *International Journal of the Computer, the Internet, and Management* 10 (2): 1–22.
- FARA (Forum for Agricultural Research in Africa). 2009. “GCARD-Africa E-Consultation Report.” Food and Agriculture Organization. <http://www.fao.org/docs/eims/upload/270028/GCARD%20Africa%20econsultation%20report%20final.pdf>, accessed February 2011.
- Flor, A. 2001. “ICT and Poverty: The Indisputable Link.” Paper prepared for the 3rd Asia Development Forum on Regional Economic Cooperation in Asia and the Pacific, organized by the Asian Development Bank, Bangkok, June 11–14. [http://kambing.ui.ac.id/onnopurbo/library/library-ref-ind/ref-ind-1/application/poverty-reduction/!%20ICT4PR/ICT%20and%20poverty%20-%20the%20link%20\(WB%20Report\).pdf](http://kambing.ui.ac.id/onnopurbo/library/library-ref-ind/ref-ind-1/application/poverty-reduction/!%20ICT4PR/ICT%20and%20poverty%20-%20the%20link%20(WB%20Report).pdf), accessed February 2011.
- Frederick, L. 2009. “Information Technologies That Extend Rural Microfinance Reach.” Chapter 10 in *New Partnerships for Innovation in Microfinance*, edited by I. Matthäus-Maier and J. D. von Pischke, 173–94. Berlin: Springer-Verlag.
- Fuchs, C., and E. Horak. 2008. “Africa and the Digital Divide.” *Telematics and Informatics* 25: 99–116.
- Ganie-Rochman, M. 2002. *An Uphill Struggle: Advocacy NGOs Under Soeharto’s New Order*. Jakarta: Lab Sosio FISIP UI.

- Gillwald, A., A. Milek, and C. Stork. 2010. *Gender Assessment of ICT Access and Usage in Africa*. Ottawa: International Development Research Centre (IDRC).
- Giné, X. 2010. "Biometric Technology in Rural Credit Markets: The Case of Malawi." *Innovations in Rural and Agriculture Finance*, Brief 9, International Food Policy Research Institute and World Bank, Washington, DC.
- Giné, X., J. Goldberg, and D. Yang. 2010. "Identification Strategy: A Field Experiment on Dynamic Incentives in Rural Credit Markets." Policy Research Paper 5438, World Bank, Washington, DC.
- Gupta, A., A. Tung, and J. Mardsen. 2004. "Digital Signature: Use and Modification to Achieve Success in Next Generational E-Business Processes." *Information and Management* 41 (5): 561–75.
- Hachigian, N., and L. Wu. 2003. "Political Implications of the Information Revolution in Asia." Chapter 2 in *The Information Revolution in Asia*, edited by N. Hachigian and L. Wu, 55–91. Santa Monica: RAND Corporation.
- Hadiwinata, B. 2003. *The Politics of NGOs in Indonesia: Developing Democracy and Managing a Movement*. London: Routledge Curzon.
- Hafkin, N. J. 2009. "E-government in Africa: Progress Made and Challenges Ahead." Presentation for Electronic/Mobile Government in Africa: Building Capacity in Knowledge Management through Partnership, sponsored by the United Nations Department of Social and Economic Affairs (UNDESA), United Nations Public Administration Network (UNPAN), and United Nations Economic Commission for Africa (UNECA), Addis Ababa, 17–19 February. <http://unpan1.un.org/intradoc/groups/public/documents/un/unpan033526.pdf>, accessed February 2011.
- Hanna, N. K. 2009. "National E-government Institutions: Functions, Models, and Trends." In *Information and Communications for Development, Extending Research and Increasing Impact*, edited by T.W. Bank, 83–102. Washington, DC: World Bank.
- Heeks, R. 2001. *Building E-governance for Development*. Manchester: Institute for Development Policy and Management University of Manchester.
- . 2002. "E-government in Africa: Promise and Practice." *Information Polity* 7: 97–114.
- Holzer, M., and A. Manoharan. 2004. "Global Trends in Municipal E-government: An Online Assessment of Worldwide Municipal Web Portals." In *Foundations of E-government*, edited by A. Agarwal and V. V. Ramana, 178–188. International Congress of E-government, accessed February 2011. http://www.iceg.net/2007/books/1/19_303.pdf.
- Hong, L., and A. Jain. 1998. "Integrating Faces and Fingerprints for Personal Identification." *IEEE Transactions on Pattern Analysis and Machine Intelligence* 20 (12): 1295–307.
- InfoDev. 2002. *The E-government Handbook for Developing Countries*. InfoDev and Center for Democracy and Technology. Washington, DC: World Bank.
- International Telecommunication Union. 2001. *The E-city: Singapore Internet Case Study*. <http://www.itu.int/ITU-D/ict/cs/singapore/material/Singapore.pdf>, accessed February 2011.
- . 2010. *The World in 2010: The Rise of 3G*. ICT Facts and Figures. <http://www.itu.int/ITU-D/ict/material/FactsFigures2010.pdf>, accessed February 2011.
- Islam, S. M., and A. Grönlund. 2010. "The Bangladesh National Biometric Database: A Transferable Success?" In *Proceedings of the First International Conference on Electronic Government and the Information Systems Perspective*, edited by K. N. Andersen, E. Francesconi, A. Grönlund, and T. M. van Engers, 189–201. Berlin: Springer-Verlag.
- IWS (Internet World Stats). 2010. *Internet Usage Statistics*. <http://www.internetworldstats.com/stats.htm>.
- Jafri, A., A. Dongre, and V. Tripathi. 2002. "Information Communication Technologies and Governance: The Gyandoot Experiment." ODI Working Paper 160, Overseas Development Institute (ODI), London.
- Jager, A., and V. Reijswoud. 2003. *E-governance: The Case of DistrictNet in Uganda*. The Hague: International Institute for Communication and Development (IICD).
- Jain, A., and A. Ross. 2002. "Learning User Specific Parameters in a Multi-Biometric System." In *Proceedings of the International Conference on Image Processing (ICIP 2002)*, New York 57–70.
- . 2006. "Biometrics: A Tool for Information Security." *IEEE Transactions on Information Forensics and Security* 1 (2): 125–43.
- Jiang, J., W. Muhanna, and J. Klein. 2002. "User Resistance and Strategies for Promoting Acceptance across System Types." *Information and Management* 37 (1): 25–36.
- Jung, J., J. Qui, and Y. Kim. 2001. "Internet Connectedness and Inequality: Beyond the Divide." *Communication Research* 28 (4): 507–35.
- Kamssu, A., J. Siekpe, and J. Ellzy. 2004. "Shortcomings to Globalization: Using Internet Technology and Electronic Commerce in Developing Countries." *Journal of Developing Areas* 38 (1): 151–69.
- Katz, J., R. Rice, and P. Aspden. 2001. "The Internet 1995–2000: Access, Civic Involvement, and Social Interaction." *American Behavioural Scientist* 45 (3): 405–19.
- Kim, R. n.d. "Virtual Communities and 'Low-Tech' Tools: Lessons Learned at the World Bank." World Bank. <http://go.worldbank.org/E62FVAM8S0>, accessed November 2010.
- Klein, J. 2000. "User Resistance and Strategies for Promoting Acceptance across System Types." *Information and Management* 37 (1): 25–36.
- Komarinski, P. 2005. *Automated Fingerprint Identification Systems*. Burlington, MA: Elsevier.
- Layne, K., and J. Lee. 2001. "Developing Fully Functional E-government: A Four Stage Model." *Government Information Quarterly* 18 (2): 122–36.
- Limao, N., and A. Venables. 2000. *Infrastructure, Geographical Disadvantage, and Transport Costs*. Washington, DC: World Bank.
- Loges, W., and J.-Y. Jung. 2001. "Exploring the Digital Divide: Internet Connectedness and Age." *Communication Research* 28 (4): 536–62.

- Lollbearree, M.B., and R. Unuth. 2001. "Contributions Network in Mauritius." World Bank. <http://go.worldbank.org/QA6A26S3R0>, accessed November 2010.
- Macintosh, A. 2004. "Characterizing E-participation in Policy-Making." Proceedings of the 37th Hawaii International Conference on System Sciences, IEEE.
- Madon, S. 2004. "Evaluating the Developmental Impact of E-governance Initiatives." *Electronic Journal on Information Systems in Developing Countries* 20 (5): 1–13.
- Mahmood, K. 2005. "Multipurpose Community Telecenters for Rural Development in Pakistan." *Electronic Library* 23 (2): 204–20.
- Malaysiakini. 2008. "About Us." http://weblog.malaysiakini.com/?page_id=2, accessed November 2010.
- Manasian, D. 2003. "Digital Dilemmas: A Survey of the Internet Society." *Economist*, January 23. http://www.economist.com/node/1534303?story_id=1534303, accessed December 2010.
- Marcelle, G. 2003. "Reconsidering Technology Transfer." *International Journal of Technology Transfer and Commercialisation* 2 (3): 227–48.
- Mathison, S. 2002. *Digital Dividends for the Poor: ICT for Poverty Reduction in Asia*. Malaysia: Global Knowledge Partnership.
- Meera, S. N., A. Jhamtani, and D. Rao. 2004. "Information Communication Technology in Agricultural Development: A Comparative Analysis of Three Projects from India." Agricultural Research and Extension Network (AGREN) Paper 135. London: Overseas Development Institute (ODI).
- Mercer, C. 2004. "Engineering Civil Society: ICT in Tanzania." *Review of African Political Economy* 31 (99): 49–64.
- Moon, M. 2002. "The Evolution of E-government among Municipalities: Rhetoric or Reality?" *Public Administration Review* 62 (4): 424–33.
- Ndou, V. 2004. "E-government for Developing Countries: Opportunities and Challenges." *Electronic Journal on Information Systems in Developing Countries* 18 (1): 1–24.
- Nguyen, Tuyen Thanh, and Hai Thi Thanh Nguyen. 2006. "Grounding E-government in Vietnam: Bringing More Government Services to Citizens." Paper presented at the Vietnam E-Government Symposium 2006, Centre for Community Networking Research, Hanoi. <http://ccnr.net/system/files/Grounding+egovernment+in+Vietnam.pdf>, accessed February 2011.
- Nilekani, N. 2010. *Review of Electronic Tollbooths*. New Delhi: Unique Identification Authority of India.
- Norris, D., and K. Kraemer. 1996. "Mainframe and PC Computing in American Cities: Myths and Realities." *Public Administration Review* 56 (6): 568–76.
- Nugent, J. 2001. "If E-democracy Is the Answer, What's the Question?" *National Civic Review* 90 (3): 221–23.
- Nugroho, Y. 2008. "Spreading the Word, Broadening Perspectives: Internet, NGOs and Globalisation Discourse in Indonesia." Manchester Business School Working Paper 544, Manchester.
- OECD (Organisation for Economic Co-operation and Development). 2003. "The E-government Imperative: Main Findings." OECD Policy Brief. <http://www.oecd.org/dataoecd/60/60/2502539.pdf>, accessed February 2011.
- Palanisami, K. n.d. *E-learning and Its Approach in TNAU*. Centre for Agriculture and Rural Development Studies (CARDS), Tamil Nadu Agricultural University (TNAU). <http://akicb.ifas.ufl.edu/pdf/e-learning%20at%20TNAU%20%20by%20K.Palanisami.pdf>, accessed February 2011.
- Pang, A. 2006. "Managing News in a Managed Media: Mediating the Message in Malaysiakini.com." *Asia Pacific Media Educator* 1 (17): 71–95.
- Parajuli, J. 2007. "A Content Analysis of Selected Government Web Sites: A Case Study of Nepal." *Electronic Journal on E-government* 5 (1): 87–94.
- Patowary, D. 2009. "Assam to Use Biometric Cards for Wage Disbursement under NREGA." *Hindustan Times*, December 2. <http://www.hindustantimes.com/Assam-to-use-biometric-cards-for-wage-disbursement-under-NREGA/Article1-482176.aspx#>, accessed December 2010.
- Polgreen, Lydia. 2011. "Scanning 2.4 Billion Eyes, India Tries to Connect Poor to Growth." *New York Times*, September 2. <http://www.nytimes.com/2011/09/02/world/asia/02india.html?pagewanted=1&r=1&hp>, accessed September 2, 2011.
- Raabe, K., R. Birner, M. Sekher, K. Gayathridevi, A. Shilpi, and E. Schiffer. 2010. "How to Overcome the Governance Challenges of Implementing NREGA." IFPRI Discussion Paper 963, International Food Policy Research Institute (IFPRI), Washington, DC.
- Reidl, R. 2001. "Limitations for Interstate E-government and Interdisciplinary Projects." In *12th International Workshop on Database and Expert Systems Applications*, edited by A. M. Tjao and R. Wagner, 377–82. Washington, DC: IEEE.
- Relani, A. 2004. "G2G E-Government: The Big Challenge for Europe." Master's thesis, Department of Informatics, University of Zurich.
- Riley, C. G. 2003. "The Changing Role of the Citizen in the E-governance and E-democracy Equation." Commonwealth Center for E-Governance, Tanzania Development Gateway. http://www.tanzaniagateway.org/docs/Changing_role_of_the_citizen_in_the_E-governance_E-democracy_equation_2003.pdf, accessed February 2011.
- Sang, L., X. Tan, and S. Trimi. 2005. "Current Practices of Leading E-government Countries." *Communications of the ACM* 48 (10): 99–104.
- Sardi, X. C., and K. Mlikota. 2002. "Overview on E-governance." Working paper prepared in the framework of the ICT cross-cutting project "ICTs as Tools for Improving Local Governance," United Nations Economic, Scientific, and Cultural Organization (UNESCO), Paris.
- Saxena, K. 1995. "Informatization and Infocrats." *DATAQUEST* 12 (37): 154–6.
- . 2005. "Towards Excellence in E-governance." *International Journal of Public Sector Management* 18 (6): 498–513.
- Schwester, R. 2009. "Examining the Barriers to E-government Adoption." *Electronic Journal of e-Government* 7 (1): 113–22.

- Selwyn, N. 2004. "Reconsidering Political and Popular Understandings of the Digital Divide." *New Media and Society* 6 (3): 341–62.
- Shepard, S. 2005. *Radio Frequency Identification*. New York: McGraw-Hill.
- Singh, S. 2006. *Selected Success Stories on Agricultural Innovation Systems*. Thailand: Asia-Pacific Association of Agricultural Research Institutions.
- Sriraman, S. 2009. "The Role of Transportation and Logistics in India: Emerging Issues and Prospects." *MITES Journal* 11 (1): 18.1–18.10.
- Somolu, O. 2007. "'Telling Our Own Stories': African Women Blogging for Social Change." *Gender and Development* 15 (3): 477–89.
- Sumanjeet, S. 2009. "Emergence of Electronic Payment Systems in the Age of Electronic Commerce: The State of the Art." *Global Journal of International Business Research* 2 (2): 17–36.
- Sustainable Initiatives. 2003. "Gyandoot, Madhya Pradesh: A Network of Empowerment for Rural People through Self-sustainable Use of Information and Communications Technology." Gamos and Big World Research Project for the Department for International Development (UK). <http://www.sustainableicts.org/Gyandoot%20F.pdf>, accessed February 2011.
- UNDP (United Nations Development Programme). 2008. "Celebrating the End of Photo Voter Registration: Challenges Overcome." UNDP, Bangladesh.
- . 2009. *PERP Evaluation Report*. Bangladesh: UNDP.
- United Nations Department of Economic and Social Affairs. 2009. *Compendium of Innovative E-government Practices*. New York: United Nations Department of Economic and Social Affairs.
- USAID (United States Agency for International Development). 2008. *Integrated Financial Management Information Systems, A Practical Guide*. Washington, DC: USAID.
- van Dijk, J.A.G.M. 2006. *The Network Society: Social Aspects of New Media*. 2nd ed. London: Sage.
- Vasavakul, T. 2002. *Rebuilding Authority Relations: Public Administration in the Era of Doi Moi*. Hanoi: Asian Development Bank.
- Warren, M. 2004. "Farmers Online: Drivers and Impediments in Adoption of Internet in UK Agricultural Businesses." *Journal of Small Business and Enterprise Development* 11 (3): 371–81.
- Wescott, C. G. 2003. "Hierarchies, Networks, and Local Government in Vietnam." *International Public Management Review* 4 (2): 20–40.
- Wolcott, P., and S. Goodman. 2000. "The Internet in Turkey and Pakistan: A Comparative Analysis." Report for the Center for International Security and Cooperation, Stanford University. http://iris.nyu.edu/~kkhoo/Spring2008/Topics/GlobalIS/Internet_Turkey-Pakistan_2000.pdf, accessed February 2011.
- World Bank. 2000. "OPEN: Seoul's Anticorruption Project." World Bank eGovernment website. <http://go.worldbank.org/BODMJL3JV0>, accessed February 2011.
- . (n.d.). *What Is Governance?* <http://go.worldbank.org/G2CHLXX0Q0>, accessed February 2011.

Module 13 ICT FOR LAND ADMINISTRATION AND MANAGEMENT

ROBIN MCLAREN (*Know Edge Ltd*) and VICTORIA STANLEY (*World Bank*)

IN THIS MODULE

Overview. This module identifies how ICT is more effectively supporting land markets and land reform activities, explores how more open approaches to public sector Information policy and innovative business models are making investments in ICT more sustainable, recognizes how ICT is an essential component of good governance, and details how interoperable ICT approaches to land information infrastructure extend and integrate land administration services into the wider e-government arena.

Topic Note 13.1: Supporting Land Markets with ICT. Innovative and competing public and private property information services help buyers and sellers make intelligent decisions and allow policy makers to monitor market trends. These services also provide transparency and thereby discourage corruption.

- **ICT-Based Property Value Estimate Information Services**
- **European Land Information Service**

Topic Note 13.2: ICT Support for Land Management, Planning, Development, and Control. Governments have established e-planning portals that allow citizens to access land-use control information, including access to zoning development plans and planning regulations. Public participation GIS is being applied to participatory community planning to help neighborhood community groups and individuals use mapping and spatial analyses in community development and public participation.

- **E-Planning Portal in Denmark**
- **Virtual Landscape Theatre**

Topic Note 13.3: ICT Support for Land Reform. Using GIS to manage the spatial complexities of managing, analyzing, deriving, and communicating new, fair distributions of parcels has become an important tool for land reform. ICT supports the entire life cycle of land reform, from identification of current owners and patterns of tenure through analysis of reallocation options to the provision of registration.

- **Sweden's Large-Scale Land Consolidation Projects**
- **Turkey Land Consolidation Project**

Topic Note 13.4: ICT Support for Good Governance in Land Administration. ICT significantly supports good governance in land administration by facilitating open, transparent access to land records for all. These records can now be obtained through mobile phones, either through Web- or SMS-based information services, greatly improving the outreach of land administration services, especially to groups that were long excluded from such information. The World Bank's Land Governance Assessment Framework offers guidance on the role of ICT.

- **ICT and the Land Governance Assessment Framework**
- **Improving Public Access to Land Administration Services in Indonesia**

(continued)

Topic Note 13.5: Public-Sector Information Policy Supporting Effective ICT-Based Information Services. Land administration agencies and policy makers must ensure the maximum exposure and reuse of land administration information in the public domain. Progress has been made in making copyright, licensing, and pricing arrangements as simple and consistent as possible. Governments have also developed open government licenses, which provide a single set of terms and conditions for anyone wishing to use or license government information.

- **A Policy Framework to Support the Lao People's Democratic Republic's National Land and Natural Resource Information System**
- **Vietnam's One-Stop Shop for E-Government Services**

Topic Note 13.6: Sustainable Funding of ICT in Land Administration. A number of countries have found that land registration systems and even the cadastre can finance themselves. Public-private partnerships are also being employed to spread the cost of development and maintenance more equitably among those who benefit from the systems.

- **ICT-Derived Efficiencies in the Kyrgyz Republic's Benefit Land Office Staff**
- **The Philippines: A Public-Private Approach to ICT Financing and Risk Sharing**

Topic Note 13.7: Designing Scalable and Interoperable Land Information Infrastructures. Data model standards help ensure that land information can be easily ported across generations of ICT, open interoperability standards allow same-generation systems to work well with each other, and Web services provide a standard means of interoperability among diverse software applications.

- **Combining Open Source Solutions with Open Geospatial Consortium Standards**
- **The Kyrgyz Republic's Open Source Strategy and GIS Solutions**
- **Social Tenure Domain Model**

OVERVIEW

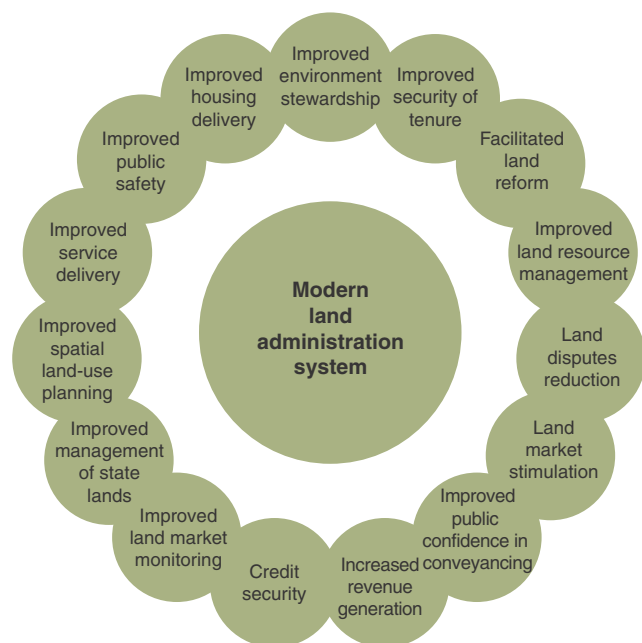
Good land administration creates accurate, accessible, interoperable, timely, secure, and complete information about land and property in an affordable and efficient way that promotes confidence between the public, its commercial enterprises, and government. The records commonly held for land administration are also the foundation for integrated spatial information systems that link multiple users in the provision of government services by electronic means (e-government). They often provide the key data needed by all local and central government organizations and, to a lesser extent, by the public.

Figure 13.1 illustrates examples of the benefits of good land administration (UNECE 2005), ranging from guarantee of ownership and security of tenure through support for environmental monitoring to improved urban planning, infrastructure development, and property tax collection. Agriculture productivity, though not explicitly featured, is also greatly increased where good land administration practices exist.

Where countries lack robust and tested land administration systems, significant dysfunctions can occur, including the following examples:

- Weak land markets, conflicts over ownership, land grabs, and social disharmony.
- Reductions in yields, diminished food security, negative impacts on the environment.
- Lack of an essential policy tool that can assist governments in creating a civil society with democratic norms.
- Reduced potential for economic growth as the large amount of capital typically invested in real property is never formalized and integrated into the financial system.

ICT has an increasingly fundamental role to play in improving the operation of land administration and in making information services more readily available in support of land markets and urban and rural economic development. ICT can provide innovative outreach channels to the poor and disadvantaged to ensure that land administration and its benefits are more inclusive and can be pro-poor. Significantly, land administration information is providing fundamental reference information, such as property addresses and transportation networks, which enables the integration of wider spatial information systems managed by the public and private

FIGURE 13.1. Benefits of Good Land Administration

Source: Adapted from UNECE 2005.

sectors. This integration facilitates the building of spatial data infrastructures (SDI) linking multiple users and allowing the delivery of a wide range of integrated e-government services. (See <http://inspire.jrc.ec.europa.eu/> on the Europe-wide SDI program; <http://www.anzlic.org.au/> on Australia-New Zealand SDI; and <http://www.fgdc.gov/nsdi/nsdi.html> for U.S. SDI information.)

This is an unprecedented moment for ICT in support of land administration and management as geospatial information improves and increases worldwide. The three core ICT technologies for land—the Internet, global navigation satellite systems (GNSS), and geographic information systems (GIS)—are converging and creating huge opportunities to manage land and property using ICT in much more thorough, inexpensive, and effective ways. It is still early in this process, and most countries are not fully prepared to take advantage of ICT and this convergence in technology; nor are countries fully ready to embrace the bottom-up potential of the emerging technology. This module provides some guidance and examples of how some jurisdictions are increasingly taking advantage of the new technology.

Elements of Land Administration

Land administration has been defined by the United Nations Economic Commission for Europe (UNECE) as “the process

of determining, recording, and disseminating information about ownership, value, and use of land, when implementing land management policies” (UNECE 1996). Typically, it is the formal governance structures within a nation that define and protect rights in land. Recognition is growing, however, that nonformal or customary institutions can and should play a role in defining and protecting land rights, and that they need to be included in the ongoing development of land administration. The following subsections describe the elements of land administration systems, with an emphasis on the range of information they encompass.

Land Tenure Systems

The term “land tenure” refers to the way in which land rights are held. There are both formal systems, laid down in statutes, and informal systems, conducted in accordance with custom and tradition. All formal systems are subject to state-imposed restrictions, such as planning legislation that limits the use rights associated with any area of land and restriction of ownership by foreigners (McAuslan 2010). The most common formal systems include what in some jurisdictions is called “freehold” or “fee-simple” or “full title” (*titulo* or *dominio pleno*), which represents the fewest restrictions on the landowner’s ability to do what he or she likes with the land, and “leasehold,” under which these rights are held for a limited period.

Informal systems operate in traditional areas and where formal systems have not been put in place or have broken down, as in squatter camps and other informal settlements. Traditional systems often impose restrictions on the disposal and use of land, which according to custom is usually regarded as belonging as much to deceased ancestors and future generations as to the present stewards of the land and therefore is not a commodity that is open to market forces. Customary law is, in general, not written but is established through long usage (Delville 2010). Sometimes, as in Uganda, customary law is recognized in formal statutes, although in many countries this is still not the case. The inclusion of informal systems of land rights is a challenge for land administration agencies.

Land Registration

A major component of any land administration system is a record of land ownership. Because of the uncertainties that can arise over who owns the land and under what conditions, in many societies it became customary to document the transfer of land rights in the form of legal deeds and

certificates. To provide additional security, official copies of these records were kept in deeds registries, or what in some countries are called land books. Historically, the deeds system was inefficient, in that it did not prove who the owner was; it merely showed that two parties had exchanged a deed of sale. Today, many deeds registries and land book systems have been computerized, with data on land rights linked to records of the land parcels, their addresses, and owners.

To improve on the deeds system, two versions of what is known as a land titling or title registration system emerged in the nineteenth century, one in England and the other in Australia (where it was known as the Torrens system). A title is a proof of ownership. In both countries the basis for the register became the parcel of land, to which the name of the owner was attached. Given the address or other reference to any particular parcel, plot, or lot of land, one could look for it in the register and find the owner, and vice versa. The certificate issued when this process is complete is known as the certificate of title and is normally guaranteed by the state.

Although quick and easy to do, the registration of title does assume that there has been a survey of the land so that its physical location, size, and shape can be described. It also assumes that prior to compiling the register, the true owner of the land and the nature and extent of the land rights have been established. The process for doing this is known as adjudication, which is a legal procedure that may entail investigations on the ground. Surveying and adjudication can be time-consuming, expensive processes. Once the information has been compiled, however, the mechanics of handling the records can be fully computerized, and the system can operate cheaply, efficiently, and effectively.

The registration of deeds, land book systems, and registration of title are often referred to as “land registration.” While many registration systems focus on the private ownership of land, either in outright ownership or in long-term leasehold, they can also include other forms of tenure such as land-use rights and shorter-term leases. These variations are important for countries where immovable property is technically “owned” by the government but where there are privately held land-use rights. As a result of modernization and computerization, combined with rigorous quality control procedures, the distinction between these systems is now minimal, each mirroring the conditions on the ground, no longer requiring investigation of the history of a parcel, and giving in effect a guarantee of ownership.

The Cadastre

Records of land parcels began to be collected long before the invention of land titling. They were known as cadastral records and were designed principally as an aid to tax collection. They identified each taxable parcel of land with the name of the taxpayer on a cadastral map. The taxpayer is not necessarily the owner, and hence in much of Europe there was and still is a dual system: The data on land ownership appear in land books under the Ministry of Justice and are often managed by the courts, whereas the data on location, shape, and size of parcels are registered in the cadastre, usually managed under the Ministry of Finance. In the great majority of countries in Latin America, registries are under the judiciary, whereas cadastres are under the executive.

The original meaning of the term “cadastre” has been extended to include a variety of land records, with the land parcel, lot, or plot at the heart of the systems. For example:

- **Fiscal cadastre**, a register of properties recording their value.
- **Juridical cadastre**, a register of parcels of land according to their ownership or use rights.
- **Land-use cadastre**, a register of land use based on individual parcels.
- **Multipurpose cadastre**, a register that includes many attributes of land parcels and addresses the wide range of issues identified in figure 13.1.

Increasingly, the cadastral and land book records are computerized and linked electronically, though not necessarily institutionally. In some cases—as in the Netherlands, where land records are integrated fully under the Dutch Kadaster—one organization manages both types of records. Similarly, in Albania, the Czech Republic, El Salvador, Honduras, Indonesia, the Lao People’s Democratic Republic (PDR), Lithuania, Romania, Serbia, the Slovak Republic, and Thailand, one agency—typically the Department of Lands or a cadastre agency—undertakes base mapping for cadastral purposes, the development of standards for adjudication, cadastral surveying, registration functions, and policy coordination. Many other countries, such as Croatia and Slovenia, have retained separate organizations.

In Latin America, a lack of institutional integration is often regarded as the single most significant challenge for achieving ICT improvements to land registration. Land registration services are often a major source of revenue for the judiciary, which are often extremely autonomous and reluctant to hand over their earnings to another part of government. In some cases, such as Brazil and Haiti, these services are carried out by private agents

who are similar to, but more powerful than, notary publics and are equally reluctant to surrender their autonomy.

Land Valuation and Taxation

As noted, the cadastre has been most commonly used to support a system of land and property taxation. A land- and property-based tax is cheap to administer, transparent, hard to avoid, and imposes political accountability at the local level. In many countries, taxes on land and property provide a significant source of revenue for local government, accounting, in some cases, for as much as 40 percent of all subnational tax revenue.

Land is both a cultural and an economic asset. In an economic sense, its value is determined from market information in countries where formal land markets exist. Land information infrastructures and GIS technology are used increasingly to support valuations and mass appraisals in which comparisons can be made between all properties in a country. Aside from recording and transmitting relevant information, ICT tools can provide transparency, leading to a reduction in the amount of fraud that can occur. Much of the cost of compiling land registers can be more than recouped using enhanced tax collections.

Land Management and Development Control

Many land administration systems are regarded as a support for land management and planning/development control, which are seen as separate functions. Others see land management as the end product of a process in which the resources of land are put to good use, and hence, as an integral part of land administration. Often, land administration officials will check and record building permits and notify the relevant authorities when regulations are breached. With the growth of the multipurpose cadastre and extensions to the use of the information recorded in land administration systems, the line of responsibility between agencies is becoming blurred. In land consolidation projects, for example, where the shape and size of parcels are redesigned, close cooperation between the recording agencies and the implementing agencies is essential and is helping to make land consolidation part of the wider rural development agenda. ICT has a crucial role to play in sharing and analyzing land information among agencies and in communicating and testing change scenarios with the citizens involved.

Location Information Infrastructure

“ICT” is an umbrella term that encompasses all forms of computing, information technology, the Internet, and

telecommunications. In the context of land administration, the terminology may be even a little broader and also covers surveying and positioning technology, including global navigation satellite systems (GNSS), such as the Global Positioning System (GPS); measuring equipment, such as total stations and electronic theodolites; Light Detection and Ranging (LiDAR), digital aerial photography, and satellite data acquisition systems and imagery processing; GIS; land data records management systems built on relational database management systems; workflow management systems; wide and local area networks; wireless technology; data storage systems, including data warehouses and Data as a Service on the Internet; and Web services delivered by Internet. The diversity of uses for ICT in land administration is remarkable.

The evolution of ICT and location information infrastructures (also known as land information systems or services) in underpinning land administration is illustrated in figure 13.2. The initial phase focuses on large-scale programs for capturing data by scanning records or conducting field surveys, with corresponding computerization of internal land administration processes. The next series of phases are all outward facing, improving the level of customer services and increasingly providing online services. Initially, this effort involved providing extranet services to key customers; as Internet services matured, they supported an increasing number of information services and e-transactions. Finally, as interoperability among government agencies improves, radical changes and efficiencies will be achieved in delivering e-government services based on land administration.

Several key ICT applications support land administration. Database management systems, usually of the relational variety, provide robust and secure repositories to manage the significant volumes of land information (textual and geospatial) in a distributed environment and to support efficient searching and querying of the information. The associated digital record management systems efficiently store and retrieve raster-scanned documents such as paper deeds. Last, GIS supports the capture and editing of geospatial information such as parcel boundaries and interfaces to the land information repositories and wider national spatial data infrastructures (NSDIs) to support spatial analysis and visualization, including a map-based interface for Web information services.

Land Administration Supporting Business

Since 2005, 105 economies have undertaken 146 reforms making it easier to transfer property (table 13.1 provides

FIGURE 13.2. Evolution of ICT in Land Administration

ICT in land administration	Surveying and data capture
1970 Manual	Traditional surveying
1980 Internal data capture and computerization DBMS/DRMS	Scanning and digital records management Total stations
1990 Internet-based information services	GNSS
2000 Transactions with customers over Internet	High-resolution satellite imagery and digital aerial photos
2005 Interoperability with other government agencies (e-gov/NSDI)	Open data sources
2010 Web and mobile-phone-based services and e-transactions with customers and suppliers	

Source: Authors.

Note: DBMS = database management system; DRMS = digital record management systems; NSDI = national spatial data infrastructure; GNSS = global national satellite systems.

examples of countries ranked by the ease of such transactions). Globally, the time to transfer property fell by 38 percent and the cost by 10 percent. The most popular feature of property registration reform in those six years, implemented in 52 economies, was lowering transfer taxes and government fees. This reform reduced the cost by 3.1 percent of the property value on average. Sub-Saharan Africa was the most active, with 22 economies lowering costs. The second most popular feature, implemented in 32 economies, was streamlining procedures and linking or improving agencies' systems to simplify registration. These measures reduced interactions between customers and agencies—saving two procedures on average—while maintaining security and controls.¹

Worldwide, 61 percent of economies have an electronic database for encumbrances, including almost all Organisation for Economic Co-operation and Development (OECD) high-income and Eastern European and Central Asian economies. But in Sub-Saharan Africa and South Asia, more than 80 percent retain paper-based systems. This lag in automation makes a difference. In economies with computerized registries, transferring property takes about

half as much time. Twenty-nine of 30 high-income OECD economies have electronic registries, and 85 percent allow online access to information on encumbrances, either for all or for professionals such as notaries. Eleven—including France, the Netherlands, and New Zealand—offer electronic registration.²

TABLE 13.1. Where Registering Property Is Easy and Where It Is Not

MOST BUSINESS FRIENDLY	RANK	LEAST BUSINESS FRIENDLY	RANK
Saudi Arabia	1	Angola	174
Georgia	2	Guinea-Bissau	175
New Zealand	3	Liberia	176
United Arab Emirates	4	Belgium	177
Armenia	5	Eritrea	178
Belarus	6	Nigeria	179
Lithuania	7	Timor-Leste	180
Norway	8	Micronesia, Fed. Sts.	181
Slovak Republic	9	Marshall Islands	182
Azerbaijan	10	Brunei Darussalam	183

Source: Doing Business database, <http://www.doingbusiness.org/data/exploretopics/registering-property>.

Note: Rankings are the average of the economy's rankings on the procedures, times, and cost to register property.

Emerging Trends in ICT for Land Administration

Recent advances and convergence of technologies applied to land administration are creating new opportunities to generate greater efficiencies in delivering land administration services, to reach out to excluded segments of society, and to integrate land administration information into the wider e-government arena. This section summarizes some emerging opportunities.

Surveying and Satellites

Advances in global positioning, mapping, and imaging technology present some of the most promising opportunities for ICT to support land administration services. By 2015, multiconstellation GNSS will provide around 100 satellites for global positioning. These new GNSS signals and constellations will provide better accuracy and reliability, leading to positioning to within centimeters in a mobile environment. This capacity opens up the potential for GNSS technology to reach a wider range of stakeholders, including citizens.

¹ "Registering Property." Doing Business, <http://www.doingbusiness.org/data/exploretopics/registering-property>, accessed May 2011.

² Ibid.

The costs of surveying (and the time it takes) have prevented many poor communities from being surveyed—the cost of the survey surpassed the value of their land. Fortunately, this situation is changing. National mapping agencies are introducing continuously operating reference stations, networks of geodetic-quality GNSS receivers that make data available for precise positioning for national survey and mapping programs, including cadastral surveying. This positioning infrastructure increases the efficiency and consistency of cadastral surveys and has multiple applications. A new generation of ground-based LiDAR, mounted on vehicles, is also emerging as the next “big” advance in surveying. Boundary features can be captured very quickly, to an accuracy of around half of a centimeter, just by driving around. Normally, such precision is not required, although some surveyors may claim that it is necessary. However, the location of physical features does not necessarily coincide with the location of legal boundaries, which means that adjudication supported by human interpretation is still needed and can be costly and time consuming.

Finally, although aerial photographs have been used in recording boundaries since the 1950s (in Kenya, for example), digital cameras, high-resolution (less than 1 meter) satellite imagery, digital terrain models, and new software techniques are increasing the availability of reasonably priced orthophotos, presenting opportunities for more cost-effective, efficient, and participatory ways of registering the boundaries of land rights. These approaches have been used successfully in Ethiopia (Lemmen and Zevenbergen 2010), Rwanda, Thailand, and Namibia. In Namibia, however, the systematic registration of communal land rights was 32 percent cheaper than surveying with handheld GPS (Kapitango and Meijs 2010).

Information Transparency

Under governments’ transparency, accountability, and citizen participation agendas, public sector information policy is changing (see Module 12 on governance for more examples of e-government interventions). Increasingly, public sector data sets once intended for internal consumption, accessed for a fee, or restricted owing to security concerns are provided as open data, free to be used for other purposes, under “data.gov” initiatives (see <http://www.data.gov.uk/> for an example). Although few countries currently release land ownership and rights information under their open data initiatives, primarily because of concerns related to revenue generation and privacy, it is just a matter of time until the wider economic benefits are understood by more countries. The private sector already makes much mapping available

for free; examples include Google (<http://earth.google.com/> and <http://maps.google.com/>) and Microsoft (<http://www.bing.com/maps/>). Prior to investing in ICT to update land administration services, it is essential that legislation and policies surrounding information transparency and access are updated, wherever possible. This step will ensure more-efficient investments in ICT and the delivery of effective land administration services by removing many current restrictions, such as restrictions on involving foreign firms in validation or requirements that all orthophotos must be produced within a country.

Integration with Wider Agendas for E-Government and National Spatial Data Infrastructure Initiatives

Most countries are developing initiatives to widen access to and use of geospatial information, but their maturity and success vary across the regions. In Latin America, for example, Chile, El Salvador, and Honduras are more advanced than others. A good example of this type of initiative is Australia and New Zealand’s Spatial Information Council, which is responsible for coordinating the collection and transfer of land-related information between the different levels of government; and promoting the use of that information in decision making. NSDIs involve the cooperation of public and private organizations to implement interoperable technologies, data standards, and business approaches within a policy framework that facilitates the sharing and reuse of geospatial information (Williamson et al. 2010). This effort normally supports the discovery of geospatial information at first but eventually supports Web-based services based on that information—in other words, Data as a Service. Over time, the myriad versions of similar data sets will be harmonized to generate and to reference common base themes in the data—such as transportation networks, property addresses, administrative boundaries, and land ownership—substantially increasing interoperability. Land administration information is a fundamental component of NSDIs. Participation in NSDIs promotes the culture shift for government agencies to share interoperable land and property information and leads to more integrated and effective e-government services for land administration, as experienced in Vietnam (Warnest and Bell 2009d). GIS technology provides the framework within NSDI to manage, integrate, and spatially analyze multiple sources of geospatial information.

More Sources of Open Data, Both Formal and Crowdsourced

“Crowdsourcing” is the term for citizens contributing content, and its roots lie in the increasing convergence of three

phenomena: (1) the widespread use of GPS and image-based mapping technologies by professionals and expert amateurs; (2) the emerging role of Web 2.0, which allows more user involvement and interaction (for example, “wikis,” which allow any number of interlinked Web pages to be created and edited via a Web browser; and standards-based authentication processes to contribute information to the Web); and (3) the growth of social networking tools, practices, and culture. Within land administration, there is growing recognition that the current surveyor-based paradigm is not scalable to meet demand. Around 70 percent of land and property is unregistered, and this figure is increasing as urbanization generates ever-higher levels of informal settlements and slums. One option to fill this gap is for surveyors to partner with citizens and communities to provide crowdsourced land administration information. For example, community-supported mapping recently occurred under the OpenStreetMap (<http://www.openstreetmap.org/>) initiative in Nairobi’s Kibera neighborhood, one of Africa’s largest slums. (See “Audio Slideshow: On the Map,” BBC, <http://www.bbc.co.uk/news/technology-12164081>.) Different levels of authentication can be applied to crowdsourced data, from simple conflict checks to legal validation, to ensure that citizens obtain some level of security of tenure along the continuum of rights.

Free, Open Source Systems

Proprietary software has traditionally supported land administration systems, even though they have recently embraced open standards. Over the past decade, however, free, open source systems have come to prominence. Licenses for these programs give users the freedom to run the program for any purpose, to modify the program, and to redistribute copies of either the original or modified program without having to pay royalties to previous developers. The promise of open source software is better quality, higher reliability, more flexibility, lower cost, and an end to proprietary vendor lock-in. (See the Open Source Initiative, <http://opensource.org/docs/osd>, and the Open Source Geospatial Foundation, <http://www.osgeo.org>.) The development of systems based on open source software also encourages local capacity building. The obvious advantages of open source development can be seen in the emergence and success of major projects like the Apache HTTP server (now running more than half of all websites globally).

The use of open source solutions for land administration will increase in developing countries that cannot afford the high costs of licensing commercial solutions. A cooperative effort among IT experts to foster open source software development and accessibility is led by FAO with support from New

Zealand’s University of Otago. The initiative—involving the extension of the Open Source Cadastre and Registration software development concept (FAO and FIG 2010) and its follow-on project, Solutions for Open Land Administration—will eventually offer governments a choice between licensing often restrictive and costly proprietary software and promoting the development of free, nonproprietary applications and communication software. (See the Solutions for Open Land Administration, <http://www.flossola.org>.)

Open source GIS solutions are being implemented in land administration in Bavaria, Bosnia and Herzegovina, Cambodia, Ghana, the Kyrgyz Republic, and Samoa, and in Solothurn, Switzerland. They underpin the initial prototyping of the Social Tenure Domain Model (Lemmen et al. 2007). Open source land registration and cadastral solutions are likely to succeed in countries where the government embraces the idea of using open source software for its information systems and supports its use in education and research. Such a national context makes it easier to find local ICT specialists who are familiar with free, open source products and form the human resource base to maintain systems.

Although the total ownership costs—including license, maintenance, and support costs—will probably be lower than costs for proprietary systems, the costs are not to be underestimated, especially the costs surrounding software integration. Open source software may make maintenance easier (problems can be solved without external support and with advice from international user and developer communities) and cheaper (the absence of license fees releases funds to maintain and further develop the system). The use of free, open source software will not change the fact that a proper business plan is the key requirement for introducing ICT systems for land administration (FAO and FIG 2010).

Risk-Sharing Relationships Between Clients and Suppliers

Under the traditional approach to investing in ICT to support land administration, the client assumed all of the risk: The client issued a tender for ICT and selected the best value proposition; the chosen supplier would deliver and provide support for the ICT solution. If the delivered solution defined by the client is delivered satisfactorily to specification but is subsequently found to be inappropriate or ineffective in operation, then the fault lies solely with the client. Under a number of new partnership arrangements, however, risk is shared more equitably. For example, the Government of the Philippines is engaging the private sector under public-private partnerships and outsourced service provision models to build computerized land information infrastructure, applications,

and land-related e-services. A private consortium is delivering a build/own/operate system that government will fully own after an agreed-on “concession” (payback) period is concluded (Warnest and Bell 2009c). These private-sector-delivered solutions may increasingly consist of some open source components.

Cloud Computing for Land Information Infrastructure

Cloud computing is a set of services or resources offered by different providers through the Internet. Characteristics of the cloud are (1) the cloud provides storage space for your files; (2) the cloud provides software to process files (word processor, photo editing, email, contact management, calendar); (3) the cloud automatically backs up files, and copies of files are stored in different geographical areas; and (4) data can be accessed by multiple users at the discretion of the creator of the data. Within the land administration context, an agency could place its entire land information infrastructure, including data, on the cloud and directly manage and maintain it over the Internet through Web services. Customers would also access it over the Internet and be unaware that it was on the cloud. The cloud is the next computing paradigm, and many land administration agencies will start to adopt it over the next five years, once confidence in security and portability is built.

The main advantages of this approach are that clients can outsource the burden of maintaining servers and applications, scale systems up or down on demand, access their data and services from anywhere with an Internet connection, and substitute regular, predictable operational expenditures for occasional heavy expenditures on ICT (for servers, for example). Cloud computing requires a robust, high-bandwidth broadband connection to the Internet and has real benefits; but there are also reasons for caution. Risks include loss of service and data if the provider has downtime or goes out of business, regulatory problems when personal data are stored internationally, security concerns when users lose control of how their data are protected, one-sided service agreements that give users little redress in the event of a calamity, and lock-in dependency on proprietary cloud applications (Thompson and Waller 2011).

Extended Scope of Land Administration Solutions

In many countries, land administration services have been notoriously difficult for some segments of the population to reach and have focused exclusively on supporting formal land rights. ICT has changed this scenario through the rise

of the Internet and mobile phones, the implementation of fully Web-based conveyancing, more local participation in the planning and development dialogue, and support for customary land rights.

Web- and Mobile Phone-Based Information Services

Online access to information services related to land administration is expanding with the expansion in broadband infrastructure and the use of mobile phones to deliver Internet and SMS-based services; Indonesia is one example of a country that had taken this approach (Warnest and Bell 2009a). Agencies that previously excluded many people, especially in rural areas, are becoming more open and rapidly building public trust through the provision of simple, transparent, and accessible services.

Mobile phones have made a bigger difference to the lives of more people, more quickly, than any previous communications technology, and their use is growing most significantly in developing countries. Mobile phones are connected to phone networks at ever-higher bandwidths, which has opened real-time access to the Internet and information services. For those living outside of the main cities, mobiles may be their only means of accessing the Internet.

E-Conveyancing

Many land administration agencies are transforming paper-based conveyancing systems into a fully electronic procedure, using electronic documents, applications, and signatures. (Developments in England and Wales are described at <http://www.landreg.gov.uk/e-conveyancing/>.) The aim is to reduce the delays and anxiety that can be experienced in current land and property transactions. Fully electronic conveyancing procedures are enabled by encouraging open access to property information and providing a mechanism for all payments relating to the transactions in a chain of property transfers to be paid simultaneously and electronically, with automatic registration on completion. The implementation of this kind of system assumes that stakeholders have the capability to support all aspects of their transactions electronically, however.

Fostering Citizen and Community Participation

Greater involvement of citizens in a dialogue with planning officials and property developers around development opportunities and development control should legitimize political decision making and ensure that it is combined with responsibility for the financial, social, and environmental

IMAGE 13.1. Women Use GIS Instruments to Map Land and Measure Soil Qualities

Source: Work funded by AgCommons, a program executed by the CGIAR.

consequences of development. Many governments have established e-planning portals that allow citizens to access information related to land-use control, including zoning development plans, planning regulations, and general land-use information. A new generation of Web-based GIS initiatives in public participation provides citizens with tools to analyze proposals, suggest and evaluate alternatives, and frame an online discussion of alternatives (Zhao and Coleman 2006) (image 13.1).

Support for Social and Customary Tenure

Until recently, land information infrastructure supported only the management of formal land rights, but a recent initiative led by UN-HABITAT and the International Federation of Surveyors (FIG) has developed a Social Tenure Domain Model (Lemmen et al. 2007), which was piloted in Ethiopia. The Social Tenure Domain Model is a specialization of the Land Administration Domain Model, which is in its final stage of reaching the status of a global International Organization for Standardization (ISO) standard (Lemmen and Zevenbergen 2010). (See http://www.gdmc.nl/publications/2010/Spatially_Enabled_Society.pdf.) The inclusion of social tenure support in land information infrastructures will result in more secure tenure for many, and it directly supports the UN-HABITAT “continuum of land rights” approach, which advocates registering a range of informal rights rather than formal rights alone (UN-HABITAT 2008).

KEY CHALLENGES AND ENABLERS

Work on improving land administration systems goes back many years. As a result of all this activity, a number of lessons have been learned, as discussed in the following subsections.

A legal framework is needed to underpin ICT-based land administration services. As ICT and e-government services are introduced into land administration, the legal framework underpinning land administration needs to change to allow for electronic signature and new electronic services, such that computerized information/records are accepted as being

legal and valid. Significant legal changes will also be required to support the recognition and inclusion of customary tenure within the formal land markets and land tenure systems. This transition needs to be well planned, as passing new legislation can be time consuming. The capacity within countries to implement legal framework reforms is also necessary and may affect the design of legal reform strategies.

It is necessary to create a land policy framework to let the land administration function more effectively. Land administration products and services must be aligned with a country's current needs. These requirements must be defined in land policy, describing how governments intend to deal with the allocation of land and land-related benefits and how land administration systems are supposed to facilitate the implementation of the policy. Such implementation includes the rules for land tenure and land tenure security, the functioning of the land market, land-use planning, development, land taxation, management of natural resources, land reform, and so on. The formulation and subsequent monitoring of land policies require access to appropriate land information. ICT in land administration has a key role in supporting and informing policy makers.

The poor do not necessarily benefit. Computerization of land administration without outreach to otherwise-disconnected segments of the population can further disadvantage the poor. However, innovation in ICT and modeling

of customary tenure is supporting outreach to rural areas, for instance in Indonesia. In many countries, although the middle classes, entrepreneurs, and rich have benefited from relatively easy and cheap methods to transfer land and secure title, the poor have been excluded by the costs and, more often, insufficient understanding of the benefits. Hardly anyone disputes the need for secure tenure and that citizens in both rural and urban areas should have guaranteed rights to the land that they legitimately use. Not everyone, however, agrees that state-backed certificates of title provide the best solution. Even where land titling is required to support a formal land market, titling may benefit the rich but not the poor. Some form of land titling along the continuum of land rights may be necessary to bring about all the potential benefits that land administration can provide, but land titling alone will not suffice to do so. Other institutional arrangements and social and economic support need to be in place.

Modernizing land administration can be challenging.

Significant legacy issues often exist, and professional and political biases are normally encountered. These can have serious detrimental effects on the modernization program unless the associated risks are understood and mitigated effectively. Here are some general principles for designing new land administration modernization programs:

- If there is a no possibility to reduce multiple agencies involved, focus on improving coordination among them with formal memorandums of understanding agreed on.
- Begin the land administration change program with a business case and associated business cases to sustain it.
- Adopt an approach that uses the same land administration regime for urban and rural land, even if the institutions must be different. However, there may be variations in the precision of cadastral surveys and development control standards, for example, between city centers and remote rural areas.
- Build in an effective and dedicated dispute resolution system that leaves the courts as a last resort.
- Try to ensure that the land administration system benefits all and that barriers to entry are low.
- If the existing data are in poor condition and decades out of date, there needs to be a plan and budget for data improvement and ongoing maintenance.
- Bring land professionals (surveyors, lawyers) into the process as partners and try to mitigate their inclination to lobby against introducing pragmatic change.

- Insist that the land administration change program has political support and a sufficient time horizon to deal with the existing problems.

Existing problems with land administration information can greatly increase system modernization costs.

The costs of implementing modern land administration solutions in countries of the former Soviet Union have been greatly reduced compared to others since they were starting with fewer legacy issues to contend with. In other regions existing land administration systems are being modernized, with inherent problems that significantly increase the costs and time frames for implementation. One of the most serious issues is the poor quality of the data on immovable property, with textual and geospatial data out of date. This can be further compounded by the number of land disputes in the courts, and the number of potential disputes that are lying dormant, which might be triggered by the process of adjudication. Simply eliminating the existing land administration system is usually not an option. The modernization program must be built around data upgrading and quality maintenance mechanisms, along with streamlined processes for resolving disputes, preferably through dedicated land dispute resolution structures. Automation by itself brings less transformative change in these cases, but can be the start of a long process of evolutionary improvement.

Governments should accept and plan for high costs and long time frames.

The implementation of a fully operational land administration system involves high costs and can take many years before the majority of properties are registered. For example, the early Thailand project involved loans of US\$183 million over 18 years, covering capacity building, surveying and mapping, and the high costs of early ICT solutions. More recent initiatives have been less expensive, especially when starting from scratch—where the cost impacts of poor quality of the data on immovable property and large numbers of active and dormant land disputes can be mostly avoided. In the Kyrgyz Republic, more than 2.5 million properties (more than 90 percent of private properties in the country) were entered into a new registry system under a seven-year project costing less than US\$12 million. A second four-year project costing about US\$7.5 million is currently making further improvements in the quality of the spatial data and overall ICT capacity, but the registry system is already highly functional. The process of surveying and registering each individual land parcel can be expensive and time consuming and, in some countries, open to corruption. There is a need to understand the local context, to assess existing judicial capacity, to prioritize implementation, adopt

faster and more innovative ICT techniques, reduce red tape and multiple procedures, and engage communities in the process. Changes in ownership due to transfers or inheritance must be undertaken at the same time as new titles are being brought into the registers, so that as the project progresses, more staff can be taken off first registration and put onto record maintenance. Certificate of title holders do not necessarily report changes, for instance, in areas where customary tenure still operates alongside the formal title system. Failure to carry out record maintenance at the same time as new titles are being added will cause records to be outdated before the system is complete. Full-life costs of a land administration system must include its maintenance.

Business models should support continual investment in ICT. Business models for land administration systems must directly generate revenue, obtain guaranteed state funding, or share the financial investment and risk with the private sector to ensure that ICT is sustainably maintained and replaced. However, choosing the appropriate business model is not easy, as it may change over time as the land market matures. Guarantees of funding over the long term are unlikely from governments. The generation of revenue depends on information policies for the public sector, which often restrict access to land information, thus reducing potential benefits and income streams as well as transparency. The recent financial crisis has precipitated crises in property markets around the world, significantly reducing the number of land administration transactions. The result has been reduced revenue streams for many land administration agencies and their ICT partners, leaving them in a financial predicament. Projects need to start with a strategy and a corresponding, robust business case, updating it as needed.

Effective and mature land administration systems need computerization. The driving rationale behind the increasing use of ICT for land administration is that the volume, complexity, and expected processing times of transactions can no longer be handled in an efficient and transparent manner through manual processes. The increasing demand by the general public and the private sector for open access to land administration information cannot be met without ICT. For example, ICT can support greater access to and sharing of information, improve data quality and completeness, increase security and transparency of operations and information (potentially reducing the risk of corrupt dealings in land), increase revenue generation around new services, and provide a basis for monitoring and evaluation.

Planners should avoid the fallacy that ICT is a silver bullet. ICT is an enabling infrastructure requiring appropriate, significant, full-life investment. Technology is changing rapidly, and what was appropriate five years ago may not satisfy today's demands. Land records may need to stand the test of time over centuries, so sustainable methods for archiving material are essential. Simply investing in new technology without understanding citizen, state, and commercial customer requirements; training staff; adequately testing and piloting solutions; building capacity; and simplifying the business processes may not achieve the desired effect and can lower staff morale and customer satisfaction. ICT may also fail to achieve some of its objectives if delivered in isolation. Although significant evidence has been gathered around the world that property titling and registration will enhance access to credit, it does not always do so (box 13.1).

BOX 13.1. Outcomes of Automating Land Registration in Andhra Pradesh

Did the gradual computerization of land registry systems across Andhra Pradesh's 387 subregistry offices influence access to credit? Quarterly data on credit disbursed by all commercial banks over 11 years (1997–2007) were aggregated at the subregistry office level and examined in light of the date when the land registry system shifted from manual to digital records. Computerization had no credit effect in rural areas but led to increased credit supply in urban areas. A marked increase of registered urban mortgages following computerization supports the robustness of the result. At the same time, the estimated effects of a reduction of the stamp duty (a tax levied on legal instruments and transactions such as those involved in sales of land or mortgages) are much larger, suggesting that, without further changes in the property rights system, the impacts of computerization will remain marginal.

Source: Deininger and Goyal 2010.

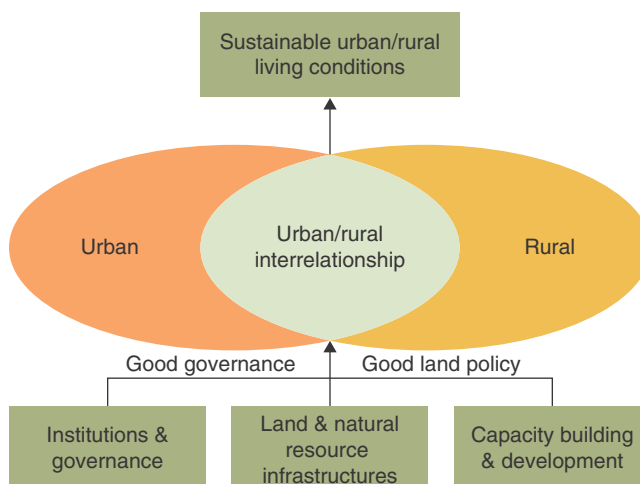
Home-grown ICT solutions should be used where possible. Within World Bank–financed projects in Europe and Central Asia, land information infrastructures have been developed either through large contracts bid out to the private sector or through building systems in house. The internal approach has generally been more successful, because systems can be built in a modular form as agencies build their own capacity to use and manage the different modules and technology. Another advantage of in-house development is

that agencies can retain their own specialists (or use local companies) to amend and maintain the software rather than being locked into their supplier's source. Large, internationally bid contracts have proven very difficult to manage, very time consuming to tender, and very slow to produce a functioning system. Moldova was one of the first countries in the region to establish a system developed by the cadastre agency's own staff with technical support, packaged software, and equipment financed by a World Bank loan. As it upgraded the system, the agency used part of the credit to hire international consultants for advice on the design and latest technology, yet the agency remained in the leading role (World Bank 2009a). Successful in-house development processes for ICT solutions have also been implemented in El Salvador and Honduras. Where in-house capacity is not available, the work can be outsourced, but it is necessary to assess the capacity of land agencies to manage large contracts and the capacity of the private sector to handle the work. Another option is to complete the work incrementally as capacity is built.

Professional and institutional compartmentalization must be eliminated. Professional and institutional compartmentalization can lead to a fragmented view of land. Cooperation, especially between ministries responsible for land registration and those for the cadastre, often has been lacking. The lack of institutional cooperation reflects a lack of cooperation between professions, notably lawyers and the surveyors, with each group taking a different view of the land and hence of priorities. Failure to take a holistic view and fundamentally change business processes leads to inefficiencies, higher costs, and time delays, and ultimately heightens the cost and complexity of offering services to citizens. It is important to keep institutional arrangements as simple as possible (World Bank 2009a), because simplicity will enable more integrated and effective ICT and e-government solutions. Single cadastre and registration agencies work best, but they are not always politically feasible, and failure to agree on a single agency should not prevent projects from going forward.

Land administration must operate efficiently in various settings. From a land administration perspective, there should be a unified land system for both urban and rural areas (see figure 13.3). There should be one land law and one set of procedures to accommodate the needs of all regions in a country, including customary tenure in rural areas. Many rural communities, which make up the agrarian sector of a country, are geographically excluded from land offices, reducing levels of registrations in rural areas. Innovative ICT solutions are supporting mobile land offices (see IPS "Improving

FIGURE 13.3. Sustainable Development Needs Both Urban and Rural Inputs



Source: FIG 2004.

Public Access to Land Administration Services in Indonesia," in Topic Note 13.4) that can provide land administration services to remote rural communities (Warnest and Bell 2009a).

Significant investment is needed in capacity building. To realize the full benefits of ICT investments in land administration, countries must implement an effective program to build technical and management capacity across the public and private sectors and civil society. The public sector has significant issues with building the capacity of, and retaining, ICT professionals, especially in developing countries. Younger professionals, having received ICT training in government service, often move to the private sector, where the short-term rewards tend to be higher. The rollout of ICT in land administration can strongly benefit from partnership with the local private sector and corresponding capacity building for professionals. Finally, government needs to coordinate awareness and capacity-building programs for the public, as an increasing number of government services are electronic. Human capacity to carry out and sustain reforms in land administration, including the management of large ICT contracts, is a long-term activity and should be built into project design from the start.

Early investment is the key to positioning infrastructures to realize benefits in a wide range of land applications. Historically, national triangulations (measurements) have formed the basis for consistency in land surveying. Today, sophisticated positioning infrastructures not only constitute the basis for land surveying and place-based land information in all its forms, but also support a wide range of land applications.

The performance of land administration has proven to be enhanced strongly by applying appropriate ICT tools, including satellite imagery, aerial photographs, and GNSS. Early investments in this positioning infrastructure are crucial and significantly reduce the cost of data capture.

ICT investments should be shared through interagency collaboration. Too often, investments in ICT are isolated within projects and do not consider the possibility of the wider sharing and reuse of the resources. This narrow

perspective has led, for example, to multiple purchases of the same remote-sensing imagery by different agencies and the generation of multiple base maps with varying specifications. Apart from the simple collaboration approach, the adoption of interoperability standards and Web services is promoting the implementation of shared services, leading to the creation of national spatial data infrastructures (NSDIs). This approach allows different agencies to access and use the same geospatial information, reducing the initial and continuing maintenance costs.

Topic Note 13.1: SUPPORTING LAND MARKETS WITH ICT

TRENDS AND ISSUES

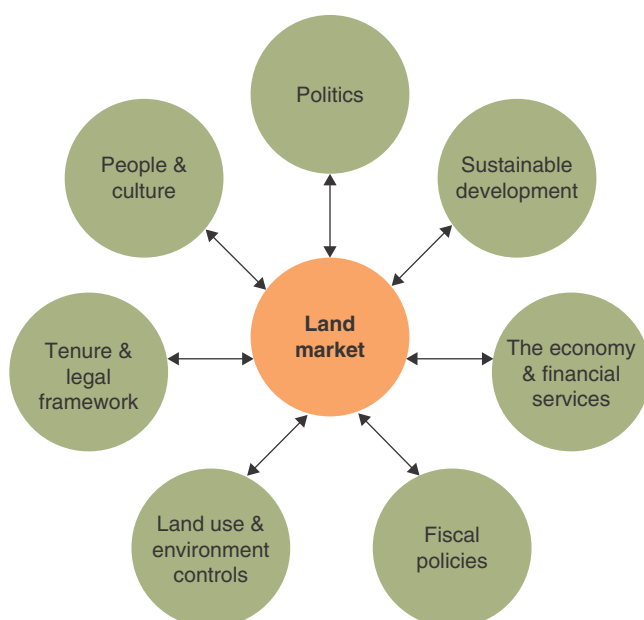
Land markets allow capital to be released, and hence influence productivity and efficiency in agriculture and the level of investment in industry. An efficient land market underpins the capacity of banks and other financial organizations to lend money and for landowners to invest. The form and success of any land market depend on a number of external factors (figure 13.4). The relationships between these elements and the market operate in two directions: They influence the day-to-day activities within the market, and they in turn are influenced by it. A successful market stimulates economic growth for individual landowners by releasing capital for investment in other fields. It can also benefit government by facilitating a

variety of forms of taxation on what is essentially wealth. The market can also encourage changes in land use and stimulate moves toward the optimal use of resources. In theory, market forces should result in the “highest and best use” of the land, although in practice other factors may prevent this outcome.

ICT plays a key role in providing information to stimulate, support, and monitor land markets. ICT can be used for the following purposes:

- Provide a single point of access to all the relevant land and property information.
- Record and analyze all land held by the state. In many countries, the state is the largest landowner; but all too often, it fails to manage its assets in an efficient and effective manner.
- Monitor the performance of property prices and make relevant information available to public and private land and property companies, and to policy makers. (For examples on residential property, see <http://www.zillow.com/> for the United States and <http://www.zoopla.co.uk/> for the United Kingdom.)
- Map the location of formal property sales.
- Compare property values as part of a mass appraisal for land and property taxation (UNECE 2002), and monitor changes in land use that may affect the taxable value of property.
- Provide transparency, and thereby discourage corruption in the land market.
- Monitor the gender and other demographics of those taking part in land transactions to discourage prejudice against women and minority groups.

FIGURE 13.4. Influences on the Land Market

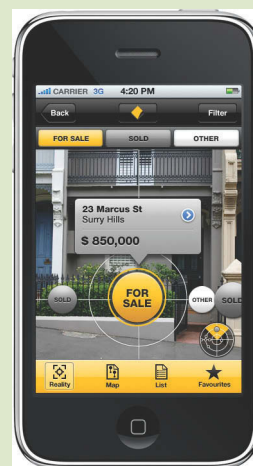


Source: Dale, Mahoney, and McLaren 2010.

Following the initial phase of computerization in land administration agencies, when land records are digitized

BOX 13.2. Augmented Reality in Real Estate Marketing

Smartphones deliver innovative, location-based services for mobile real estate marketing. Using a smartphone, a person can walk up to the front of a house for sale, aim the phone's camera at it, and within seconds view and capture all the information about the real estate listing. The viewer can see pictures of the property, watch a video walkthrough of the property, browse information about the property (such as the selling price), email the information, and contact the listing agent. This kind of mobile marketing is achieved using an augmented reality browser such as Layar (<http://www.layar.eu/>). The mobile phone opens a window into the virtual real world where you can directly point at features and obtain the associated information.

Example of Augmented Reality in Real Estate Marketing

Source: McLaren 2010; source for figure, <http://buildar.com/>.

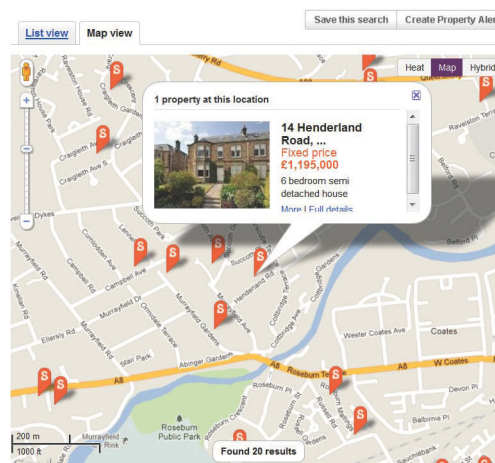
and land and property transactions are supported, land administration agencies normally start to provide information services on land market activities and trends, such as statistical trends in house prices by geographical region. In many countries this land and property information is then made available to the private sector for other uses, either under a chargeable license or free. The release of this information usually requires amendments to public sector information policy and associated legislation. Once the information is in the public domain, the private sector innovates and starts to deliver new information services to the land market. These services include locating a property to buy or rent in a specific area, identifying the price paid for properties sold in an area of interest, estimating the market value of a property, and receiving an email or SMS alert if a property of a certain type, cost band, and location comes on the market. Some information services encourage owners of properties to enter more detailed information about their properties so that more accurate valuations can be estimated. GIS technology is also used to determine the amenities in an area of interest to support property-buying decisions. These applications are increasingly available on mobile phones, and some are starting to use augmented reality, in which a user can point the device at properties and obtain corresponding information (see box 13.2). These innovative and competing public and private information services reflect an open, transparent, and competitive land market that needs to be supported by effective ICT within land administration.

INNOVATIVE PRACTICE SUMMARY

ICT-Based Property Value Estimate Information Services

In mature land markets, a number of innovative land and property information services allow users to identify properties for sale or rent that meet their specific requirements, obtain an estimated market value, and select and contact a range of professional and financial services to support their transaction. Good examples can be found at <http://www.zillow.com/> in the United States and <http://www.zoopla.co.uk/> (figure 13.5) in the United Kingdom.

FIGURE 13.5. A Property Information Service in the United Kingdom



Source: Zoopla.co.uk.

At the heart of these information services are computer-based value estimate systems, often known as automated valuation models. The Zoopla valuation algorithm, for example, continuously analyzes property data from multiple sources—including government, real estate agents, surveyors, and users—on all 27 million homes in the United Kingdom. The model looks at the relationships between transaction prices and property characteristics (type, style, number of bedrooms, and other variables) and uses these patterns and trends to estimate present values. The algorithm uses previous sale prices for the specific property and recent transactions nearby, changes in market values for similar local properties, various characteristics of the property in question and those around it, current asking prices for specific properties and others in the local area, the size of the property in question relative to those around it, and the current values of comparable properties.

The model works on an extremely local level and adapts to the specific information available for each property, thereby creating a custom approach to valuing each property. In effect, tens of thousands of models work together, each optimized for the accuracy of the small set of properties they exist to serve. New data are received continuously from a variety of sources, and the systems are built to absorb this information quickly into the valuation process, allowing estimates to take advantage of the most recent data. Each day, the valuation algorithm knows more than it did the day before. Estimates are found to be within 10 percent of the actual transaction price in the majority of cases. The estimated valuations allow users to identify properties within their price range and support their property bid price.

INNOVATIVE PRACTICE SUMMARY

European Land Information Service

The European Land Information Service (EULIS) (<http://eulis.eu>) is an online portal for professionals to access land and property information from land registries across Europe. It is also a hub of information on land registration conditions in each country. EULIS's long-term mission is to underpin a single European property market through cross-border lending, involving 23 organizations representing the land registries of 20 member states. Currently, the land registries of five countries are connected to EULIS: Austria, Ireland, Lithuania, the Netherlands, and Sweden.

The main applications of this cross-border land and property information service are as follows:

- **Second home searches.** Europe is becoming smaller because it is easier to travel, live, and work across borders. EULIS makes it possible for solicitors and real estate agents to check out property and land in other countries for their clients, paving the way for second home purchases.
- **Business acquisition.** EULIS investigates premises and land on behalf of international businesses seeking to acquire sites for their operations.
- **Credit checks.** A risk assessment is required when citizens request credit or make other financial commitments. Lending institutions can use EULIS to confirm ownership of any assets such as land and property proposed as collateral for such commitments.

Topic Note 13.2: ICT SUPPORT FOR LAND MANAGEMENT, PLANNING, DEVELOPMENT, AND CONTROL

TRENDS AND ISSUES

In countries fortunate to have mature ICT infrastructures, governments have established e-planning portals that allow citizens to access land-use control information, including

- access to zoning development plans, planning regulations, and general land-use information;
- submission of development applications;
- access to proposed developments, associated drawings, and their current status;
- submission of comments associated with proposed developments to be used as material evidence in the decision-making process; and
- access to the results of development control decisions.

A new generation of GIS-based tools is now available, supported by maturing spatial data infrastructures, to enhance the interaction experience and effectiveness with the citizen. Public participation GIS (PPGIS) is being applied to participatory community planning (Zhao and Coleman 2006) to help neighborhood community groups and individuals use mapping and spatial analyses in community development and public participation. A new generation of Web-based PPGIS initiatives is providing users with tools to analyze existing proposals, suggest and evaluate alternatives, and frame an online discussion of alternatives within a geospatial context.

The ease and increasing use of mashups (websites or applications that seamlessly combine content, typically sourced from

third parties via a public interface, into an integrated experience) and wider access to open geospatial data allows communities, citizens, or pressure groups to create an accessible simulation of the proposed development. This environment can then form the basis for dialogue among stakeholders.

Mobile phones are also opening channels for citizen participation in the development control process and have significant potential to increase constituents' participation. For example, citizens can register for mobile phone alerts on specific types and/or locations of new development proposals and can text objections to development proposals to the planning authorities with associated authentication (Enemark and McLaren 2008).

INNOVATIVE PRACTICE SUMMARY

E-Planning Portal in Denmark

One of the most advanced and participatory e-planning portals is in Denmark (see <http://plansystemdk.dk>). The solution provides public access to all statutory land-use plans, such as municipal plans and development plans (called a *lokalplan*), both adopted or proposed, across Denmark. The map-based interface provides a range of navigation tools, including address, cadastral parcel number, municipality, and area polygons (see figure 13.6, showing the region of Aalborg). The areas of the development plans can be displayed in combination with cadastral maps, topographic maps, orthophotos, and other kinds of land-use constraints, such as conservation

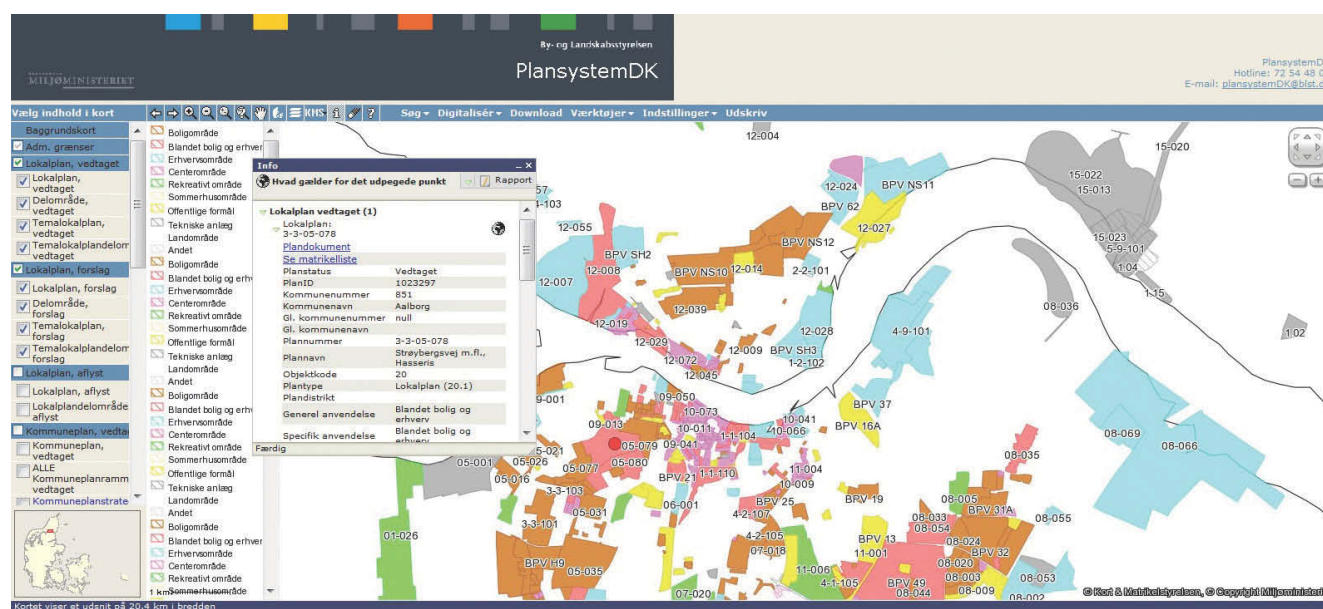
areas and coastal protection zones. Once the citizen has identified the development plan of interest, the system provides direct access to an electronic copy of the *lokalplan* and can display and generate a list of all properties (cadastral parcel numbers) affected by the development plan. The e-planning portal also allows citizens to provide direct feedback on proposed development plans during the statutory eight-week consultation period. Citizens preparing to build or extend their house can use the system to determine what planning restrictions apply in their area. This open, transparent e-planning portal also serves as an authoritative legal register. It is an excellent example of land registration and cadastral information services being integrated into wider e-government services.

INNOVATIVE PRACTICE SUMMARY

Virtual Landscape Theatre

For many citizens, the use of PPGIS environments is either too advanced for their use or they are on the wrong side of the digital divide. However, there are emerging virtual and augmented reality techniques that allow citizens to access sophisticated GIS and visualization technology through mediators. One such example is the Virtual Landscape Theatre, developed by the Macaulay Institute in Scotland, which uses cutting-edge virtual reality technology to recreate landscapes and provide a forum for people to visualize and assess impacts of proposed change (Macaulay Institute 2011). By allowing

FIGURE 13.6. Example of E-Planning Portal



Source: <http://plansystemdk.dk>.

groups of people the opportunity to view, debate, and offer informed opinions, the planning process benefits from a greater understanding of what is really valued in the landscape and what is not. The Virtual Landscape Theatre is composed of a mobile, curved-screen projection facility in

which people can be immersed in computer models of their environment to explore landscapes of the past, present, and future. Small groups have the opportunity to experience landscapes by moving around the virtual world and can provide feedback by means of a voting handset.

Topic Note 13.3: ICT SUPPORT FOR LAND REFORM

TRENDS AND ISSUES

The term “land reform” has different meanings in different regions or countries. At its simplest level, land reform refers to the various processes involved in altering the pattern of land tenure and land use of a specified area. It is most often applied to rural areas to allocate more land for settlement by landless people, to provide stability in the pattern of land settlement through land tenure reform, or to consolidate land holdings and increase agricultural efficiency by redistributing an existing pattern of land parcels. For example, in Latin America it typically means land redistribution from large *haciendas* or *latifundia* to smaller farms, while in South Africa land reform also involves restitution of lands and land tenure reform. The procedures adopted for land reform can be applied to urban areas and used to address some of the problems of informal urban settlement.

ICT supports the entire life cycle of land reform, from identification of current owners and patterns of land tenure through the analysis of reallocation options to the provision of land registration. ICT can be used to:

- Identify owners, extent of ownership, land use, and land values in areas where land consolidation is planned.
- Design new parcels using GIS, in which all landowners voluntarily trade land parcels or are allocated an area that is as equivalent as possible to the size and quality of their existing holdings. The GIS is also used to support citizens’ participation in the design and evaluation of reallocation options, speeding up the consultation and decision process.
- Calculate levels of compensation when necessary as a result of adjustments to the status quo or when land has to be expropriated for state purposes.
- Help in planning new infrastructure, such as roads, underground services such as drainage, and other subsurface and above-surface utilities.
- Assist in the preparation of plans for land allocation to landless or otherwise-dispossessed people.
- Maintain records of state land that is being held in anticipation of future needs.

- Map informal settlements, using aerial photography or satellite imagery, to plan any upgrades.
- Support the creation of forest inventories and associated valuations by using laser scanning.

Land reform is costly and time consuming. There must be a strong business case or political driver for its implementation. For example, large cooperative farms in Ukraine were broken up and distributed to citizens as part of political and market reforms, but it is still forbidden to buy and sell agricultural land, and there is no formal land market. Prior to land reform in Moldova, parcels were so fragmented that agriculture was very inefficient, and no active land market existed; now the land market is very active.

Land consolidation is becoming an integral part of rural development. ICT enables a more holistic approach that takes into account broader environmental requirements, leisure and other social needs, rural business development, and other factors. Now it is also common to include land consolidation in urban settings to promote business districts and urban development. For example, Germany currently does more urban land consolidation than rural consolidation. The FAO advocates a voluntary approach to land consolidation based on buying, selling, and exchanging parcels in a coordinated way (for a recent successful example, see Republic of Moldova 2009). Other approaches are more formal and involve significant, compulsory intervention, as in the examples from Sweden and Turkey that follow.

INNOVATIVE PRACTICE SUMMARY

Sweden’s Large-Scale Land Consolidation Projects

Sweden consolidates land through formal, large-scale procedures that rely on compulsory rules in the Property Formation Act. An intervention can cover 2,000–54,000 hectares, can involve up to 2,000 participating landowners,³ and normally takes five years to implement. Appeals of the principal decisions are rare; since 1990, only 33 landowners have appealed to the court and only seven appeals have been upheld. This positive result comes from strong mediation and negotiation with landowners and effective use of ICT.

3 The information in this section was provided through personal communication with Mats Backman, Telia.

In 1995, Sweden introduced a customized GIS to help implement its land consolidation reforms. The system, GISOM, is based on ESRI products and other database and analysis tools; it manages layers of information from the land registry, cadastre, cadastral index map, and photogrammetric and field data. Additional GIS applications have been developed to match the requirements of the authorities and landowners, including valuation methodology, reallocation design, and decision support. The valuation methodology in forest land consolidation projects ranges from the complete enumeration of trees to the use of aerial photointerpretation combined with laser scanning, which is now very successful.

The use of GIS allows landowners to view proposed reallocation designs and show them the consequences of changes in geographical location and size of the proposed reallocation. It also allows changes to the reallocations to be made in real time. Normally, landowners wish to decrease the monetary compensation in land consolidation as much as possible. The use of GIS has made it possible to match their desires to a great extent.

INNOVATIVE PRACTICE SUMMARY

Turkey Land Consolidation Project

Turkey's rural population is growing rapidly. Because most rural dwellers cannot pursue livelihoods in sectors other than agriculture,⁴ agricultural land is often split into successively smaller farms. Consequently, most farmers operate on highly dispersed parcels whose small size is not suitable for irrigation and mechanization. On average, only 50 percent

of the parcels have access to irrigation and transportation networks.

Land consolidation was initiated in the 1980s, when legislation was passed to support the Ministry of Agriculture and Rural Affairs in its responsibility to prepare and implement land consolidation projects. Further land consolidation legislation was passed in 2005 to empower other government ministries to implement land consolidation projects involving, for example, irrigation and transportation infrastructure. The private sector is involved in implementing the projects.

Turkey faces the tremendous challenge of consolidating approximately 8 million hectares in eight years. The government plans to meet this challenge through a major national land consolidation program, primarily intended to resolve agricultural issues. Under a project with the Netherlands, Turkey has developed a land consolidation approach, supported by ICT, which can be scaled to meet the ambitious targets of the national land consolidation program. A key component of the approach is a GIS-based solution, called TRANSFER, to support reallocation design within project areas. TRANSFER uses a variety of data sets to support reallocation, including soil maps, productivity maps, digital terrain models, proximity to villages and roads, ownership boundaries, and owners' preferences for new allocations. Figure 13.7 shows a project area before and after land consolidation. The result features a new parcel pattern, minimizing parcel transfer in accordance with the wishes of villagers (the average parcel size is bigger than before); new roads (placed to minimize the impact on agriculture and provide access to all new parcels); a new irrigation scheme accessible to all new parcels; and a reduction in the number of parcels per farmer, which reduces transportation between parcels.

4 This section draws on information from Jansen et al. (2010).

FIGURE 13.7. Parcels Before and After Land Consolidation with New Irrigation Network



Source: Jansen et al. 2010.

Topic Note 13.4: ICT SUPPORT FOR GOOD GOVERNANCE IN LAND ADMINISTRATION

TRENDS AND ISSUES

The need for good land governance is reinforced by three broad global trends. First, increased and more volatile commodity prices, population growth, and the resulting increased demand for rural and urban land make it all the more important to define and protect rights over land resources as a precondition for the broad sharing of benefits from economic development. Second, climate change is likely to have particularly damaging effects on land in areas traditionally considered hazardous or marginal. Adequate land-use planning, together with geospatial tools that use land administration information to manage disasters, can help mitigate or adapt to these problems. Finally, global programs to provide resources for environmental services (for example, reduced deforestation) are likely to affect behaviors at the local level and thus accomplish their objectives only if local land rights are recognized and resources are transferred effectively to right holders (Deininger et al. 2010).

Good governance requires a legal framework and a will to enforce it. Legislation that, for example, outlaws gender discrimination is often flouted in practice when it comes to land ownership and inheritance, which is why organizations such as the Huairou Commission were established (see <http://huairou.org/issue> and <http://huairou.org/land-housing>). Good governance is essential, because land administration is often perceived as one of the most corrupt sectors of government. Although individual amounts may be small, petty corruption on a wide scale can add up to large sums. In India the total amount of bribes paid annually by users of land administration services is estimated at US\$700 million (Transparency International India 2005), equivalent to three-quarters of India's total public spending on science, technology, and the environment. For an example of how ICT can stem corruption in land transactions, see box 13.3.

ICT significantly supports good governance in land administration by facilitating open, transparent access to land records for all. Until recently, land records were available only on paper in land offices or to a few large customers over the extranet. These records can now be obtained through mobile phones, either through Web- or SMS-based information services. As the example from Indonesia indicates, ICT can greatly improve the outreach of land administration services, especially for groups that were long excluded from such information, and the cost of providing services has fallen.

BOX 13.3. Reducing Corruption in Land Offices

The mobile phone can play an important role in reducing corruption associated with financial transactions in the land sector. For example, in Pakistan's Jhang District, all clerks were asked to submit a list of their daily transactions, giving the amount paid and the mobile numbers of the buyers and sellers. Supervisors then called buyers and sellers at random to find out whether they had been asked to pay any extra bribes or commissions. After charges were brought against one clerk who had asked for a bribe, service improved markedly. This two-way interaction with clients opens opportunities for essential feedback and quality checks.

Source: "A Special Report on Telecoms in Emerging Markets," The Economist, 2009.

Aside from investing in broadband and mobile phone infrastructures to extend coverage, land administration agencies need to ensure that the national public sector information policy supports open and transparent land records. They must also launch awareness programs to raise interest in and knowledge of the new information services. These information service initiatives are good opportunities for leveraging investment and knowledge from the private sector through public-private partnerships.

INNOVATIVE PRACTICE SUMMARY ICT and the Land Governance Assessment Framework

Guidelines on how to achieve good governance have been prepared by the World Bank. The Land Governance Assessment Framework (World Bank 2010) addresses five thematic areas: legal and institutional framework; land use planning, management and taxation; management of public land; public provision of land information; and dispute resolution and conflict management. Given that ICT in land administration generates statistics to determine many of the Land Governance Indicators, land administration computerization projects need to be guided by the role of ICT in the Land Governance Assessment Framework. The following are some of the areas where ICT can support Land Governance Indicators (LGIs) within this framework.

LGI-2(iv): A high percentage of land registered to physical persons is registered in the name of women, either individually or jointly.

ICT can increase the involvement of the so-called Third Sector of nongovernmental and local organizations, including those representing women. Transparency and analysis of land administration information will highlight any gender imbalances in ownership across a country. Online communities (for example, <http://www.womenandhumansettlements.org/> and <http://www.huairou.org/>) allow grassroots women's organizations to share experiences and advance their capacity to collectively influence local to global political spaces on behalf of their communities.

LGI-5(iv): Information related to rights vis-à-vis land is available to other institutions that need this information at reasonable cost and is readily accessible, largely due to the fact that land information is maintained in a uniform way.

ICT can overcome the historic separation between the land registry and the cadastre by providing electronic linkages between both organizations. ICT can also be a catalyst for better interoperability and integration with other departments of government, although there must be the political will to make this happen. ICT can also reinforce links between the public and private sectors. In recent years, many land administration functions and activities—from surveying through the provision of ICT to the delivery of various land information services—have been shared with the private sector, often through formal public-private partnerships.

LGI-7(ii): In urban areas, public input is sought in preparing and amending changes in land use plans, and the public responses are explicitly referenced in the report prepared by the public body responsible for preparing the new public plans. This report is publicly accessible.

ICT, and especially GIS, can provide effective forums for public consultation, allow more scenarios to be presented, and extend the normal outreach of the consultations.

LGI-10(i): The assessment of land / property values for tax purposes is based on market prices, with minimal differences between recorded values and market prices across different uses and types of users; and valuation rolls are regularly updated.

ICT can compare property values as part of a mass appraisal for land and property taxation, monitor changes in land uses that may affect the taxable value of property, and compare prices paid for similar properties.

LGI-12(v): All the information in the public land inventory is accessible to the public.

ICT can provide efficient Internet access to public registers that are transparent and searchable following a number of criteria, including map-based searches.

SMS-based property enquiry services via mobile phone remove the need for intermediaries to access land administration services and provide simple, transparent, and accessible services that can rapidly build public trust.

LGI-16(i): Most records for privately held land registered in the registry are readily identifiable in maps in the registry or cadastre.

ICT can provide efficient access, including Internet information services, to public registers that are transparent and searchable following a number of criteria, including map-based searches.

LGI-18(iii): There is significant investment in capital in the system to record rights in land so that the system is sustainable but still accessible by the poor.

ICT can provide innovative channels to deliver services to many who had previously been excluded, especially in rural areas. Mobile phones can be used to deliver Internet- and SMS-based services, and remote access to the Internet can support mobile land offices.

INNOVATIVE PRACTICE SUMMARY

Improving Public Access to Land Administration Services in Indonesia

With World Bank support, Indonesia's National Land Agency, Badan Pertanahan Nasional (BPN), has set out an exciting and ambitious plan for land reform, with ICT at the center. Improving public access to land services is a priority of the BPN Karanganyar office in Central Java, where involvement in the land office computerization project triggered innovative uses of ICT to build public trust in land administration. The office has expanded its services to include an SMS-based property inquiry service, known as Interactive Land Information. This service removes the need for intermediaries to access BPN's services. It is simple, transparent, and its accessible services rapidly build public trust.

The BPN Karanganyar office has also developed the People's Land Titling Service (LARASITA), a mobile land office (see image 13.2) that travels to villages to provide to BPN's property

services to previously disconnected communities. The mobile office (a modified van) is equipped with laptops connected to the main database in BPN's Karanganyar office through wireless connectivity (WLAN), and a 2.4 GHz wireless antenna installed on top of the van and on top of a 60-meter tower behind the BPN office. This infrastructure enables the LARASITA van to operate in real time within a 20-kilometer radius of the tower. The head of the BPN Karanganyar office observed that "as long as we can bring BPN presence and services closer to the people, and provide the right information, then LARASITA has achieved its mission." BPN rolled out LARASITA to an additional five provinces in 2009, increasing its outreach significantly.

IMAGE 13.2. LARASITA: A Mobile Land Office in Indonesia



Source: Warnest and Bell 2009a.

Topic Note 13.5: PUBLIC SECTOR INFORMATION POLICY SUPPORTING EFFECTIVE ICT-BASED INFORMATION SERVICES

TRENDS AND ISSUES

Since open, transparent access to land administration information is a prerequisite for developing effective land markets, reducing corruption, and building a trusting relationship with civil society, it is essential that land administration agencies work closely with policy makers to ensure the maximum exposure and reuse of land administration information in the public domain. Recent progress in making copyright, licensing, and pricing arrangements as simple and consistent as possible includes the following developments:

- Many countries release land administration information, at a charge, to the private sector to allow innovative information services to be created. Such services require robust copyright, licensing, and pricing arrangements; but if these arrangements are too complex and too variable across customers, they will deter uptake, innovation, and potential revenues. The National Mapping Agency of Great Britain recently overhauled and greatly simplified its licensing agreements with partners. (See "Licenses and Agreements Explained, Ordnance Survey (United Kingdom), <http://www.ordnancesurvey.co.uk/oswebsite/licensing/index.html>.) This change involved close dialogue with partners in the private sector and reduced the overheads of public-private partnerships.
- A number of governments recently introduced transparency agendas that emphasize the need for governments to be accountable to taxpayers and have driven programs to publish key government data sets through the establishment of a single access point for government data. In parallel with this development, governments have also developed open government licenses, which provide a single set of terms and conditions for anyone wishing to use or license freely available government information. This form of licensing allows developers and entrepreneurs wishing to use government data to create new applications without any formal application for permission. It is normally interoperable with other internationally recognized licensing models, such as Creative Commons (box 13.4). Although these government open data initiatives have not yet influenced land administration domains, inevitably they will come under increasing pressure to release their data as open data. This move will

BOX 13.4. Creative Commons Supports Open Government Licenses

Creative Commons (<http://creativecommons.org>) develops, supports, and stewards a legal and technical infrastructure that maximizes digital creativity, sharing, and innovation. The infrastructure consists of a set of copyright licenses and tools that create a balance inside the traditional “all rights reserved” setting that copyright law creates. The tools give everyone from individual creators to large companies and institutions a simple, standardized way to keep their copyright while allowing certain uses of their work—a “some rights reserved” approach to copyright—which makes their creative, educational, and scientific content instantly more compatible with the full potential of the Internet. This combination of tools and users is a vast and growing digital commons, a pool of content that can be copied, distributed, edited, remixed, and built upon, all within the boundaries of copyright law. A recent example of an open government license was created by the National Archives in the United Kingdom, where it is now being adopted by agencies providing open geospatial information services.

Source: “Open Government License for Public Sector Information,” National Archives (United Kingdom), <http://www.nationalarchives.gov.uk/doc/open-government-licence/>, accessed May 2011.

test the sustainability of their business models, as revenue streams from selling data and information services will be challenged. Land administration agencies must work closely with their governments to ensure the fine balance between supporting the transparency agenda and the financial sustainability of their organizations.

Policies ensuring that copyright, licensing, and pricing arrangements are kept as simple and consistent as possible will enable strong business interoperability and generate cooperation and shared services among government agencies and their partners. Two examples—one from the Lao PDR and the other from Vietnam—emphasize the important role of public information policy in e-governance. Information for the examples comes from Warnest and Bell (2009b, 2009d).

INNOVATIVE PRACTICE SUMMARY A Policy Framework to Support the Lao PDR's National Land and Natural Resource Information System

In the Lao PDR, land registry officials, decision makers, and urban planners use a variety of ad hoc and often nonstandardized

GIS and mapping applications, and in many instances still rely on paper-based processes. However, new approaches to computerizing land records and delivering e-government services are helping expand the land information services offered to the Lao PDR's urban and rural communities.

In 2004, with support from UNDP, the Lao PDR's Science, Technology, and Environment Agency (STEA) developed the ICT for Development Project under the Office of the Prime Minister. The project's main objectives were to develop a policy framework for the management, standardization, and exchange of national digital information to implement the government's ICT master plan and strategy for 2006–10.

A critical component of a national information base is information on land and natural resources. The Lao PDR's comprehensive strategy for land information coordination and management centers on the development of the Lao Spatial Data Infrastructure, a framework of land information, access policies, data standards, and ICT infrastructure that will benefit a range of users and agencies. Two key organizations are building the LSDI: the National Geographic Department, and STEA. LSDI is being piloted in Vientiane Capital City.

As part of this effort, the second phase of the Lao Land Titling Project (2004–09) developed a computerized national land information service to serve as the backbone for an efficient land administration system. The planned national information service will give registry officials access to a complete, reliable land inventory linked to information on who has rights over land. This information will be stored in an interoperable database available online, seamlessly linking textual and mapping information. The land information service will free government agencies from paper-based processes and make it possible to deliver the full range of land services in each land office and online. Kiosks in rural districts will enable communities to access government land services online.

LSDI is viewed as an increasingly important factor in the Lao PDR's socioeconomic development. Integrating land use, ownership, planning, agricultural, and environmental data themes, the LSDI will eventually support all land-related governance and management activities at the central and local levels. The far-reaching benefits will include improved natural resource management and environmental protection, which are vital, given the increasing pressure on the Lao PDR from international investors. Success in implementing the comprehensive strategy for land information coordination and management has been achieved by consolidating responsibilities for land under one organization, formulating and approving land policy, implementing institutional and regulatory reform, building institutional capacity, and strengthening project management mechanisms.

INNOVATIVE PRACTICE SUMMARY

Vietnam's One-Stop Shop for E-Government Services

The government of Vietnam views land reform as a core component of its gradual market reforms (*doi moi*), which are recognized as one of the most important drivers of Vietnam's rapid growth and poverty reduction. The Vietnam Land Administration Project (VLAP), approved in March 2008, will develop a land information system and deliver government land services online. In this way, VLAP will provide greater accessibility and community participation in Vietnam's land administration system, improving transparency and strengthening accountability. VLAP focuses particularly on modernizing the land registration system and improving the delivery of land registration services.

One of the most active e-government initiatives, the Bac Ninh land information system, is providing online services and electronic service centers in rural districts. Just 30 kilometers from Hanoi, Bac Ninh Province is Vietnam's smallest and most densely populated province, with an estimated population of 1 million. Twenty-one local area networks have been established to serve government agencies, and an additional seven to serve rural districts outside the capital city. Remarkably,

each department in the province is connected via fiber-optic networks to the provincial Data Integration Center.

The integrated land and house management information system established in Nam Dinh City is a successful example of the synergy between land administration, house management, and ICT. The city's new Center for Land and House Information and Registration is a one-stop shop for critical and highly demanded land services, extending from land titling and urban land plans to construction permits, management, and taxation. ICT removed the walls between the local government agencies involved in these procedures—such as the departments for land, house management, and taxation and the people's committees—in 25 wards. They have been able to review and streamline their business processes and maintain close collaboration through online data exchanges and process monitoring.

The prime minister has approved a Strategy for Information Technology Application and Development for Natural Resources and Environment to Year 2015 with a vision to 2020. A central element of the proposed reforms is the development of a system for accessing, retrieving, and distributing land information nationwide.

Topic Note 13.6: SUSTAINABLE FUNDING OF ICT IN LAND ADMINISTRATION

TRENDS AND ISSUES

Land administration systems need to be a revenue-generating, self-sustaining activity. Most land administration agencies have adopted computerized technology, the life span of which is rarely more than four years and often less. The more an agency becomes capital intensive, the more it needs to spend on maintaining and replacing its ICT.

It is generally agreed that the state has primary responsibility for ensuring that appropriate policy, legal, and institutional frameworks for land administration are in place and that the formal land market operates efficiently. But should land administration be operated only by the state, and should it be paid for wholly by the state? Should there not, for example, be a partnership with the private sector to charge for services based on the concept that those who benefit most contribute most to the cost? Strategic and business planning are needed to develop modern business models for land administration and for services to be provided in a business-like, cost-effective manner.

Sustainable Business and Organizational Models

The experience of a number of Western countries and increasingly of countries in Eastern Europe, Latin America, and Asia (including Central Asia) shows that land registration systems and even the cadastre can finance themselves. These agencies can achieve full cost recovery by charging for the goods and services they provide, once the necessary basic investment has been made and services have been made more efficient.

There are two elements in financing a land information infrastructure: the building of the infrastructure, and its maintenance. Building a national cadastre and land registration solution is expensive. The cost of rebuilding an out-of-date cadastre can run into many millions of dollars, depending on the size of the country and the precision of the survey data. Such an investment is hard to justify unless it can be shown to generate sufficient revenue when it has reached a critical mass of transactions. For this reason, one of the first tasks in modernizing land administration is to understand the different types of users, determine their specific requirements for

services, and create a business case for the corresponding investments in ICT. This type of strategic planning is often anathema to traditionally state-funded, output-based organizations such as land administration agencies.

It is generally accepted that building a land administration infrastructure needs a substantial level of support from the state or external funding sources. Maintaining the system is a different story, and experience suggests that self-sufficiency is possible. Where there is no attempt at cost recovery and all operations are paid for by the state, there is always a risk that the funds needed to improve service and replace equipment will not be provided, especially when government funds are in short supply. With governments currently trying to reduce the burden of public services on their state treasuries, there is a good opportunity to establish self-funding, autonomous, business-oriented agencies. El Salvador, the Kyrgyz Republic, the former Yugoslav Republic of Macedonia, Serbia, and Singapore have all planned autonomous, self-financing land administration agencies, while Lithuania, Moldova, and Georgia have attained self-financing agencies. The registration agency in Kazakhstan was obliged to be self-financing from the day it was established.

Leveraging Knowledge and Finance from the Private Sector

New models are being adopted for involving the private sector in sharing the investment and risk in designing, implementing, and sometimes operating land administration infrastructure and associated services. The complexity and management requirements of these large, lengthy ICT programs are frequently underestimated. As discussed, some of the earliest investment in ICT for land administration featured large, internationally bid contracts that proved difficult to manage, involved lengthy tendering periods, and ultimately were slow to deliver operational solutions. In-house development has generally proven more successful and allows agencies to either retain their own specialists or use local companies to build and sustain local capacity. This approach is easier to manage; is more compatible with incremental implementation; and, of particular importance, is very effective at amending and maintaining the solution downstream.

An innovative approach is to engage the private sector under public-private partnerships. For example, the Register of Scotland (<http://www.ros.gov.uk/>) has formed a 10-year partnership with a technology provider under which it shares the ICT investment; but the agency still delivers the services. Another model of public-private partnership has emerged in the Philippines, where a private

consortium has been contracted to deliver a build/own/operate system for the Land Registration Authority over an estimated 10-year project period. In such partnerships, after the agreed-on concession (payback) period is concluded, the government fully owns the land administration infrastructure. Until that time, revenue generated through an agreed fee structure will be retained by the consortium (Warnest and Bell 2009c).

There are risks associated with these long-term public-private partnerships, as the assumptions underpinning the agreements will inevitably change over the extended time frames. A good example is the recent global financial crisis, which depressed land and property markets and reduced the revenue streams that support ICT investments and service provision. It is therefore essential that these public-private partnerships have flexibility for change over their life cycle to accommodate new business realities.

When setting fee rates within a self-sustaining business model, the danger is that the cost of transactions will deter some people from registering property transfers, with the result that an informal land market runs in parallel with the formal one. The cost of transactions needs to be kept at a level that will encourage citizens to engage with and benefit from land administration. While underpricing may encourage use of the data and generate volumes sufficient to achieve lower unit costs through economies of scale, there will come a time when nonusers, including the poor, are effectively subsidizing the rich.

Behavioral Change Requirements

The idea that a government agency should operate as a business making at least a marginal profit has required a significant cultural shift that is often very difficult for those who have been accustomed to a central government service-driven environment. In reality, it should improve the provision of services, based on what people want and need rather than on what those in authority think is good for the general public. Agencies become more accountable to the public and develop an improved understanding and identification of those products and services that are of a commercial nature and those that are essentially a public good. The downside of the commercial approach is that financial incentives that benefit individual agencies may be incompatible with “joined-up” government and attempts to encourage cooperation between government departments. Yet if each department works to its own business plan and the maximization of its own income, the common good can become marginalized.

INNOVATIVE PRACTICE SUMMARY

ICT-Derived Efficiencies in the Kyrgyz Republic Benefit Land Office Staff

Kant Registration Office is one of the Kyrgyz Republic's most successful land registration offices and is financially self-sufficient, with the status of a state enterprise.⁵ Growth in business increased revenues from its services (land transactions, information, and other services) from around US\$90,000 in 2005 to US\$265,000 in 2008. Fees are the standard (low) fees set by Gosregister, the national coordinating agency. Despite the low fees, the revenues cover all operating costs, including salaries, utilities, materials, and renewals of equipment and furnishings. (Start-up investments, however, were financed by the Land and Real Estate Registration Project.) The land registration office itself has funded the progressive digitization of old paper records.

Kant Registration Office pays its staff well above government rates and adds bonuses quarterly and on special holidays. The director has nearly tripled staff members' salaries in the last four years. She believes that such salaries develop trust and provide incentives for quality work. As fees are modest in comparison to those charged in most countries, financial self-sufficiency has been achieved primarily through gains in efficiency.

INNOVATIVE PRACTICE SUMMARY

The Philippines: A Public-Private Approach to ICT Financing and Risk Sharing

One approach for the public sector to finance ICT is to share the risks and rewards of ICT investments with

private organizations or consortia.⁶ The Philippines has adopted this approach for a 10-year project to computerize 159 local and provincial Registries of Deeds, 16 regional Registers, and the central Registry of Deeds office in Manila. The project is implemented by the private consortium LARES, which will deliver a build/own/operate system for the Land Registration Authority. The International Finance Corporation, part of the World Bank Group, is one of the financiers, providing US\$22 million. The project aims to digitize all Land Registration Authority records. Local and wide area network infrastructure will be installed to enable interagency and public online access to land information and land titles. The revenue generated by the new system will accrue to the consortium until the agreed-on concession period ends, at which time the government will fully own the system.

The Philippines has also been successful with ICT innovations for e-government and online land services. Outsourcing service provision to the private sector is the Philippines' leading strategy for harnessing ICT to communicate with citizens and conduct business effectively. The telecommunications company SMART developed an innovative "I-Connect" SMS-based customer management service. The potential benefits of I-Connect are many when coupled with land information infrastructure technologies such as those in Leyte, Quezon, and the longer-term Land Administration and Management program. It is anticipated that readily accessible online land services and property inquiries via mobile phone will improve public perceptions of government and confidence in land administration.

Topic Note 13.7: DESIGNING SCALABLE AND INTEROPERABLE LAND INFORMATION INFRASTRUCTURES

TRENDS AND ISSUES

Implementing land information infrastructures to support land administration is a complex process, normally achieved over a number of years. Many countries will take up to 10 years to achieve comprehensive coverage with a rich set of e-services. Over this period, a number of disruptive technologies will arrive to challenge and potentially change the choice of ICT. This note aims to identify approaches to ensure that investments in ICT possess the scalability and interoperability that will potentially sustain the solution over the life cycles of new technology and reduce the risk of becoming

prematurely obsolete. A robust, extensible architecture should be defined, tested, and available early in the project.

There are no turnkey solutions. However, there is a great deal of practice and experience worldwide on implementing ICT for land administration, and there is no need to reinvent the wheel. The following issues have been dealt with in other countries, and there is much to learn from those experiences. An ICT solution should never be developed in isolation from trends and experience worldwide.

⁵ Information in this section is drawn from World Bank 2010.

⁶ Information in this section is drawn from Warnest and Bell 2009c.

Data Model Standards

The major investment component in land information infrastructure is in the collection and maintenance of land registration and cadastral information. It is imperative that this information be easily ported across generations of ICT. This possibility is gradually being achieved through interoperable data model standards. For example, European countries implementing the EU INSPIRE Directive must be able to make specific data themes discoverable and accessible through adherence to data specifications (that is, data model standards). One of these themes is “cadastral parcels.” (See http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_CP_v3.0.pdf.) Another initiative in setting data model standards is the Social Tenure Domain Model under the wider Land Administration Domain Model developed by UN-HABITAT and FIG (Lemmen et al. 2007), which provides a standard model for social/customary tenure that ISO is ratifying and adopting. The Land Administration Domain Model is being used to support the Solutions for Open Land Administration (SOLA) Project (see <http://www.flossola.org>).

Open Interoperability Standards

The implementation of shared information services within the concept of an NSDI has only been possible through the agreement on and adoption of open standards. ICT has a vast array of open standards, but within the geospatial domain, the Open Geospatial Consortium, Inc. (OGC) is a nonprofit, international, voluntary, consensus standards organization that is leading the development of standards for geospatial and location-based services (<http://www.opengeospatial.org/>). OGC standards are technical documents that detail interfaces or encodings. Software developers use these documents to build open interfaces and encodings into their products and services (see IPS “Combining Open Source Solutions with Open Geospatial Consortium Standards”). Ideally, when OGC standards are implemented in products or online services by two software engineers working independently, the resulting components “plug and play” with other components compliant with the same OGC standards. OGC works closely with the ISO TC 211 Geographic Information / Geomatics and submits OGC standards for ISO approval and adoption (see http://www.iso.org/iso/iso_catalogue/catalogue_tc/). When bidding for land administration ICT, it is essential that the statement of requirements explicitly specifies the use of the appropriate OGC/ISO standards in the design of the solution to ensure interoperability of the solution.

Service-Oriented Architecture and Web Services

Web services provide a standard means of interoperation among diverse software applications, running on a variety of

platforms and/or frameworks. Web services are characterized by their great interoperability and extensibility, as well as their descriptions, thanks to the use of XML (Extensible Markup Language). Today, XML is one of the most widely used formats for sharing structured information—between programs, between people, and between computers and people, both locally and across networks. Web services can be loosely coupled to achieve complex operations. Programs providing simple services, which can be built on different hardware and software platforms, can interact with each other to deliver sophisticated added-value services (see <http://www.w3.org/standards>).

As an example of how Web services can be used, a message could be sent from a home location application to a Web-service-enabled properties-for-sale search website, such as a real estate price database, with the parameters needed for a search. The property-search website would then return an XML-formatted document with the resulting data, such as prices, location, and features. Because the data are returned in a standardized format, they can be integrated directly into the application. The home location application could then send messages to other Web-service-enabled sites to obtain other property information on local amenities, crime statistics, public transportation facilities, and similar parameters. The information could be integrated easily into the home location application to support decision making. Service-oriented architecture and Web services are increasingly used in designing modern land information infrastructures to support incremental development, extension, and ease of integration with other Web-based information services.

INNOVATIVE PRACTICE SUMMARY

Combining Open Source Solutions with Open Geospatial Consortium Standards

GeoServer, MapServer, and Deegree are open source map server products focusing on Internet mapping applications using Open Geospatial Consortium (OGC) WebGIS standards. These OGC interoperability standards—such as WMS, WFS, and WFS-T—allow the cross-platform exchange of geographic information over the Internet.⁷ Using these standards, map data stored in ArcSDE or Oracle Spatial and PostGIS databases, for example, can be accessed over the Internet with a standard Web browser or GIS client software. With WMS, map data can be accessed and displayed as an image that can be overlaid with GIS data from other data sources to produce composite maps. With WFS, users can

7 Information in this section drawn from FAO and FIG 2010.

access the actual geographic features in vector format, while WFS-T allows features to be created, deleted, and updated.

MapServer, GeoServer, and Deegree are server-based “map engines” that display spatial data (maps, images, or vector data, depending on the OGC Web service) over the Internet to users based on their requests. MapServer has proven to be a very mature and reliable product for distributing maps from GIS data sources over the Internet through the WMS, WCS, and other OGC interoperability standards. GeoServer and Deegree are more recent projects built with Java technology. While comparable to MapServer in many ways, GeoServer and Deegree go further by supporting transactional WFS services, allowing users to insert, delete, and modify geographical data at the source from remote locations. In land administration solutions, this functionality would allow notaries to sketch new parcel boundaries resulting from property transactions on a digital map in their preferred GIS client software and send this new boundary information in the GML data format to the cadastral database on the WFS-T server.

A number of European cadastres already use WMS and/or WFS to give citizens access to public cadastral data sets over the Internet, and are thus following the INSPIRE principles to provide public access to spatial data sets that are collected by the government. With the availability of high-quality, open source Internet mapping tools, other national cadastre agencies are expected to follow this trend.

INNOVATIVE PRACTICE SUMMARY **The Kyrgyz Republic’s Open Source Strategy** **and GIS Solutions**

The Kyrgyz Republic has adopted a national strategy, “ICT for Development,” that envisions ICT as an engine for economic development throughout the country.⁸ The major components of the strategy are e-commerce, e-government, e-education, and the public sector. In all of these areas, open source technologies provide a mechanism for achieving strategic goals and overcoming the digital divide. ICT-based development requires active growth in the local community of IT professionals, and open source projects provide local IT professionals with very effective opportunities to accumulate and share experience. As local capabilities develop and as support for open source systems grows, government and industry can rely more on local firms to build cost-effective open source solutions. In this iterative process, the more open source systems a country uses, the greater the growth of the local ICT industry and the greater the possible savings for government and industry in building more open source

systems. Starting from a base of a few projects, the process should result in consistent economic growth.

For example, the Land and Real Estate Registration Project in the Kyrgyz Republic was implemented to support the development of markets for land and real estate through the introduction of a reliable and well-functioning land and real estate registration system. The open source approach adopted by the project appears to be successful. For example, open source GIS software piloted by the Bishkek Land Registration Office is being rolled out to the other 46 land registration offices (World Bank 2011). The project has also been successful in the sense that the value of annual property sales rose from US\$120 million in 2002 to US\$1.5 billion in 2007, and the annual value of new mortgages increased from less than US\$100 million in 2002 to US\$1.3 billion in 2008.

From this experience, the open source initiative appears to have potential to focus implementation of the national ICT for Development strategy and enable rapid ICT development in the Kyrgyz Republic. This model may be applicable in other developing countries that view ICT as a strategic tool for economic development.

INNOVATIVE PRACTICE SUMMARY **Social Tenure Domain Model**

In developing countries, large portions of land remain untitled, with less than 30 percent of cadastral coverage conforming to the situation on the ground.⁹ Where there is little land information, there is little land administration and management. Conventional land information systems cannot adequately serve areas that do not conform to the land parcel approach applied in the developed world. A more flexible system is needed for identifying the various kinds of land tenure in informal settlements. This system has to be based on a global standard, and the local community must be able to manage it. The Social Tenure Domain Model (STDM) introduces new, unconventional approaches in land administration by providing a land information management framework that integrates formal, informal, and customary land systems as well as administrative and spatial components.

STDM relies on tools for recording all forms of land rights, all types of rights holders, and all kinds of land and property objects or spatial units, regardless of the level of formality. The thinking behind STDM goes beyond established conventions. For example, traditional or conventional land administration systems relate names or addresses of persons to land parcels via rights. An alternative option provided by STDM relates

8 Information in this section is drawn from Abdrisaev et al. (2005).

9 Information in this section is drawn from FAO and FIG (2010).

personal identifiers, such as fingerprints, to a coordinate point inside a plot of land through a social tenure relation such as tenancy. The STDM thus provides an extensible basis for an efficient and effective system for recording land rights.

FURTHER READING

Bell, K. 2005. *Land Administration and Management: The Need for Innovative Approaches to Land Policy and Tenure Security*. Expert Group Meeting on secure land tenure, ESCAP, Bangkok, December 8–9. http://www.fig.net/commission7/bangkok_2005/, accessed May 2011.

Cornia, G., and J. Riddell (eds.). 2008. *Towards a Vision of Land in 2015*. Cambridge, MA: Lincoln Institute of Land Policy.

Dale, P., and J. McLaughlin. 1999. *Land Administration*. Oxford: Oxford University Press.

Deininger, K. 2003. *Land Policies for Growth and Poverty Reduction*. World Bank Policy Research Report 26384. Oxford and Washington, DC: Oxford University Press and World Bank.

Deininger, K., C. Augustinus, S. Enemark, and P. Munro-Faure. 2010. “Innovations in Land Rights Recognition, Administration, and Governance.” Joint Organizational Discussion Paper, Issue 2, World Bank, Global Land Tool Network (GLTN), Fédération Internationale des Géomètres (FIG), and Food and Agriculture Organization (FAO), Washington, DC.

Deininger, K., H. Selod, and T. Burns. 2009. “Using the Land Governance Assessment Framework (LGAF): Lessons and Next Steps.” World Bank. <http://siteresources.worldbank.org/EXTARD/Resources/336681-1236436879081/5893311-1271205116054/SelodNewPaper.pdf>, accessed April 2011.

Economist. 2009. “A Special Report on Telecoms in Emerging Markets.” September 24.

FAO (Food and Agriculture Organization). 2003. “The Design of Land Consolidation Pilot Projects in Central and Eastern Europe.” FAO Land Tenure Studies 6, Rome.

———. 2004. “Operations Manual for Land Consolidation Projects in Central and Eastern Europe.” FAO Land Tenure Manuals 1, Rome.

———. 2007. “Good Governance in Land Tenure and Administration.” Land Tenure Studies 9, Rome.

———. 2009. “Towards Voluntary Guidelines on Responsible Governance of Tenure of Land.” Land Tenure Working Paper 10, Rome.

GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit). 2009. *Geographic Information System (GIS): The Spatial Dimension to Development Cooperation*. Eschborn: GTZ.

Krishna Murthy, Y. V. N. 2010. “A State-wide Land Information System for Natural Resource Management and Disaster Mitigation: Scope for Land Administration.” In *Innovations in Land Rights Recognition, Administration, and Governance*, edited by K. Deininger et al., 83–95. Washington, DC: World Bank, Global Land Tool Network (GLTN), Fédération Internationale des Géomètres (FIG), and Food and Agriculture Organization (FAO).

Quan, J. 2006. “Land Access in the 21st Century: Issues, Trends, Linkages, and Policy Options.” LSP Working Paper 24. FAO Livelihood Support Programme, Rome.

Stoter, J. E. 2004. *3D Cadastre*. Delft: Netherlands Geodetic Commission.

UNDP (United Nations Development Programme). 1998. “Capacity Assessment and Development in a Systems and Strategic Management Context.” Technical Advisory Paper 3, New York.

Williamson, I., A. Rajabifard, and M-E. Feeney. 2003. *Developing Spatial Data Infrastructures: From Concept to Reality*. London: Taylor & Francis.

Williamson, I., and J. Wallace. 2006. “Spatially Enabling Governments: A New Direction for Land Administration Systems.” *Proceedings of the 23rd FIG Congress, Munich*, October 8–13. https://www.fig.net/pub/fig2006/papers/ts23/ts23_05_williamson_wallace_0261.pdf, accessed May 2011.

World Bank. 2006. “Investment in Land Administration, Policy, and Markets.” Module 10 in *Agriculture Investment Sourcebook*. Washington, DC: World Bank. <http://go.worldbank.org/CZLWF64800>, accessed May 2011.

REFERENCES

Abdrisaev, B. D., Z. S. Djusupova, and A. I. Semyonov. 2005. “Case Study: Kyrgyzstan’s Experience in Promoting Open Source for National ICT Development.” *Systemics, Cybernetics, and Informatics* 3 (2): 19–22.

Bhutta, A. R. 2007. “Punjab: Land Records Management and Information Systems.” State Bank of Pakistan, Islamabad. http://www.sbp.org.pk/sbp_bsc/BSC/DFSD/Workshop/Land-Records-Automation-Punjab.pdf, accessed May 2011.

Dale, P., R. Mahoney, and R. McLaren. 2007. *Land Markets and the Modern Economy*. London: Royal Institution of Chartered Surveyors (RICS).

Deininger, K., and A. Goyal. 2010. “Going Digital: Credit Effects of Land Registry Computerization in India.” Policy Research Working Paper 5244, World Bank, Washington, DC. http://www-wds.worldbank.org/external/default/WDSCContentServer/IW3P/IB/2010/03/29/000158349_20100329110509/Rendered/PDF/WPS5244.pdf, accessed May 2011.

Delville, P. L. 2010. “Registering and Administering Customary Land Rights: Can We Deal with Complexity?” In *Innovations in Land Rights Recognition, Administration, and Governance*, edited by K. Deininger et al., 28–42. Washington, DC: World Bank, Global Land Tool Network (GLTN), Fédération Internationale des Géomètres (FIG), and Food and Agriculture Organization (FAO).

Economist. 2009. “A Special Report on Telecoms in Emerging Markets.” September 24.

Enemark, S., and R. McLaren. 2008. “Preventing Informal Development – through Means of Sustainable Land Use Control.” FIG Working Week Proceedings, Stockholm, June.

Enemark, S., R. McLaren, and P. van der Molen. 2010. *Land Governance in Support of the Millennium Development Goals: A New Agenda for Land Professionals*. FIG Publication 45. Copenhagen: Fédération Internationale des Géomètres (FIG).

FAO (Food and Agriculture Organization) and FIG (Fédération Internationale des Géomètres). 2010. *FLOSS in Cadastre and Land Registration: Opportunities and Risks*. Rome: FAO. <http://www.fao.org/docrep/012/i1447e/i1447e.pdf>, accessed April 2011.

- FIG (Fédération Internationale des Géomètres). 2004. *Marrakech Declaration: Urban-Rural Interrelationship for Sustainable Development*. FIG Publication 33. Copenhagen: FIG.
- Jansen, L. J. M., M. Karatas, M. Küsek, C. Lemmen, and R. Wouters. 2010. "The Computerised Land Re-allotment Process in Turkey and the Netherlands in Multi-purpose Land Consolidation Projects." Proceedings of the 24th FIG Congress, Sydney, 11–16 April. http://www.fig.net/pub/fig2010/papers/ts09h/ts09h_jansen_karatas_et_al_4574.pdf, accessed May 2011.
- Kapitango, K., and M. Meijs. 2010. "Land Registration Using Aerial Photography in Namibia: Costs and Lessons." In *Innovations Land Rights Recognition, Administration, and Governance*, edited by K. Deininger et al., 60–72. Washington, DC: World Bank, Global Land Tool Network (GLTN), Fédération Internationale des Géomètres (FIG), and Food and Agriculture Organization (FAO).
- Lemmen, C., C. Augustinus, P. van Oosterom, and P. van der Molen. 2007. "The Social Tenure Domain Model: Design of a First Draft Model." FIG. http://www.fig.net/pub/fig2007/papers/ts_1a/TS01A_01_lemmen_augustinus_oosterom_molen_1373.pdf accessed May 2011.
- Lemmen, C., and J. Zevenbergen. 2010. "First Experiences with High-Resolution Imagery-Based Adjudication Approach in Ethiopia." In *Innovations in Land Rights Recognition, Administration, and Governance*, edited by K. Deininger et al., 96–104. Washington, DC: World Bank, Global Land Tool Network (GLTN), Fédération Internationale des Géomètres (FIG), and Food and Agriculture Organization (FAO).
- McAuslan, P. 2010. "Ensuring Access to Land for Private Investors." In *Innovations in Land Rights Recognition, Administration, and Governance*, edited by K. Deininger et al., 149–57. Washington, DC: World Bank, Global Land Tool Network (GLTN), Fédération Internationale des Géomètres (FIG), and Food and Agriculture Organization (FAO).
- McLaren, R. A. 2010. "Can the Innovative Use of Mobile Phones Support More Effective Land Administration Services?" Proceedings of the 24th FIG Congress, Sydney, 11–16 April. http://www.fig.net/pub/fig2010/papers/ts03b/ts03b_mclaren_4447.pdf, accessed May 2011.
- Republic of Moldova. 2009. *Implementation of Land Re-Parceling Pilots in Six Villages (Moldova Land Re-Parceling Pilot Project) Final Report*. Ministry of Agriculture and Food Industry, Republic of Moldova, February.
- Macaulay Institute. 2011. *Virtual Landscape Theatre*. <http://www.macaulay.ac.uk/landscapes/>, accessed June 2011.
- Thompson, B., and A. Waller. 2011. *The Role of Cloud Computing in Commercial Property*. Coventry: Royal Institute of Chartered Surveyors (RICS).
- Transparency International India. 2005. *India Corruption Study 2005*. New Delhi: Transparency International India.
- UNECE (United Nations Economic Commission for Europe). 1996. *Land Administration Guidelines*. Geneva: UNECE.
- . 2002. "Mass Evaluation Systems of Land (Real Estate) for Taxation Purposes." Proceedings of the UNECE Working Party on Land Administration Workshop, Federal Land Cadastre Service of Russia, Moscow.
- . 2005. *Land Administration in the UNECE Region: Development Trends and Main Principles*. Geneva.
- UN-HABITAT. 2008. *Secure Land Rights for All*. Nairobi: United Nations Human Settlements Programme.
- . 2011. *The State of Asian Cities 2010 / 2011*. Nairobi: United Nations Human Settlements Programme.
- Warnest, M., and K. C. Bell. 2009a. "Country Focus Indonesia." Information and Communications Technology (ICT) Utilization in Land Administration in the East Asia Region, Land Administration in EAP—Issues and Experiences with Information and Communications Technology, ICT and Rural Access Workshop, Sustainable Development Network Week, World Bank, Washington, DC, February 26.
- . 2009b. "Country Focus Lao PDR." Information and Communications Technology (ICT) Utilization in Land Administration in the East Asia Region, Land Administration in EAP—Issues and Experiences with Information and Communications Technology, ICT and Rural Access Workshop, Sustainable Development Network Week, World Bank, Washington, DC, February 26.
- . 2009c. "Country Focus Philippines." Country Focus Indonesia, Information and Communications Technology (ICT) Utilization in Land Administration in the East Asia Region, Land Administration in EAP—Issues and Experiences with Information and Communications Technology, ICT and Rural Access Workshop, Sustainable Development Network Week, World Bank, Washington, DC, February 26.
- . 2009d. "Country Focus Vietnam." Information and Communications Technology (ICT) Utilization in Land Administration in the East Asia Region, Land Administration in EAP—Issues and Experiences with Information and Communications Technology, ICT and Rural Access Workshop, Sustainable Development Network Week, World Bank, Washington, DC, February 26.
- Williamson, I., S. Enemark, J. Wallace, and A. Rajabifard. 2010. *Land Administration for Sustainable Development*. Redlands: ESRI Press.
- World Bank. 2006. "Investment in Land Administration, Policy, and Markets." Module 10 in *Agriculture Investment Sourcebook*. Washington, DC: World Bank. <http://go.worldbank.org/CZLWF648O0>, accessed May 2011.
- . 2009a. *Thailand Land Information System Project*. Technical Report. Washington, DC: World Bank.
- . 2010. *Land Governance Assessment Framework: Implementation Manual for Assessing Governance in the Land Sector*. Washington, DC: World Bank.
- . 2011. "Kyrgyz Republic: Second Land and Real Estate Registration Project (SLRERP)." Project Implementation Support Mission, March 7–17, Internal World Bank report, Washington, DC.
- Zhao, J., and D. J. Coleman. 2006. "GeoDF: Towards a SDI-Based PPGIS Application for E-Governance." Proceedings of the GSDI 9 Conference, Santiago, November. <http://www.gsdidocs.org/gsdiconf/GSDI-9/papers/TS9.3paper.pdf>, accessed May 2011.

Module 14 USING ICT TO IMPROVE FOREST GOVERNANCE

TUUKKA CASTRÉN (World Bank) and MADHAVI PILLAI (World Bank)

IN THIS MODULE

Overview. Information and communication technology (ICT) applications can be harnessed to enhance public participation and transparency, make law enforcement more efficient, and improve forest management. This module uses the World Bank's Framework for Forest Governance to assess the potential of ICT applications to address different aspects of forest governance.

Topic Note 14.1: Pillar 1—Transparency, Accountability, and Public Participation. Approaches to increasing transparency, accountability, and public participation for forest management through ICT include e-government services and open government applications, advocacy campaigns through text messaging and Internet social networking sites, community radio, crowdsourcing, and collaborative and participatory mapping.

- **Participatory Mapping in Cameroon**
- **The Central Vigilance Commission Website in India**
- **PoiMapper in Kenya**

Topic Note 14.2: Pillar 2—Quality of Forest Administration. Comprehensive forest management information systems have been seen as the ideal solution, yet it is possible to deploy smaller-scale ICT solutions to manage information requirements in key areas, such as the management of fires, inventories, and wildlife tracking.

- **Fire Alert Systems Integrating Remote Sensing and GIS**
- **Kenya: Solving Human/Elephant Conflicts with Mobile Technology**

Topic Note 14.3: Pillar 3—Coherence of Forest Legislation and the Rule of Law. Effective law enforcement systems in the forest sector usually follow the steps of prevention, detection, and suppression. Technology has an important part to play in each of these steps in the efforts to curb illegal logging, transportation, and processing of timber and illegal trade in wildlife.

- **Ghana National Wood Tracking System**
- **Liberia: LiberFor Chain of Custody**

Topic Note 14.4: Pillar 4—Economic Efficiency, Equity, and Incentives. ICT applications can promote business transactions with the private sector, as with the online auction of public timber, or e-auction. ICT applications such as RFID chips can increase productivity and improve efficiency in the supply chain.

- **RFID Chips for Efficient Wood Processing**

OVERVIEW

The management of forests is very dependent on information, knowledge management, and the capacity to process information. This module presents lessons learned on the use of ICT to promote good forest governance.¹ The main

focus is on institutions, their interaction with stakeholders, and how their performance can be strengthened. It does not cover forest inventories and technical resource assessment. While the module is intended to be comprehensive on particular subjects, it does not present all possibilities and current practices of ICT use in forest governance. The objective is to demonstrate the range and diversity of approaches and feasibility of using technology in forested areas (see image 14.1).

¹ The module builds on the 2011 World Bank report "Forest Governance 2.0—A Primer on ICTs and Governance," available at <http://www.profor.info>.

Forest Governance as a Development Challenge

Good governance is a vital ingredient in development and sustainable resource management (Collier 2007); investments in sustainable development are widely recognized to yield better development outcomes within conducive governance environments. Poor governance in the forest sector manifests itself in several ways. Forest crime—such as illegal logging, arson, poaching, or encroachment—is a problem in many areas. In many countries, corruption in the forest sector and rent seeking have caused forest agencies to lose both revenue and credibility. They have created an uneven playing field for legitimate private sector actors due to price undercutting and unreliable access to forest resources. The unpredictable business environment has also led to short-term profit maximization and has discouraged socially and environmentally responsible long-term investments in the forest sector.

The Impact of Poor Forest Governance

Poor governance in the forest sector is an impediment to achieving good development outcomes within the sector. In developing countries, an estimated 1 billion rural poor depend at least partially on forests for their livelihoods, and about 350 million live in and around forests and are heavily dependent on them for economic, social, and cultural needs.

In developing countries, illegal logging in public lands alone causes estimated losses in assets and revenue of more than US\$10 billion annually, more than eight times the total official development assistance dedicated to the sustainable management of forests. As much as US\$5 billion is lost to governments annually because of evaded taxes and royalties on legally sanctioned logging. In addition to financial and economic costs, the equity impact of poor forest governance and illegality is considerable. These rough global estimates give an idea of the magnitude of the problem but mask country-specific variations. Despite the grim global estimates, the situation has improved in some countries. For example, a recent Chatham House mapping shows that illegal logging has fallen more than 50 percent in the past 10 years in Cameroon, the Brazilian Amazon region, and Indonesia.²

Using ICT to Reduce Emissions from Deforestation and Forest Degradation

All schemes to reduce emissions from deforestation and forest degradation (REDD+) emphasize the fundamental

IMAGE 14.1. Scanning Barcodes in Forests Enhances Forest Management



Source: Helveta Ltd.

importance of good governance. Forests ensure the sustainability of environmental services—biodiversity conservation, carbon sequestration, and watershed protection. All these services are at risk if forests are not managed in a sustainable manner.

Pilot projects around the world are currently testing different approaches to REDD+. Some projects are focusing on increasing the involvement of and benefit sharing with indigenous and local communities, especially in terms of mapping and measuring forest boundaries, degradation, and carbon levels. Interesting examples are the Community Carbon project in Mexico (Peters-Guarin and McCall 2010) and the Surui Indigenous Peoples project in the Brazilian Amazon.³ Both projects experiment with smartphones/PDAs with preloaded software for data collection on biomass from sample plots and boundary demarcation using global positioning system (GPS) functions. These projects are training local communities to update data and use simple interfaces on the devices to convert the data into carbon estimates.

² Information in this section was drawn from World Bank 2006a and Lawson 2010.

³ Amazon Conservation Team, Google Earth Outreach, and Moore Foundation (http://www.amazonteam.org/index.php/233/The_Sete_de_Setembro_Indigenous_Reserve) & (<http://www.google.org/earthengine/>).

A pilot project in Ethiopia⁴ also tried to have farmers access the international carbon offsets market and receive payments directly, through a mobile phone. In this case, smallholders near Bahir Dar were asked to measure the diameters of trees on their land twice a year and put the information into a text message, which was sent, along with each farmer's unique identification code, to the regional Watershed Users' Association office. Standard software computed the amount of carbon stored on each farm as well as the change from the previous measurement; any increase in stored carbon dioxide was converted into cash using the going rate of carbon dioxide on international markets, and farmers were paid by their local association.

The Pillars of Forest Governance

It needs to be recognized that even legal activities may lead to unsustainable management of resources and that good governance and legality do not always deliver sustainability. The opposite also holds true: not all technically illegal activities are unsustainable. Development outcomes in forestry depend on many factors both inside and outside the sector. To help improve forest governance, the World Bank has developed a conceptual framework for forest governance that consists of five pillars or building blocks, each with two to seven subcomponents (World Bank 2009) (see box 14.1). This module analyzes each principal component and assesses how information management and ICT can be used to promote the specific dimension of forest governance. It is clear that governance cannot be promoted by knowledge management and technology alone; fundamentally, it is a matter of political choice and the capacity to implement those choices. Therefore, the mere introduction of information technology will not lead to reforms and good governance if the overall environment is not conducive.

Information Management, Development, and Governance: The Role of ICT

New technologies have dramatically changed the way this information is collected and applied in the forest sector. For example, World Bank experiences in Eastern Europe and South Asia demonstrated the importance of appropriate management and generation of information and the need for information on financial and operational issues, as well as performance assessment of state agencies. Public access to this information is a prerequisite for greater accountability (World Bank 2008, 2005).

4 Personal communication, project team.

BOX 14.1. The Building Blocks of Forest Governance and Their Principal Components

Pillar I: Transparency, accountability, and public participation

- Transparency in the forest sector
- Decentralization, devolution, and public participation in forest management
- Accountability of forest officials to stakeholders
- Accountability within the forest agencies

Pillar II: Stability of forest institutions and conflict management

- General stability of forest institutions
- Management of conflict over forest resources

Pillar III: Quality of forest administration

- Willingness to address forest sector issues
- Capacity and effectiveness of forest agencies
- Corruption control within the forest sector
- Forest monitoring and evaluation

Pillar IV: Coherence of forest legislation and the rule of law

- Quality of domestic forest legislation
- Quality of forest law enforcement
- Quality of forest adjudication
- Property rights recognized/honored/enforced

Pillar V: Economic efficiency, equity, and incentives

- Maintenance of ecosystem integrity—sustainable forest use
- Incentives for sustainable use and penalties for violations
- Forest products pricing
- Commercial timber trade and forest businesses
- Equitable allocation of forest benefits
- Market institutions
- Forest revenues and expenditures

Source: World Bank 2009.

These lessons gradually resulted in forest management information systems (FMIS) becoming an essential element in forest sector institutional reform programs. These systems were tried in forestry projects in countries as diverse as Argentina, Bosnia and Herzegovina, Kazakhstan, the Russian Federation, Romania, Vietnam, and several states in India (World Bank 2008). The systems focused on forest administration in the

narrow sense and lacked cross-sectoral linkages.⁵ Information system development has also been integrated into wider forest sector reform programs, as described in the following section and box 14.2.

Experience of World Bank Support for Forest Management Information Systems

Implementation completion reports for a sample of recent World Bank forestry projects show that the introduction of computerized information management systems to facilitate institutional reform had limited success.

For three forestry projects in India, the report notes that the project objectives for FMIS implementation were not achieved or were limited in their success due to delays in assigning the consultancy contracts and a lack of technical capacity.⁶ More positive outcomes have been noted in projects in Romania and in Bosnia and Herzegovina.⁷ In Romania, the report found that “the full system has been installed and tested in headquarter and field office.” The project in Bosnia has had a positive outcome, and the reason for this seems to be a phased approach. The initial focus was on developing overall IT capacity, followed by the introduction of more specialized capabilities such as geographical information systems (GIS) mapping tools.

While forestry administrations seem to have welcomed computers, the link between technology, information management, and institutional reform was not always maintained. The most important reason often was the lack of clarity on how to get the best from the technology. There was inadequate analysis of how technology could be used to improve information management to improve core business processes. Technology was seen as a means to spruce up the “front office” while

“back office” processes largely remained unaltered. Based on these findings, it would be easy to assume that forestry departments did not need information technology to improve their functions. However, it would be more appropriate to conclude that information management needs were insufficiently assessed before executing such a large-scale introduction of new technologies. Other important reasons these projects were not as effective include the following:

- FMIS components were too big and complex.
- Government staff were less familiar with the technical side of information management, and thus drawing up specifications for consultants to develop the systems was difficult.
- Delays in award of contracts meant that the systems could not be tested by the client until the end of the project period.
- Insufficient attention to “change management” to generate “buy in” from staff at all levels.

BOX 14.2. Vietnam: Management Information System for the Forestry Sector

The Management Information System for the Forestry Sector (FORMIS) aims to introduce modern approaches to information management in the Vietnamese forest sector. This includes technological solutions for information integration, remote-sensing technologies, and mobile technologies. FORMIS will contain a number of subsystems and modules to provide information for steering and managing the forestry sector toward sustainable forest management. The FORMIS information strategy will also guide the Ministry of Agriculture and Rural Development in aligning IT investment in other development projects to obtain a harmonized, cost-effective system.

FORMIS is expected to reduce the fragmentation of information by harmonizing standards within the Agriculture Ministry. The project will come up with consistent data structures, standardized and consistent data collection methodologies, and centralized coding systems. The fragmented nature of existing forestry information is partially caused by a case-by-case approach when planning and building information systems, without having a strategic overview. The project pays particular attention to the initial planning of the information strategy and the information system architecture of the systems to be built.

Sources: “Development of Management Information System for Forestry Sector (FORMIS): Overall Work Plan” (March 3, 2010, unpublished); Fowler et al. 2011; Vietnam Development Report 2011.

5 See, for example, the Bosnia and Herzegovina case study in World Bank (2008).

6 The report for the Andhra Pradesh Forestry Project notes that “the project has, in the latter stages, obtained up-to-date GIS hardware and software and established a new Geomatics Centre . . . However, the system has only been fully operational in the latter stages of the project.” The report for Uttar Pradesh Forestry Project notes that “the main weaknesses at (project) entry were . . . an expectation that the implementing agency would manage large consultancies (such as the Forest Management Information Systems, FMIS) when its capacity in this area was limited. Other shortcomings were in the development of the FMIS which was rudimentary and not a full-fledged planning tool at project closure.” The Madhya Pradesh Forestry Project report found that “another shortcoming in sector management was the failure to deliver an improved macro-level planning process supported by a FMIS and associated capacity building.”

7 Romania Forest Development Project (P067367) and Bosnia-Herzegovina Forest Development and Conservation Project (P079161).

ICT in Forest Governance: Experience from Three Countries

Three detailed country reports were prepared to analyze what lessons could be drawn from the experiences of countries with different forest governance challenges and different stages of advancement in the application of ICT in development. The country reports are from Finland, Ghana, and Uganda.

Finland is one of the world's leading countries in applying ICT across all levels of society and different economic sectors. Forests have held a remarkable role in Finnish society for over a century. Alongside the rapid overall development of ICT, forest sector actors have actively developed and applied different ICT solutions to improve efficiency. Conventional ICT applications have been developed to support decision making and to improve the efficiency of the wood supply. During the past decades, the importance of communication between forest actors and the general public has become an emerging requirement, and new solutions have been introduced in response. ICT solutions in Finland are currently in a transition period to second-generation solutions, with a large proportion of solutions and e-services being revised and improved. The major drivers for this are the changes in the operating environment and the rapid development of hardware and communication possibilities.

In general, the readiness for ICT solutions in the Finnish forest sector is very high, which reduces the need for capacity building and technical support in introducing new solutions. The key success factors for ICT solution development and application processes are the involvement of stakeholders, adequate capacity, and a high level of trust between the government and private forest owners. For developing countries, the Finnish model presents two important lessons: (1) good outcomes from ICT solutions can be expected only through a good communication strategy and upfront involvement of stakeholders; and (2) piloting with a smaller user group is beneficial for the final product quality.

The Uganda report shows that the country has put in place the legal and policy architecture for expanding the role of ICT in all spheres of development. However, in general, the forest sector has been lagging behind in adopting these technologies. The high cost and specialized technical skills needed for traditional remote sensing and GIS applications have been a limiting factor. However, corruption, illegal logging, and other forest crimes are notable governance problems in the country. The lack of avenues for citizens to hold their public office bearers accountable has been cited as one of the governance challenges in the sector. On the other

hand, the growth of mobile phone connectivity in the country is being exploited by illegal loggers and poachers.

The experience in Uganda also demonstrates how linking ICT and e-readiness assessment with extensive governance diagnostics provides a good basis for reform.

The important example from Uganda is the spontaneous development of ICT applications through radio and SMS in response to governance challenges (see box 14.5). Other initiatives led by the private sector are using technologies to optimize plantation management and processing. Thus, Uganda is an example where the government has created the space for ICT applications to be widely used, but has not really provided direct support. It is an environment where low-cost, innovative applications would thrive and where radio is still the most influential technology to reach the rural population.

In the case of Ghana, while the country has made a lot of progress with Internet and mobile connectivity in general, applications in the forest sector are lacking. The National Wood Tracking System, which aims to establish a system for tracing the chain of custody, is a notable exception. The system is still being piloted and when complete will enable the forest department to trace timber slated for exports all the way back to the stump, thus meeting its requirements to certify legal timber under the Voluntary Partnership Agreement with the European Union. However, it is a donor-driven system, which does raise questions regarding its sustainability after external funding ends.⁸

Developing a More Integrated Approach

The three main interlinked drivers of change toward a more integrated approach in forest sector information management are as follows:

- 1. Technological change and convergence:** Enables exploring data from anywhere in the world and collaborating with others.
- 2. Increased openness, transparency, and participation:** The forest sector can no longer work in isolation and needs to share information with other stakeholders.
- 3. National e-strategies and e-development programs:** Forest sector information systems development needs to have a whole-government approach.

⁸ Information in this section is drawn from country reports for Finland, Uganda, and Ghana—unpublished consultant reports, available at <http://www.profor.info/profor/knowledge/information-management-and-forest-governance>.

ICT experiences in the forest sector have not been systematically studied, but new applications are being piloted in various countries, and there is a wealth of experience from the field. Experience with ICT tools in other sectors—such as banking, agriculture, fisheries, and public sector governance—has also generated lessons on how ICT can be effectively used to improve governance and service delivery. This module explores the range of ICT applications available and relevant for forest governance, using a sample of field experiences. While most of the cases are directly from the forest sector, nonforestry cases have been included for their relevance to the forest sector. The discussion is focused on understanding what works under real-world conditions, the potential for replication and scaling up, and what can be learned from other sectors.

To understand how ICT can best serve forest governance needs, this module uses the World Bank's framework for forest governance (see box 15.1) to classify the selected examples. Information is a key crosscutting requirement for all the pillars of forest governance. The role of ICT in improving information management under each pillar is explored with the help of field examples through the subsequent topic notes (each topic note represents a pillar). Table 14.1

summarizes the relationship of ICT to the five pillars. The only pillar in the World Bank's framework that has not been specifically addressed is "Stability of Forest Institutions and Conflict Management." This is closely related to the four other pillars. If issues such as transparency, quality of administration, and economic efficiency are ensured, conflicts in the sector can be reduced.

KEY CHALLENGES AND ENABLERS

Though there is great potential for using ICT to improve forest governance, there are no ready-made or easy solutions. This section looks at the operational challenges that confront national forest agencies and practitioners when using ICT for forest governance. It also reviews the key enablers that can help to overcome these challenges. Some of the following discussions address issues generic to all agricultural ICT and e-government initiatives, while others deal with issues specific to forestry.

Be familiar with national ICT policies and e-readiness. Projects can be developed in countries with low readiness, but they must be designed accordingly. E-readiness is an essential factor ensuring that e-services can be used

TABLE 14.1. Pillars of Forest Governance and ICT

PILLAR OF GOVERNANCE	WHAT IS THE INFORMATION MANAGEMENT PROBLEM?	WHICH ICT APPLICATIONS CAN HELP?
I. Transparency, Accountability, and Public Participation	<ul style="list-style-type: none"> • Insufficient access to key information on forest management, land tenure, concessions, etc. • No forums for public to share ideas, alert forest managers, or register complaints. • Lack of information or public consultations on planned development projects and major land use changes. 	<ul style="list-style-type: none"> • E-government and open government applications • Advocacy and awareness campaigns through text messaging and Internet social networking sites • Community radio • Crowdsourcing to increase public participation • Collaborative and participatory mapping
II. Stability of Forest Institutions and Conflict Management	(Applications presented under other pillars.)	
III. Quality of Forest Administration	<ul style="list-style-type: none"> • Costly and difficult to gather detailed information for forest inventories and carbon estimation. • Extensive damage from forest fires and insufficient advance information for forest managers to take action. • Conflicts between humans and wildlife; wildlife poaching. 	<ul style="list-style-type: none"> • Forest cover and carbon stock assessment with CLASlite and airborne LiDAR • Real-time fire alerts • Wildlife tracking and conflict management
IV. Coherence of Forest Legislation and the Rule of Law	<ul style="list-style-type: none"> • Difficult to monitor movement of logs from forest areas. • Information for legality verification is easily tampered with. • Lack of awareness of forest laws. • Surveillance of all critical areas for illegal activities is expensive. 	<ul style="list-style-type: none"> • Technologies for surveillance and deterrence—computerized check posts and GPS • Technologies for tracking timber—chain of custody systems • Legal information management systems: Global Legal Information Network • Mobile and online crime reporting services
V. Economic Efficiency, Equity, and Incentives	<ul style="list-style-type: none"> • Lack of transparency in auctions, sales, and allocations of licenses for planting. • Accurate information on distance and time needed to optimize timber transportation and increase cost-efficiency. 	<ul style="list-style-type: none"> • Online timber sales, licenses, and auctions • Logistics • Mobile phone or PDAs for carbon estimation and receipt of payments

Source: Authors.

and that investments in new systems provide the desired outcomes. The existing and potential capacity needs to be assessed and mapped, and applications need to match the capacity. Development programs may also have components to strengthen the e-readiness in partner forest organizations; this needs to happen in full alignment with national e-government development strategies. Particularly in environments with weak capacity, there is a risk of systems being developed independent of each other, adding to the difficulties associated with building e-government systems across sectors.

Define the problem clearly, assess the information needs, and compare possible solutions. Defining the problem to be addressed is a fundamental requirement for any project, and ICT projects are no exception. ICT applications are tools or enablers, and having good devices alone is no assurance that forestry management will be improved. Therefore, it is essential to properly identify the underlying causes and effects before looking for a technological solution. The objective is also to find the most cost-efficient and feasible solution. Mobile and Internet applications provide many benefits, but traditional communication channels may also be appropriate. Particularly in environments where access to information networks and electricity is limited, lower-tech solutions may be needed. If no systematic feedback systems are required or the information is not time sensitive, conventional strategies like public posters, community meetings, or radio can also help disseminate important information.

Determine the best entry points and the appropriate technology. In ICT, the gradual introduction of new services based on existing ones can be also beneficial. In particular, systems that are aimed at the public and where extensive end user training cannot be provided should be based on familiar user interfaces. Another decision that needs to be made when selecting entry points is the type of technology to be used. Technology choice depends heavily on the existing capacity; mobile phones and even smartphones are much more common in poorer developing countries than Internet-connected computers.

Design culturally appropriate and relevant content. Services provided have to be locally adapted and relevant and meet the requirements of the target audience. The key element is to ensure that applications do not require language skills that are not widely available. Particularly in areas with low literacy rates, it is essential that e-applications form part of a more extensive service package where illiterate users can also access the information through various agents that help them with the applications. This can be arranged through

public agencies or voluntary nongovernmental organizations (NGOs). Working at the local level ensures that applications are responsive to local needs and that there is uptake of the models being developed.

Information and communication technologies can improve forest governance, but operation, maintenance, and project design issues must be addressed. All cases show that if planned properly, both mobile and Internet applications can be developed to improve various aspects of governance. Moreover, these systems can be combined with others to provide a full range of services to public and forest professionals. But having appropriate technology alone is not adequate. One needs to consider two issues crucial to the long-term sustainability of the applications: (1) Project design has to be appropriate and focused on meeting demand; and (2) operational and maintenance issues must be addressed. Recurrent issues like power supply (for recharging laptops, mobile phones, and PDAs), spare parts (such as replacement batteries), and service also need to be addressed.

Some services are consumer driven and can become financially self-sustaining, while others are public goods and need to be financed from public sources. In designing projects, consider costs, long-term financial sustainability, and scalability. Many pilot studies and applications are funded and subsidized by international donors, NGOs, or national governments. However, particularly for commercial services, the long-term sustainability of an application depends mainly on end user participation and out-of-pocket expenditures. These costs arise from the purchase of various information technology services, such as sending responses to text messages, in which cases the total cost depends on the cost of a text message. Very few pilot projects have focused on the financial sustainability of the models, including how much investment is required. To be sustainable, programs need to consider scaling up and replication. This is exceptionally important for forestry because the sector is inherently public service oriented. For example, law enforcement is a public good and should be financed from public resources. Well-functioning business models and reliable revenue streams are critical to public forest management (image 14.2).

Address data security and privacy issues, and develop risk mitigation to prevent the misuse of technology and inaccurate data. Having access to ICT to track illegal activities facilitates better law enforcement; the converse could also be true. Loggers and wildlife poachers may intercept communications between forest authorities and voluntary informers, and text messages can be used to mislead law enforcement agencies. Consequently, law enforcement bodies need to be

IMAGE 14.2. Long-Term Investments Are Critical to Scaling Up Interventions

Source: Douglas Sheil, CIFOR.

prepared to counter disinformation, have at least comparable resources, and be capable of investigating criminal activities. If ICT applications are developed to encourage public participation in forest law enforcement—for example, by opening hotlines for reporting corruption, illegal logging, poaching, or other forest sector crimes—it is critical that the identities of sources not be disclosed, as this could jeopardize their personal safety.

Ensure that there is adequate information on the resource (for example, forest inventories and resource assessments) or readiness to improve data collection.

Having adequate data to be processed in the system is a precondition for transparent information sharing. The lack of data cannot be overcome by any investment in technology. Nevertheless, these investments do not need to be sequential. In most cases it is possible to collect inventory information while developing ICT applications.

Identify the right stakeholders and ensure their participation and avoid local elite capture; include indigenous peoples, women, and the rural poor. The forest sector, by its nature, has diverse stakeholders with varying levels of competence. Large enterprises, senior management, and technical specialists in forest administrations and international NGOs have better knowledge than rural and

indigenous communities, which may have little formal knowledge of the sector and poor or no access to information networks. Also, within the communities, access may be unequal and women or the poor may be excluded, even if local elites have some access and knowledge. To avoid any potential unintended exclusion of key stakeholders, it is essential that any information system development plan include comprehensive stakeholder or client mapping. This should assess what the information needs are and how to provide the required information services, including training.

Ensure buy-in from forest authorities at all levels. Ensuring adoption of an e-governance agenda in forest agencies may also happen through

other means. It may require strong normative guidance from national e-government programs and agencies and may also require the provision of financial incentives. Often, increased use of new technology is driven by efficiency gains and cost savings. If these can be clearly analyzed and demonstrated, agencies have incentives to stay engaged and expand the use of ICT. Even if many NGOs and international organizations have been developing innovative models, if the right authorities are not involved, the new systems will have limited value if their operators do not have access to relevant information and data. Frequently, donor-funded projects have been able to equip the project implementation units with modern hardware and software while other departments remained much more poorly equipped. If wide-scale ICT reforms are expected to happen, it is essential that relevant agencies be upgraded in a way that allows for their participation. This requires adequate investment funding for upgrading hardware, system development, and human capacity building.

Users are able and willing to use new technologies, but they need to be aware of the service and motivated to use it. Even models that are fully functional from a technical perspective may fail to deliver or perform below expectations if users are not aware of them or do not have the right incentives. It is essential for clients to be able to provide feedback

and to be genuinely involved. Making information available by the forest authorities serves several purposes: information is a basis for public consultations and inclusive decision making. However, even limited dissemination is beneficial; if the authorities disseminate information through websites, for example, the information is available to the media and NGOs for scrutiny, even if the public only has limited access to the information.

Applications using mobile phones, radio, and the Internet can be deployed quickly with minimal technological

support. In many cases, the underlying technology already exists and only applications need to be developed. The examples discussed in the topic notes clearly demonstrate that many of the forest applications have been developed on existing platforms based on a demand-driven innovation. These have been used in a number of ways to increase public participation and surveillance of forest areas, to monitor fires, and to reduce human/wildlife conflicts around protected areas.

Additional observations and practical implications from the field examples in the topic notes are summarized in table 14.2.

TABLE 14.2. Summary of Field Examples

PILLAR OF GOVERNANCE	SUITABLE ICT APPLICATIONS	ISSUES TO BE CONSIDERED
Transparency, Accountability, and Public Participation	<ul style="list-style-type: none"> • E-government and open data initiatives • Advocacy and awareness campaigns through text messaging and internet social networking sites • Community radio • Crowdsourcing to increase public participation • Collaborative and participatory mapping 	<ul style="list-style-type: none"> • Applications are mostly Internet and mobile phone based, technologically less challenging, and cheaper to deploy. Cell phone applications would be more useful in forested areas. • Legal and political support is necessary for e-government and open data initiatives, and these applications are best led by government agencies. • NGOs and civil society can establish and manage mobile phone applications, community radio, and participatory mapping. • Costs to users/communities need to be offset through funding from donors / private sector. Community radio (FM) stations can be set up for US\$5,000–US\$15,000 and managed by community members; SMS can be purchased at bulk rates from cell phone companies. • For mapping applications, GPS capability is necessary; PDAs (US\$800–US\$1,200) or smartphones (US\$150–US\$200) can be used, depending on how rugged the device needs to be.
Quality of Forest Administration	<ul style="list-style-type: none"> • Forest cover and carbon stock assessment with CLASlite and airborne LiDAR • Real-time fire alerts through MODIS • Wildlife tracking and conflict management through mobile phone applications 	<ul style="list-style-type: none"> • These applications are for government agencies. • Satellite imagery is now available at lower or no cost; recent developments have simplified software for interpretation. However, technical training is essential to interpret images and generate maps. • The LiDAR approach for carbon assessment is still in the early stages, and costs are estimated at US\$0.10/Ha. Currently, the Carnegie Institution for Science (Department of Global Ecology) is the main provider of the LiDAR technology for forest cover and carbon assessment. • CyberTracker software is free to download onto PDAs and can be tailored for different uses: tracking wildlife, movement of logs, location of specific tree species, etc. It is a good technology for working in collaboration with communities. • Fire alerts from MODIS and through Fire Alert system are free text and email services.
Coherence of Forest Legislation and Rule of Law	<ul style="list-style-type: none"> • Technologies for surveillance and deterrence: computerized checkpoints and GPS tracking of vehicles • Technologies for tracking timber—chain of custody systems • Legal information management systems: Global Legal Information Network • Mobile and online crime reporting services 	<ul style="list-style-type: none"> • Comprehensive chain of custody systems are expensive operations. They are useful where the benefits of legality assurance outweigh the costs, such as in timber exporting countries. Costs of these systems could be shared between industry and government as benefits accrue to both. • Less expensive crime reporting hotlines could be set up to work through voice and text messages. All crime reporting systems need to assure citizens anonymity and safety.
Economic Efficiency, Equity, and Incentives	<ul style="list-style-type: none"> • Online timber sales, licenses, and auctions • Logistics 	<ul style="list-style-type: none"> • These applications would work well in situations where the forest sector is fairly advanced in the use of information technology. While the government agency may need to set up and maintain the applications initially, some services such as online auctions and inventory data, which are used by the industry can have a user fee to offset the cost to the public sector.

Topic Note 14.1: PILLAR 1—TRANSPARENCY, ACCOUNTABILITY, AND PUBLIC PARTICIPATION

TRENDS AND ISSUES

Information availability is a precondition for transparency, accountability, and efficient public participation. Enhancing the accountability of the government and its institutions, including forestry institutions, is a key issue in all countries. Transparency and access to information are essential if public sector forest institutions are to be held accountable for their performance. Making the public aware of forest sector's policies, laws, and the rights and responsibilities of citizens and the state is the first step in increasing transparency and accountability. Public participation and support for forest activities can be increased by actively seeking public opinion and suggestions on government actions through easily accessible avenues. Approaches to increasing transparency, accountability, and public participation through ICT include the following:

- e-government services and open government applications
- advocacy campaigns through text messaging and Internet social networking sites
- community radio
- crowdsourcing—mapping for the people, by the people
- collaborative and participatory mapping.

E-Government and Open Government / Open Data Applications

Open government, open data, and e-government initiatives are meant to increase access to government-owned information and increase transparency and accountability in general. Open government and open data initiatives are giving more access to information that would otherwise be out of bounds. On the other hand, e-government solutions are designed from the perspective of increased efficiency, reduced corruption, and better service delivery. While open government / data may not strictly be the same as e-government, all of these approaches use ICT to make governments more transparent and efficient.

Websites are the first and simplest point of communication with the public in the digital world. Several ministries of forests and the environment have websites with information on key policies, programs, and organizational responsibilities; however, only a few have interactive features that allow them

to receive information from the site's users. A very advanced example is the website of the Forestry Commission of the United Kingdom. This site provides users with information, access to relevant policies and procedures, and links to wider e-government applications in the country (see box 14.3).

BOX 14.3. Website of the Forestry Commission, United Kingdom

The Forestry Commission of the United Kingdom is one of the best examples of e-government in action in the forest sector. The commission's website (<http://www.forestry.gov.uk/>) not only disseminates information on the forests under its jurisdiction but also serves as a platform for interaction with citizens, including e-commerce services. The site is user friendly and, from a governance perspective, has a number of features:

- Information on all aspects of forestry (educational, recreational, scientific, and industrial).
- Up-to-date statistics on timber production, sales, and inventory.
- Information search feature through the land information search, which is a map-based tool giving information about land designations.
- Information on grants and licenses for planting and felling, with a feature for online comments on individual applications.
- Environment impact assessment register shows details of the decisions that the commission makes after assessing the potential environmental impact of work to carry out afforestation or deforestation or to build forest roads or quarries.
- Online auctions through the e-timber sales portal.

In addition to these interactive features, the site provides the commission's policies and standards for sustainable forest management, the government's policies on freedom of information, the rights of citizens to information held by state agencies, and the process of consultation the commission follows before planting or felling in any woodland. The commission also carries out an annual survey where public opinion on forestry is gathered and posted on its site.

Source: <http://www.forestry.gov.uk>.

Australia, New Zealand, and the United Kingdom have open government or open data policies to share information with the public. There are numerous benefits of having access to such large volumes of public data. For example, budget information for the forest sector could be used to monitor the performance of state agencies' projects; and data on harvesting volumes and area could be used by interested civil society organizations to monitor whether harvest levels are sustainable and whether critical ecosystems are being protected.

While open data policies are primarily initiated by government agencies, the Open Budget Initiative demonstrates that it is possible for civil society organizations to generate demand for open data policies. The Open Budget Initiative is a global advocacy program to promote public access to budget information and the adoption of accountable budget systems. It is anchored in a biennial Open Budget Survey that evaluates whether governments give the public access to budget information and opportunities to participate in the budget process at the national level. To measure the overall commitment of the countries surveyed for transparency and for comparisons among countries, the Open Budget Index (OBI) was developed, which is a score assigned to each country based on the information it makes available to the public throughout the budget process. The OBI was initiated by the NGO International Budget Partnership. The OBI could also be applied in the forest sector, and NGOs could initiate an OBI for the forest sector in their country. The role of ICT in this case could be to increase access to information through websites or mobile phones.⁹ The Central Vigilance Commission in India is another example of a "partial" open government initiative.

E-government services have been high on the agenda of many countries for over a decade. The primary motive for launching e-government services, from the perspective of the government, is often to improve the efficiency and cost-effectiveness of operations; reducing corruption is often not stated as one of the objectives. However, studies have shown that e-government programs have a great impact on user perception of corruption and transparency. For example, the World Bank (2009) found that in India, users' perception of corruption in the electronic land registration and records services called Bhoomi, CARD, and Kaveri was lower when compared to the older manual systems. (For a discussion of ICT in land management, see Module 13.)

⁹ <http://www.internationalbudget.org/what-we-do/open-budget-initiative/>.

BOX 14.4. Advocacy and Awareness Tools

FrontlineSMS is free, open source software that turns a laptop and a mobile phone into a central communications hub. Once installed, the program enables users to send and receive text messages with groups of people through mobile phones. Its features include the following:

- No Internet connection is required.
- A phone and SIM card can be attached, and the local mobile phone service operator paid per SMS as usual.
- All phone numbers and records of all incoming and outgoing messages are stored.
- Data are stored on the user's computer, not on external servers.
- Messages can be sent to individuals or large groups and can be replied to individually, which is useful for fieldwork or during surveys.
- Easy to install and requires little or no training to use.
- Developers can freely take the source code and add their own features.
- It can be used anywhere in the world by switching the SIM card.

Source: <http://www.frontlinesms.com/>.

Advocacy and Awareness Campaigns through Text Messaging and Social Networking Sites

The large number of mobile phone subscribers in developing and developed countries and the relatively simple technology for setting up mass text messaging systems (see box 14.4) are helping NGOs and advocacy groups reach out to greater numbers than is possible through traditional mass media. NGOs have used text messages effectively in their campaign for a new forest law in Argentina and to generate public pressure on a food company to stop it from sourcing palm oil from companies that cut down primary rain forests to make room for oil palm plantations. Sites such as <http://www.mobileactive.org> connect NGOs and advocacy groups using mobile technologies for social change and help them with information on the latest trends, do-it-yourself guides, and reviews of mobile applications.

The growth of text messages in advocacy campaigns could be attributed to the following:

- Mobile phones are carried everywhere as a personal accessory and are kept switched on almost 24 hours each day, so the target audience is almost always accessible.
- Messages targeted at individuals are more likely to generate a response than those broadcast to a mass audience.
- Responding to a text message is easier and quicker than making phone calls or sending letters, especially when the responder does not have to pay for sending the message.
- Mobile phones allow two-way interaction, and feedback can be received almost instantly.

NGO campaigns have started using Internet social networks such as Facebook and Twitter to target the youth, who are the primary users of these networks. For example, an international NGO carried out a two-month campaign through Twitter, Reddit, Facebook, and online video against an international food company during 2010 for its use of palm oil from suppliers linked to rainforest destruction. As a result of the campaign, the food company announced in May 2010 that it would partner with the Forest Trust, an international nonprofit organization, to rid its supply chain of any sources involved in the destruction of rain forests.¹⁰ This approach may be more feasible in medium- and high-income countries, where there is more access to the Internet, than in low-income countries. In many developing countries, text messaging is still the primary means of data collection and dissemination. A combination of media can be used successfully, as the example from Uganda demonstrates (see box 14.5).

Community Radio

The use of radio to broadcast development issues is not new. However, community radio is relatively new, and over the past decade several community radio stations have been established around the world to help women and marginalized groups to build networks and gain access to information on health, livelihoods, farming, weather, and markets, as well as to educate communities on democracy, citizen rights, and gender issues.

Radios are relatively cheap and easily repaired and widely available, even in the poorest regions. In several African countries, radio broadcasts are the primary medium for communicating political and religious messages. In the poorest

BOX 14.5. Uganda—Environment Alert: Civil Society Organizations Use ICT in Advocacy Campaigns

In 2007, the government of Uganda wanted to give away a third of the Mabira Central Forest Reserves to a sugar company after the government was asked to remove the reserve status of the forest and allocate the land to the company. At the same time, sensitivity to environmental matters had been heightened in Uganda by the campaigns about the impact of the loss of forests on floods, unpredictable weather, and rising food prices.

As a result, civil society organizations used ICT to alert individuals about official actions that would affect them adversely and to mobilize them to save the Mabira Forest. Environmentalists took their fight to discussion groups on FM radio stations and used text messages to campaign against buying the company's sugar until the plan to grab part of Mabira Forest was dropped.

The text messages were particularly effective. The company saw a decline in sales, and some retail businesses withdrew their products from store shelves entirely. Environmentalists argued that apportioning part of the Mabira Forest would bring more adverse effects than the sugar shortage. Opposition politicians also picked up the slack and started criticizing the government for its lack of concern. In this particular example, text messages helped by alerting people what would happen next if they did not join the movement to stop the forest giveaway. The campaign of the civil society organizations was complemented by other actions in the country and strong reaction from the international development partners. Eventually, the plan was withdrawn.

Source: Uganda country report (available at <http://www.profor.info/profor/knowledge/information-management-and-forest-governance>).

areas of the globe, radio is the medium of choice, far outstripping other mass media in terms of audience numbers. For instance, in West Africa, radio ownership dwarfs that of all other communication equipment, including TV and mobile phones. In Africa in general, between 80 and 90 percent of households have access to radio.¹¹

Radio programs can be combined with other media as well. Radio browsing of the Internet is a more recent format that

10 <http://www.mongabay.com> and <http://www.greenpeace.org>.

11 Statistics for 11 countries for which consistent data were available, Myers (2010).

combines the power of the Internet with the reach of the radio. During the program, the presenter browses the Internet with a local expert (for example, a forestry or agriculture extension official or a community development expert), and together they describe, explain, and discuss the information in the languages used by the community. This has been successfully demonstrated by the community media centers piloted by UNESCO in Sri Lanka, Bhutan, and Nepal, among others. Similarly, mobile technology is being combined with radio programming, where listeners can call or text message the program.

With the availability of bandwidth on WorldSpace satellite radio subscription through First Voice International or RANET, community radio stations in remote locations can access news and entertainment programs on other stations. However, the main benefits of community radio are in programming that is in local languages, in formats that communities relate to, and on issues of local importance. For example, in Papua New Guinea, a mix of community radio and digital audio programming has been used to convey messages on forest management and sustainable land management.¹² The programs

were presented in the form of drama in several local dialects and were listened to in community meetings, where the questions raised by the key characters were discussed by the gathering. This technology could serve forest communities in other countries as well, to keep them aware of policy changes and developments that can affect their resources and their lives. Box 14.6 summarizes how community radio can help promote better forest governance. (See IPS “Farm Radio International Involves Men and Women Farmers,” in Module 6, for more on participatory radio.)

Crowdsourcing to Increase Public Participation

Combining a Web-based platform with inputs from text messages increases the versatility of information gathered. Information can be instantly geo-referenced and provide an overview to a decision maker on where activities should be prioritized. In addition to increasing transparency and public

12 <http://ictupdate.cta.int/en/Feature-Articles/Digital-audio-in-Papua-New-Guinea>.

BOX 14.6. How Can Community Radio Benefit Forest Governance?

Fighting corruption and increase awareness of citizens’ rights: In **Malawi**, the Development Communications Trust broadcasts “village voice” recordings from a network of radio clubs around the country. These programs report (among other things) on local-level delays, corruption, malpractice, and mismanagement by service providers, including international NGOs and local authorities and politicians. These problems are then broadcast on national radio, and the ministry, individual, or organization responsible is invited to reply on air in a context of a mediated dialogue with the community in question. The Development Communications Trust says that 70 percent of radio club problems are resolved satisfactorily after they have been aired nationally. It is currently supported by UNDP, Oxfam, and the Malawi national AIDS body.

Reporting on corruption and governance: In **Sierra Leone**, KISS-FM in Bo and SKY-FM started a series called “Mr. Owl” to report on local police corruption. This resulted in increased pay for the police and the establishment of a community affairs department. A voter education program, “Democracy Now,” resulted in higher voter turnout in the station’s listening area compared to other parts of the country.

Increasing women’s empowerment: USAID’s Women in Governance pilot program in **Mali** distributed more than 500 Freeplay radios to women’s listening groups in April 2004. The radios were designed for rural African conditions and can function without batteries. Instead, batteries can be charged manually by winding or through solar power.

Increasing awareness of environmental issues and public participation in policy development: In September 2009, Developing Radio Partners (DRP), a U.S. NGO, launched a year-long pilot project called “Our Environment, Our Future” that brings residents the information they need in the way they can best use it. DRP is working with 99.6 Breeze-FM, a community-oriented private station in Chipata, Zambia, to help six radio stations in rural Zambia and Malawi create and broadcast local environmental programming. It also encourages innovative use of mobile phones to expand the stations’ interaction with listeners, using the text messaging software FrontlineSMS (box 14.4). The project is helping build skills in environmental reporting and in developing relevant content on topics such as the impact of deforestation on local agriculture, sustainable farming methods, and many others.

Sources: Myers 2010; USAID 2005; <http://developingradio.org>.

participation, it can also serve as a means to track accountability of civil servants. This application gained popularity after Ushahidi became a success story in the aftermath of the Kenyan riots in 2008, as a means of keeping citizens informed on safety and security through information reports from individuals. The success of Ushahidi has led to its replication in other countries for other purposes (see box 14.7).

A similar application by the Blue Link Information Network in Bulgaria was initiated to gather information on illegal logging, which was simultaneously posted on the website, to show the authorities where the illegal activities were concentrated. The project “Expose and Improve—The Power of Information

BOX 14.7. Public Participation and Crowdsourcing of Data

Ushahidi, which means “testimony” in Swahili, is a platform designed to take input from hundreds of people by mobile phone or e-mail. It uses free software called FrontlineSMS that turns a laptop and a mobile phone into a text-broadcasting hub. As an SMS is sent from a hot zone, the message syncs with the Ushahidi software and shows up in a Web administrator’s inbox. The Web administrator can decide to send a text message back to the sender to verify the information, send out a blast alert to large numbers of people, or post the information onto a Web page with location information from Google Maps (or do all three). Ushahidi is free, and although it was primarily developed as a quick information-gathering and broadcasting tool during the riots in Kenya in 2008, it has quickly been adapted for uses other than crisis response. The following programs use the Ushahidi platform to gather information from people and then show on a map where the events are happening and how large an area is affected:

- Wildlife Trackers is a citizen science project in Kenya.
- Stop Stockouts is an initiative to track near-real-time stockouts of medical supplies at pharmacies (in a medical store or health facility) in Kenya, Uganda, Malawi, and Zambia.

The Ushahidi platform combines the benefits of the Internet and mobiles phones and could be used to generate near-real-time information on forest crimes, fire, wildlife sightings, and so on. The advantage of mobile SMS-based data inputs is immense in remote and rural areas.

Source: <http://www.usahidi.com/>.

Technologies (IT) in Combating Illegal Logging” was started in 2008 by developing a broad network of active citizens and NGOs to support the integration of a Web-based platform for information alerts about instances of illegal logging into the work of Bulgaria’s forestry administration.

Crowdsourcing can be used for many different purposes. While it is a useful and cost-efficient way of collecting information, there needs to be a way to ensure that the data entered are valid and have not been fabricated. The managers of the urban forest map in San Francisco, California, have built in some specific algorithms to raise red flags in case of dubious data inputs. They also propose carrying out random verifications in the field (box 14.8). Alerta Miraflores in the municipality of Miraflores in Peru is an expansive system for tracking and reporting incidences of crime.

BOX 14.8. Citizen-Powered Urban Forest Map of San Francisco

An example of crowdsourcing, this project is a collaboration of the government and nonprofits and businesses and citizens of San Francisco to map every tree in the city. Citizens can create an account and upload a tree’s location, its diameter, and a photo of the tree following instructions on the website. There is a link to an online guide called “Urban Tree Key” to help in the identification of the trees.

The project is the first of its kind, and there has been concern regarding the quality and authenticity of the data entered by the public. The collaborators intend to overcome this challenge by carrying out field verification of random samples of data.

Sources: <http://www.urbantreekey.org>; <http://www.urbanforestmap.org>; Friends of the Urban Forest (<http://www.fuf.net>).

Collaborative and Participatory Mapping

Maps are vital for decision making in forestry. While public sector forestry institutions prepare maps to record changes in cover with data from satellites, day-to-day changes at a smaller scale are often not recorded or not available in easily accessible formats to a wider audience. Mapping devices and software have been out of reach for nonspecialists until recently. However, new software makes it possible to put the power of creating and updating spatial information in the hands of field staff and local communities (see image 14.3). Open source programs make this more affordable for application developers. Communities can partner with forest agencies to help create and update information on forest maps. Information

IMAGE 14.3. User-Friendly Tools Allow Local Participation in Forest Mapping

Source: Helveta Ltd.

on boundaries, use rights and planned developments, and small-scale logging or clearing for agriculture have implications for land-use management and governance. Information presented on maps is a powerful visual tool for decision making. It also increases transparency, which is essential when the interests of several stakeholders are involved.

Collaborative mapping is a tool to facilitate spatial data collection and analysis. This tool is more appropriate for the forest sector than basic crowdsourcing, as it allows mapping of points of interest and other geo-referenced information such as specific routes and areas. It can be useful for the staffs of forest departments, NGOs, and national-level planning and policy-making bodies.

With the availability of open source and simpler software for desktop computers, even nonspecialists can view and upload data to maps. Greater accessibility to data is expected as a result of high-speed Internet services around the world, and data on forest cover, deforestation rates, density, and so on are now accessed by a wide range of audiences. Collaborative mapping has the potential to increase and widen the scope of stakeholder participation in project design and management and to facilitate the viewing and updating of project data. Three applications relevant for forestry are discussed:

- PoiMapper
- World Wildlife Fund's Moabi
- CI Earth's Participatory Mapping

Moabi is a collaborative mapping system that enables groups and individuals to build a large database for sharing, viewing, editing, and discussing spatial information relevant to REDD+. The system has been developed by the World Wildlife Fund (USA) and is current being applied in the Democratic Republic of Congo. Moabi allows policy makers, research institutions, and carbon project developers to view, download, and edit relevant spatial data. It will facilitate on-the-ground monitoring of activities such as illegal logging, mining, and the bush-meat trade. By using mobile mapping devices, data can be collected and directly uploaded to the system either through the Internet or mobile phones. To compensate for slow Internet connectivity, data can be sent to proxies who will upload the data, making it available

to global users. The site is built on open source, widely used free software such as Google Maps and Drupal, which is a Web content management system. This helps ensure that the design is flexible, easily customizable, and functional on a wide variety of computers and Web browsers.

Any registered user in Moabi can post data to the website, but the data can only be approved by a peer review member. Users will be able to view both approved and unapproved data in the system and provide ratings on comments on any material posted. The system provides users with incentives to contribute information by recognizing regular contributors through elevated status or promotion to the peer review panel. For mobile phone contributors, incentives may be offered through phone credit awards. Moabi is being developed with funding from a donor. However, once the first pilot is successfully tested in the Democratic Republic of Congo, it is thought that subsequent replications can be developed with a smaller budget of US\$30,000 to US\$50,000.¹³

Moabi has a high level of utility in forest governance, to increase transparency and public interest and participation in development activities that could lead to deforestation and illegal logging and to promote law enforcement. This application

13 WWF (USA), pers. comm.

will be more useful when it allows data collection and uploads via mobile phones to offset the lack of Internet connectivity in rural areas. However, the peer review process for information displayed on the portal may become a point of contention between different stakeholder groups, and it would be important to ensure the integrity of the peer review process.

Participatory mapping is used extensively by development agencies and NGOs around the world. However, customizing a handheld PDA with icons and images and training members of local and indigenous communities in its use are important advances in this area. Helveta Ltd., an international corporation that develops and deploys supply chain and asset management software for timber and agrocommodities has pioneered the use of its Control Intelligence (CI) Earth software to create maps of forest inventory in an online environment accessible by all registered users.

This innovative project is not without its share of problems. An interim review pointed out a number of concerns, mainly with project management and coordination between project partners and improvements in technology, such as more appropriate methods of recharging the GPS batteries, for which the communities currently travel long distances, and to improve the icon designs.¹⁴

The use of handheld computers by local communities shows that technology can be customized for all needs, and that it need not be a barrier for illiterate members of the community. However, the handheld devices currently used in the project cost between US\$800 and US\$1200, putting them out of reach for most forestry departments. The need for such expensive devices may be justified by the nature of the task—extensive data collection in remote locations necessitating the need for rugged devices—but the appropriate technology has to be selected on a case-by-case basis.

INNOVATIVE PRACTICE SUMMARY **Participatory Mapping in Cameroon**

This project has been implemented in a partnership between local and indigenous forest communities across the southern forest zone of Cameroon and the Forest Peoples Programme, University College London, Centre pour l'Environnement et le Développement, and Helveta Ltd. Local forest-dependent communities were trained in using GPS-enabled handheld

computers with the specially developed icon-driven software CI Earth, which requires no literacy skills, to create forest inventory maps. Data are captured using CI Mobile and GPS reader technology. CI Mobile combines handheld data entry with data from GPS, RFID, and barcode readers to gather accurate records of how assets are being managed and processed in the forest or factory. CI Earth uses a CI Mobile interface configured to record data types that are relevant to the particular user or region. CI Earth data are synchronized with CI World through any locally available means of Internet connection, ranging from satellite to dial-up modem. GPS-referenced data are then made available within CI World in chart form and through GIS applications such as Google Earth and ESRI's ArcView.

The communities are meant to use the devices during their daily expeditions to the forest, recording their use of the resources and their observations of illegal logging activities. These data are then transferred to a secure website via satellite to a data center in the United Kingdom and can be accessed by authorized users and translated into maps. Accurate manipulation of these devices will thus create reliable data and maps that can define resource use, document customary areas, and expose illegal logging practices. So far, data have been collected south of Dimako in eastern Cameroon. Logging activities were monitored both in and outside communal forest areas where Baka Pygmies currently reside or hunt. Forest communities in the Mbalmayo region recorded bulldozer tracks that indicated industrial logging activities near illegally felled trees found outside of the legal commercial logging boundaries. Data gathered by local communities assisted a logging company operating in the area in identifying which communities it should consult over management plans for local forest areas as part of their Forest Stewardship Council certification process.

The CI Earth software with handheld computers has also been used in Nigeria to monitor biodiversity in the Afi Mountain Wildlife Sanctuary, which is home to a subpopulation of the critically endangered Cross River gorilla.¹⁵

INNOVATIVE PRACTICE SUMMARY **The Central Vigilance Commission Website in India**

The Central Vigilance Commission (CVC) was designed to be India's top vigilance institution, free of control from any

14 Interim evaluation report of project, "Enabling Independent Monitoring of Forest Resources by Local and Indigenous Forest Communities" (unpublished, November 2009).

15 The source of information within this section is http://corporate.helveta.com/uploads/news/20100107015150-Helveta%20Cameroon%20CaseStudy_2009.pdf.

executive authority. It monitors all vigilance activity under the central government and advises various authorities in central government organizations on planning, executing, reviewing, and reforming their vigilance work. The CVC is a statutory body, and its website (<http://cvc.nic.in/>) contains the following sections and features:

- Information on its role, responsibilities, and strategies to combat corruption.
- Communication directly with the public through messages and speeches to bolster confidence in the institution.
- Instructions for how any citizen can lodge a complaint against corruption, without fear of disclosure or reprisal.
- Central vigilance officers list: Each organization is expected to nominate a senior officer to whom an employee can take a complaint on corruption.
- Statistical reporting of the achievements of the CVC and its annual report.
- Details of convictions of public servants by the courts, along with information on officers against whom an inquiry has been initiated or a penalty imposed. This section also highlights the performance of various departments responsible for conducting investigations.

A decade ago, publishing the names of officers undergoing inquiries on charges of corruption on the CVC website created a stir in the media, but it quickly caught the public's attention. Despite the low level of access to computers and the Internet, the information was widely disseminated by radio and print media throughout the country. Thus, the site has had a wider impact than what could be expected based on India's computer density alone.

Given the explosion in mobile phone ownership and widespread use of the Internet, the CVC has stepped up its use of ICT. The "Blow Your Whistle" site is a technology-supported anticorruption initiative of the CVC. The site allows citizens to report through mobile phones and the Internet by uploading text, audio, and video files. Known as Project Vigeye, the system requires registration, and once a complaint is filed, the complainant can log in and check the status of the complaint. The "Blow Your Whistle" site also has discussion forums and podcasts on corruption in the country, videos, and links to other resources.¹⁶

¹⁶ The source of information within this section is <http://blowyourwhistle.in/pages/about-us/>.

INNOVATIVE PRACTICE SUMMARY

PoiMapper in Kenya

PoiMapper ("Poi" stands for "point of interest") is being piloted by Plan in Kenya to develop a geospatial database for project planning and management. Plan Kenya field staff upload answers to preloaded questionnaires on mobile phones and take photos to record the status and use of development infrastructure such as schools, drinking water sources, and clinics. Information collected includes the number of school-age children and population without access to sanitation facilities; each point of interest, such as a school, is tagged with GPS referencing. This information is uploaded to the PoiMapper portal, where it is overlaid on a digital map to provide the agency with a spatial overview of its projects. This database provides the management of Plan Kenya a comprehensive overview of its projects in the field, and facilitates better planning for available resources. One feature of this application is that it allows organizations to share their data, especially when working in the same region.

PoiMapper is a mobile geomapping, data management, visualization, and sharing solution that can be integrated with open source portal tools such as Drupal or Vaadin and map engines such as Google Maps or Geoserver. It runs on standard low-end GPS-enabled phones as well as on smartphones. It enables mapping of

- **places**, such as locations of schools and water points;
- **routes**, such as roads and water pipes;
- **areas**, such as community boundaries, forests, and fields;
- **structured survey data**, such as numbers, text, exclusive, and multiple choice; and
- **multimedia**.

PoiMapper can be used in offline mode for work in locations where connectivity is unavailable and allows viewing data on digital maps on a Web browser. It eliminates the need for expensive hardware and license investments or the need for software licenses. The application allows open access of the stored data and the possibility to integrate open source analytics tools such as Pentaho for data mining (image 14.4).

The system requires a subscription fee and registration for users to download the software and upload their data to the portal. It will be tested for use in the forest sector through a pilot in Vietnam. Having offline and online capabilities is an advantage in the forest sector, where access to the Internet or cellular networks is often erratic. The cost of the application as a software-as-a-service is a monthly fee per active user. The

IMAGE 14.4. POIMapping in Kenya

Source: Plan Kenya.

price depends on volume, whether a project is associated with it, and in which country it is used. The current default pricing is US\$15 for NGOs and local users in developing countries and US\$30 for commercial organizations and users in developed countries. The developer currently requires a minimum monthly engagement of US\$750 (25 users) to set up a new database and support agreement. The price of mobile phones on which the system works starts from US\$50 if GPS is not

required and US\$150 with embedded GPS, making them affordable for certain project-specific applications. Field staff already use mobile phones, and the application, if useful for project management, is no more complicated than text messaging.

Multiple users can browse and update the same information, and previous versions of data are maintained for tracking purposes. Data are accessible via a Web browser, with appropriate authorization. Once an organization registers on the PoiMapper website and creates its account, the software can be downloaded to the mobile phone. Questionnaires relevant to the organization's work can be created and downloaded to the mobile phones. Existing data from a particular location on the portal

can be downloaded, and only new fields can be updated, which makes the system fast and efficient. The application is available for a monthly subscription fee per user, which allows the organization to store its data and edit them on the PoiMapper portal. At this stage, PoiMapper does not have options for data input through icons, which can be developed if needed, but this would restrict the type of data that could be collected or monitored.¹⁷

Topic Note 14.2: PILLAR 2—QUALITY OF FOREST ADMINISTRATION

TRENDS AND ISSUES

High-quality professionals and good information management are key requirements for effective forest management. Distance learning programs are now available on the Internet from a wide range of universities around the world. In addition, some public sector forest service websites host customized training packages online. For example, the U.S. Forest Service has several online training programs for a number of technical tasks, ranging from basic statistics to cruising and scaling. One application on this site is the "Timber Theft Program," which uses regression analysis to estimate standing tree volumes from stumps. Demonstrations include how

to input data, how to perform regression analysis, and how to generate reports in the program.¹⁸

Not all online training courses have been sustainable. For example, in Chile, the Catholic University of Chile developed extensive online professional development courses and modules for forestry professionals called UC Virtual. After some time, these had to be discontinued due to lack of user demand.¹⁹

¹⁷ The source of information within this section is <http://www.pajatman.com>.

¹⁸ <http://www.fs.fed.us/fmnc/measure/index.shtml>.

¹⁹ Gurovich (2006) and pers. comm.

Information management—and, more specifically, spatial information management—is the second key requirement for forest administration. In Finland, MESTA is a free, Internet-based software application that is used to prepare and discuss forest management plans with communities (see box 14.9). Similarly, in the United Kingdom, the Forestry Commission found that discussions about management plans with communities were more productive when the commission was able to present digital plans with three-dimensional maps

BOX 14.9. MESTA: Participatory Forest Management Application

MESTA is open access Internet software developed and funded by Metla (a Finnish forest research institute). It was first developed to serve as a tool for Metsähallitus (a state entity that manages state forests and most protected areas) for participatory forest management, but it has become available to private forest owners for evaluating different management strategies. Developed for holistically evaluating different decision alternatives, it is based on the definition of so-called acceptance borders for decision criteria (for example, the minimum income from the forest cuttings).

The strength of the software is that it can facilitate the illustration of the effects of different strategy alternatives at stakeholder meetings. A better understanding of the different alternatives and corresponding results can help one stakeholder group in accepting the needs of another stakeholder group. Through the evaluating process, the stakeholders will get information concerning potential costs and benefits.

MESTA has been used in participatory forest management by Metsähallitus in eastern and western Lapland, where decision making often requires difficult compromising on different objectives and needs, such as combining logging with nature-based tourism.

Compared to other methodologies for evaluating different management alternatives, MESTA allows the study of alternatives with less input information and knowledge on the subject. Therefore, it is considered to be efficient, especially when used in communicating with stakeholder groups that have less direct contact with forestry.

Sources: Finland country report (available at <http://www.profor.info/profor/knowledge/information-management-and-forest-governance>); http://mesta.metla.fi/index_eng.cfm.

and images that make the presentations more appealing and make it easier for nonspecialists to comprehend the long-term outcomes of the proposed management actions.

The quality of forest administration also depends on good policy and administration, financial and human resource management, law enforcement and land tenure, and timber sales and revenue management—all of which require unhindered information flows both within the forestry department and with other parts of the government, as well as with the private sector and citizens. Comprehensive forest management information systems have been seen as the ideal solution to enhance the capacity of public sector forestry institutions to manage these information flows. However, it is possible to deploy smaller-scale ICT solutions to manage information requirements in key areas, such as the management of fires, inventories, and wildlife tracking, without investing thousands of dollars in hardware and software. Four such applications are discussed below:

- Real-time fire alerts
- Forest cover and carbon stock assessment with CLASlite and airborne LiDAR
- Google Earth Engine
- Wildlife tracking

Real-Time Fire Alerts

One innovation in forest management is the near-real-time fire alert system that has been developed by combining NASA's Moderate Resolution Imaging Spectro-radiometer (MODIS) data with GIS. The Fire Information for Resource Management System (FIRMS) by the University of Maryland analyzes the data from MODIS and presents it in a form that is easy to use by field personnel. The system can deliver email alerts to subscribers with information on likely fires in their area of interest.

A more focused alert system is being developed by Conservation International. The Fire Alert System has been developed for use in specific biodiversity hot spots around the world and is currently being piloted in Madagascar, Bolivia, Peru, and Indonesia. This system delivers alerts on fires within a few hours after the NASA satellites sweep the Earth. The Fire Alert System is a fully automated analysis and alert system that delivers a range of products tailored to a user's specific needs.

There are some other highly advanced fire management systems, such as the one used by the New South Wales Rural Fire Service in Australia, which received a Meridian Award

in 2007 (<http://www.meridianawards.com>). HeliFIRE turns MapInfo Professional into a purpose-built application for the airborne mapping of fires. Using a GPS connection, HeliFIRE becomes a moving map application, showing the user's current position. Fire features such as active/non active fire edge, fire trails, threatened properties, water sources, and firefighter locations can be recorded accurately as the aircraft flies over the features. This information is transmitted immediately via the Internet to users on the ground who make the response decisions.

A second application, MapDesk, turns this information into updated fire maps. This custom application from MapInfo Professional has several features that have been standardized to allow the quick generation of maps with minimal training. Information derived from these applications is delivered to all 70,000 personnel, many of whom are volunteers, as well as to other agencies and the broader community.²⁰ These custom systems are expensive to build and maintain. But the email and text message updates such as the ones sent by FIRMS are free.

Forest Cover and Carbon Stock Assessment with CLASlite and Airborne LiDAR

The Carnegie Institution for Science's CLASlite (Carnegie Landsat Analysis System-lite) is a software package designed for highly automated identification of deforestation and forest degradation from satellite imagery. Outputs from CLASlite include maps of the percentage of live and dead vegetation cover, bare soils, and other substrates, along with quantitative measures of uncertainty in each image pixel (see image 14.5).

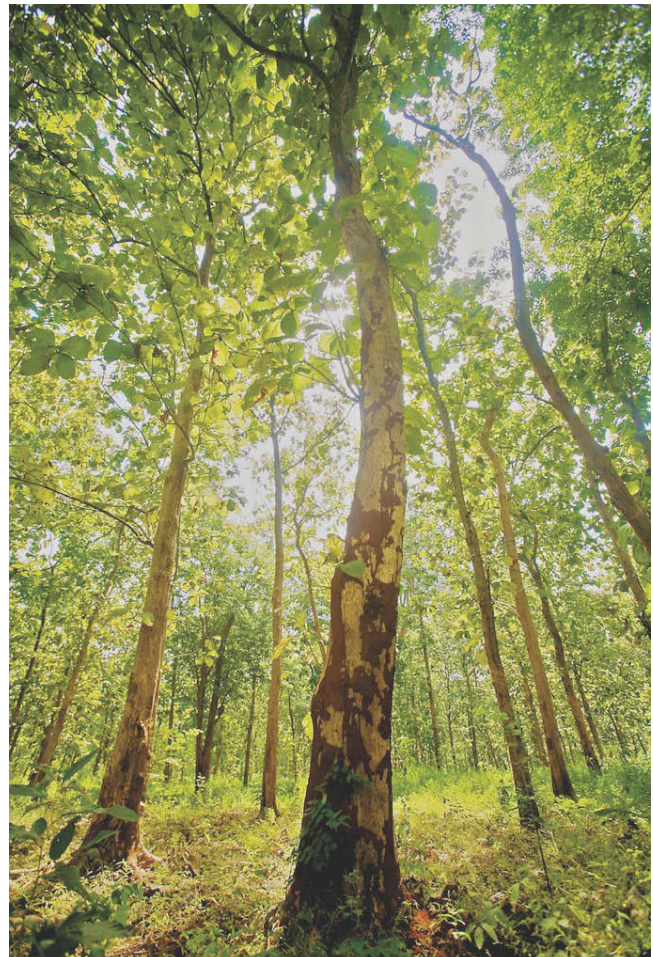
CLASlite converts satellite imagery from its original (raw) format—through calibration, preprocessing, atmospheric correction, and cloud-masking steps—and then performs a Monte Carlo Spectral Mixture Analysis to derive high-resolution output images. Its algorithms easily identify and accentuate areas where clearing, logging, and other forest disturbances have recently occurred. CLASlite does not provide a final "map" but rather a set of ecologically meaningful images identifying forest cover, deforestation, and forest degradation that can be readily analyzed, processed, and presented by the user.

The new approach involves four steps undertaken in concert to produce a rapid high-resolution assessment of forest carbon:

1. Mapping of vegetation type and forest condition using freely available satellite data and CLASlite.
2. Large-area mapping of forest canopy three-dimensional structure using airborne LiDAR.
3. Conversion of LiDAR structural data to above-ground carbon density estimates using LiDAR-carbon metrics along with a tactical use of field calibration plots.
4. Integration of the satellite map with the airborne LiDAR data to set a regional, high-resolution baseline carbon estimate.

CLASlite runs on standard Windows-based computers and can map more than 10,000 km² (at 30 m spatial resolution) of forest area per hour of processing time. While CLASlite is highly automated, its user guide recommends a level of training corresponding to the complexity of the forest area.

IMAGE 14.5. Satellite Imagery Can Map Levels of Vegetation, Forest Cover, and Forest Degradation



Source: CIFOR.

20 <http://www.meridianawards.com/hall-of-fame/view/combating-bushfire-wild-land-fires-in-the-state-of-nsw-australia/>.

According to the developers of the system, the cost of using a combination of commercial and free data sources is approximately US\$0.10 per hectare and is likely to fall further. Free licensing of CLASlite is granted to nonprofit/noncommercial organizations in Latin America following completion of technical training. The CLASlite website²¹ reports that as of June 2010, more than 150 governmental institutions, NGOs (non-commercial), and academic or research institutions had been trained in the use of CLASlite.

The developers of CLASlite have also tested airborne Light Detection and Ranging (LiDAR) in conjunction with remote sensing and ground mapping to carry out carbon stock assessments, to establish it as a low-cost and efficient method of assessing carbon in different types of tropical forests (see Module 5 on productivity for more on LiDAR).²²

Mapping in the Cloud: Google Earth Engine

Google Earth Engine is a technology platform that puts an unprecedented amount of satellite imagery and data—current and historical—online for the first time. It enables global-scale monitoring and measurement of changes in Earth's environment. The platform will enable scientists to use Google's extensive computing infrastructure to analyze this imagery. The images of Earth from space contain a wealth of information. Scientific analysis can transform these images into useful information—such as the locations and extent of global forests, detecting how forests are changing over time, directing resources for disaster response, or mapping water resources. The challenge has been to cope with the massive scale of satellite imagery archives and the computational resources required for their analysis. As a result, many of these images have never been seen or analyzed. Now scientists will be able to build applications to use these data on Google Earth Engine and will be able to take advantage of the following features and benefits:

- Landsat satellite data archives over the last 25 years for most of the developing world available online, ready to be used together with other data sets, including MODIS. A complete global archive of Landsat is expected to be available soon.
- Reduced time to do analyses, using Google's computing infrastructure. By running analyses across thousands of computers, for example, unthinkable tasks are now possible for the first time.

- New features that will make analysis easier, such as tools that preprocess the images to remove clouds and haze.
- Collaboration and standardization by creating a common platform for global data analysis.

Google Earth Engine can be used for a wide range of applications—from mapping water resources to ecosystem services to deforestation. Initial use of Google Earth Engine is most likely to support the development of systems to monitor, report, and verify efforts to stop global deforestation.

During the United Nations Framework Convention on Climate Change, COP 16, in Cancun in December 2010, it was announced that 10 million CPU-hours a year over the next two years would be donated on the Google Earth Engine platform to strengthen the capacity of developing-world nations to track the state of their forests, in preparation for REDD. The Earth Engine was developed in collaboration with the Gordon and Betty Moore Foundation, the U.S. Geological Survey, Mexico's state forest agency (CONAFOR), scientists at the Carnegie Institution for Science, the Geographic Information Science Center at South Dakota State University, and Imazon to develop and integrate their desktop software to work online with the data available in Google Earth Engine.²³

Wildlife Tracking and Management

Conflicts between humans and wildlife are common where communities live in or near wildlife sanctuaries and parks. The following applications prove that ICT can be used for wildlife tracking and management with the assistance of communities. Even simple mobile text messages sent on a regular basis to communities to keep them updated on the movement of wild animals can go a long way in helping people stay safe and in turn not harm the wildlife. "Push to talk" is a rather infrequently used feature of mobile phone networks in developing countries. However, there is an interesting example of its use to alleviate conflicts between humans and elephants in the Laikipia District of Kenya. This case demonstrates that park management, communities, and the private sector can, assisted by the innovative use of mobile phones, come together to find a viable solution for management of wild elephants and crops.

21 <http://claslite.ciw.edu/en/index.html>.

22 The sources of information within this section are Asner et al. 2009, <http://claslite.ciw.edu/en/index.html>, and http://claslite.ciw.edu/documents/CLASlite_PeruREDD.pdf.

23 Information in this section is drawn from Google Blog (<http://googleblog.blogspot.com/2010/12/introducing-google-earth-engine.html>) and <http://www.unep.org/stap/Portals/61/docs/SFM/20.Moore.pdf>.

Another example of ICT being employed to track wildlife is CyberTracker, a free software application that was developed to enable indigenous communities with little or no literacy to track wildlife in game parks. The software uses icons and pictures to guide data inputs and works on handheld computers with GPS capability. One of the longest ongoing uses of CyberTracker is at Kruger National Park in South Africa, where rangers collect vast amounts of data on, among other things, the movements and behaviors of key species, fires, availability of water, illegal presence and activities of humans, and the presence of new or invasive species of plants. CyberTracker has been piloted in several countries in Africa, mainly for recording and monitoring wildlife and biodiversity data to aid research and management (CyberTracker Conservation 2007).

INNOVATIVE PRACTICE SUMMARY **Fire Alert Systems Integrating Remote Sensing and GIS**

Remote sensing and GIS are now being integrated to provide timely information on large-scale fires in the tropics. The Moderate Resolution Imaging Spectro-radiometer (MODIS) that orbits on NASA's Aqua and Terra satellites as part of the NASA-centered international Earth Observing System provide the data. Both satellites orbit Earth from pole to pole, seeing most of the globe every day.²⁴

The Fire Information for Resource Management System

While NASA's MODIS Rapid Response system provides near-real-time images and data on global fires in the public domain on the Internet, forest managers in the field would be unable to find the time and technical skills to analyze the data quickly. The University of Maryland developed the Fire Information for Resource Management System (FIRMS) to serve MODIS fire observations to this community. FIRMS displays active fires detected in near-real time using thermal and mid-infrared data from the MODIS instruments; this means the data are processed and available on the Web four to six hours after the satellite passes over. Subscribers can sign up for email alerts on fires in their area of interest. The Web Fire Mapper of FIRMS is an open source, Internet-based mapping tool that delivers locations of hot spots and fires. These can be viewed on an interactive world map showing hot spots or fires for a specified time, combined with a selection of GIS layers and satellite imagery. Each hot spot / active fire

location represents the center of a 1-kilometer (approx.) pixel flagged as containing one or more hot spots or fires within that pixel. FIRMS is currently being transitioned to an operational system at the United Nations Food and Agriculture Organization.

Conservation International's Fire Alert System

The Center for Applied Biodiversity Science at Conservation International, International Resources Group, Madagascar's Ministère de l'Environnement, des Forêts et du Tourisme, and USAID have teamed up with the MODIS Rapid Response System and FIRMS to develop an email alert system for fires in or around protected areas and areas of high biological importance. This system currently focuses on four biodiversity hot spots: Madagascar, Bolivia, Peru, and Indonesia. The Fire Alert System is a fully automated analysis and alert system that delivers a range of products tailored to a user's specific needs. These include simple text-based emails containing the coordinates of active fires within protected areas, areas of high biodiversity, different vegetation and land cover types, administrative units, or user-defined regions. The emails can include JPEG attachments showing a satellite image of a protected area with the active fire depicted as red squares, ESRI shape files for importing into GIS software, and KML files for importing data into Google Earth. Each email alert also provides information on the time and date of satellite observations and a confidence value for each fire detected. Subscribers may select from a range of background images and maps. The next phase of this system will include multivariate/multicriteria analysis, which enables more flexible user customization, and an advanced report generator.

In addition to fire response and management, the Fire Alert System is now being extensively used to monitor and inform enforcement officials of suspected illegal activity, such as illegal logging and encroachment taking place in protected areas.

INNOVATIVE PRACTICE SUMMARY **Kenya: Solving Human/Elephant Conflicts with Mobile Technology**

The Laikipia District is home to the second-largest population of wild elephants in Kenya. There is competition for land between the wealthy farmers who own large ranches and private conservancies, small agriculturists, and the elephant herds whose natural habitat and corridors have been made inaccessible by human activity. The frequent encounters between people and elephants have caused human and elephant deaths.

²⁴ Information within this section is drawn from Davies et al. 2009 and <https://firealerts.conservation.org/fas/home.do>.

To find a viable solution to this situation, the GSMA Development Fund—in collaboration with the University of Cambridge Laikipia Elephant Project, the Laikipia Nature Conservancy, Laikipia Wildlife Forum, Safaricom, Wireless ZT, Nokia, and Nokia Siemens Networks—devised a closed-group communication network between the park staff, ranch owners, and farmers in the district with special push-to-talk mobiles. This technology combines the functionality of a walkie-talkie or two-way radio with a mobile phone and enables communication between two individuals or a group of people, as needed, with the push of a single button. With stakeholder consultations and training, the pilot project initiated communication between the Kenya Wildlife Service staff, ranch owners, farmers, and NGOs that normally would not take place in a systematic way. The pilot was meant to reduce human/elephant conflict by facilitating early communication between the stakeholders regarding elephant movement and seeking the help of wildlife rangers when needed.

The results of this pilot proved that improved communication between the various stakeholders significantly reduced human/

elephant conflict: 73 percent of the users in the pilot said that the technology provided early warning of elephant raids and allowed the farmers to take preventive actions. Sixty-five percent of the users also reported that the system helped prevent theft of livestock and recover stolen livestock. Twenty-one percent also reported that the management response improved, especially by the Wildlife Service staff. An important observation by one user was that group communication increased pressure on the government staff, because several members listen in to a request for intervention. Thus, accountability of the Wildlife Service staff seems to have increased. The use of this technology was also appreciated by the Wildlife Service, which reported that receiving reliable information over a larger area helped it to be more effective in the job.

While the results of this pilot were very encouraging, the service was not rolled out on a larger scale. Cellular operators did not find this technology commercially attractive in Kenya. Nevertheless, the pilot proves that “push to talk on cellular” has benefits in specific situations and could be used in other locations where similar challenges in wildlife management exist.²⁵

Topic Note 14.3: PILLAR 3—COHERENCE OF FOREST LEGISLATION AND THE RULE OF LAW

TRENDS AND ISSUES

In the forest sector, various types of resource use, both commercial and noncommercial, are governed by various laws. At the same time, forests have several characteristics that make them prone to timber theft and other illegal activities:²⁶

- owner absent
- potential witnesses indifferent or hostile to owner
- easy to bribe way out of trouble
- asset unsupervised/unguarded
- loot easy to sell
- owner/manager unaware of inventory and value
- police untrained, underequipped, uninterested
- staff untrained and underpaid
- lax business practices/procedures

Many of these vulnerabilities can be addressed through ICT. Effective law enforcement systems in the forest sector

usually follow the steps of prevention, detection, and suppression. Technology has an important part to play in each of these steps in the efforts to curb illegal logging, transportation, and processing of timber and illegal trade in wildlife. A variety of ICT applications can be used to improve deterrence and response measures, and these have been discussed in detail in previous World Bank reports.²⁷ A few innovative ones are reviewed here:

- **prevention**—e.g., crime mapping, corruption hotlines
- **detection**—e.g., timber tracking, chain of custody systems, checkpoints, satellite images, GPS surveillance
- **suppression**—e.g., crime databases, case management systems

Mobile and Online Crime Reporting Services

Governments around the world are increasingly involving citizens in crime reporting through e-government services

²⁵ Information within this section is drawn from Graham et al. 2009.

²⁶ William Magrath, “Presentation at the World Bank–FAO Workshop on Forest Law Enforcement and Governance in the Asia-Pacific,” Kuala Lumpur, November 2009, unpublished.

²⁷ See, for example, Magrath et al. 2007, Asia-Pacific Forestry Commission 2010, and Dykstra et al. 2003.

to report incidences of corruption and crime. Members of the public can send text messages, leave a voice message, or send emails to report incidences of corruption and crime. Allowing citizens to report crime to the authorities is a cost-effective and reliable way of preventing crime. The website of India's Central Vigilance Commission has a similar system, where anonymous callers can report corrupt officials of state agencies. The example from a crime prevention project in Peru shows how citizens can effectively contribute to law enforcement and crime reduction in a municipality. The municipality of Miraflores in Peru has developed a system called Alerta Miraflores to manage crime, using an Internet- and phone-based system that does the following:

- gives citizens a way to report incidents to local security officials to record and take action
- captures data electronically and displays the information on reports and maps to let public safety officials pinpoint the areas from which citizens are calling, define priorities, and dispatch the closest officers
- allows municipal officials to manage citizen security proactively, respond more rapidly, and analyze results

By improving its ability to rapidly respond to reported incidents, providing timely feedback to citizens, and capturing detailed crime information, the municipality was better able to prevent crime and increase citizen security. Alerta Miraflores has reported a 68 percent drop in robberies since 2003, a 30 percent reduction in assaults, and a significant reduction in overall crime.

The tools and methods used in this project have a lot to offer to the forest sector. One application was used by the Blue Link Information Network's project in Bulgaria called "Expose and Improve—The Power of Information Technologies (IT) in Combating Illegal Logging." Individuals participate by registering alerts (30 alerts have been logged

in the system since its launch in July 2009) and by supporting NGO experts in the preliminary checks on the registered alerts. Alerts are checked against a checklist of indicators to verify the criminal character of the case before submitting it to the authorities. Established environmental NGOs in Bulgaria have demonstrated their genuine interest and active support of the project by providing expert advice on forestry issues, participating in preliminary checks, and lobbying for the integration of the online platform into the work of the Bulgarian forestry administration. While this project was developed and executed by an NGO, it could be easily undertaken by forest law enforcement agencies. The system could enlist the services of interested NGOs and citizens to report suspicious activities that can trigger additional investigation by the forest agency. The ability to receive information via mobile text messages or voice messages helps the system to be used by anyone.²⁸

A key issue to be solved is the confidentiality of information and safety of the informants. It is essential that all information is dealt with very carefully both to ensure the safety of the individuals who report crimes and to ensure that the reporting system is not used for spreading unfounded allegations.

Tracking and suppressing illegal logging and trade in endangered wildlife often needs information beyond the borders of a single country. The United Nations Office on Drugs and Crime has developed a series of software applications to help countries collect, analyze, and share intelligence and information on international crime (see box 14.10).

Technologies for Surveillance and Deterrence

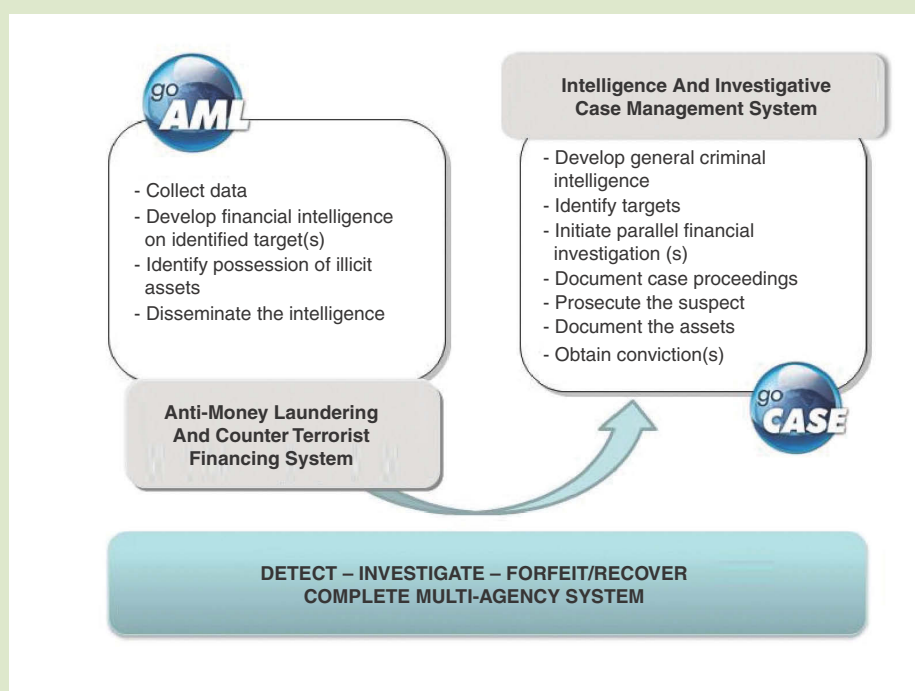
While there are several sophisticated technologies available for crime detection, only some are specific to the forest

28 <http://www.spasigorata.net/> and <http://www.bluelink.net/en/>.

BOX 14.10. UNODC's "Go" Family of Products

The Information Technology Service of the United Nations Office on Drugs and Crime (UNODC) specializes in the development, deployment, and support of software applications for use by member states in a range of UNODC's program areas. The Government Office ("go") family of products is part of UNODC's strategic response to crime, particularly serious and organized crime. The "go" family includes integrated investigative case management and intelligence analysis tools for financial intelligence units, law enforcement, investigative, intelligence, regulatory, prosecution, and asset recovery agencies, and for courts and other government agencies involved in the criminal justice process. All the software products include multifaceted integration and can function as stand-alone applications or together to form one global system, depending on the needs of the country. The application of systems able to interface with each other encourages interagency and cross-border cooperation and information sharing at the national, regional, and international levels.

(continued)

BOX 14.10. *continued*

Source: <http://goim.unodc.org/goim/en/products.html>.

sector. The computerization of checkpoints in Gujarat, India, is a good example of how technology can lead to better law enforcement and increased revenues for the state.

A slightly different approach to surveillance—with the help of GPS—has been tried with success in fisheries in West Africa under the Sustainable Fisheries Livelihoods Program, sponsored by FAO and the UK Department for International Development. Community surveillance of fishing grounds in Guinea has succeeded in reducing illegal incursions by industrial trawlers by 59 percent. Members of the fishing community on Guinea's northern coast use GPS technology to track poachers. The fishermen can calculate the exact location of a poaching trawler using a handheld GPS receiver and radio the information to the nearest coast guard station. The GPS coordinates generate an alert if the trawler is in within the prohibited zones.²⁹ The fisheries example has a lot of relevance for the forest sector; while communities may not be

in a position to monitor vehicle movement inside forests, the forest authorities could use similar means to track vehicle movement in unauthorized locations.

Technologies for Timber Tracking and Chain of Custody Systems

Radio-frequency identification (RFID) holds considerable promise for use in systems tracking the timber supply chain. RFID uses radio waves to exchange data between a reader and an electronic tag attached to an object, for the purpose of identification and tracking. Some tags can be read from several meters away and beyond the line of sight of the reader.

On average, an appropriate RFID chip costs from US\$0.07 to US\$0.15. An important advantage of RFID systems for log tracking is that signals can be read rapidly, remotely, and under difficult conditions. RFID labels can potentially store a large amount of data with a high level of security. The labels are difficult to counterfeit or tamper with and can provide a high level of covert security. These devices can significantly facilitate data capture, data processing, and security audits. It is possible to encode RFID labels at all stages of the wood

29 Peter Lowrey, 2004. "SFLP: Arming Fishermen with GPS to Combat Poachers." *ICT Update* No. 16, February 2004 (<http://ictupdate.cta.int/en/issue/16>); <http://www.fao.org/english/newsroom/focus/2003/sflp4.htm>).

supply chain from the field to the end user. RFID labels can enhance logistics and inventory functions.

Microtaggant tracers are microscopic particles composed of distinct layers of different colored plastics that can be combined to form a unique code. Millions of permutations are possible by combining several colors in different sequences. Codes can be read in the field with 100-power pocket microscopes. These tracers can be used together with other labels to provide additional security and to aid investigations of log theft or log laundering. They do not represent a stand-alone labeling technology.

Chemical and genetic fingerprinting offer promise for the future but are currently too expensive and have not been fully developed for routine use in wood supply chain tracking systems. They are likely to prove most useful in proving the origin of wood in investigations of log theft or log laundering.

GPS tracking devices for vehicles can be used to track the movement of vehicles and can quickly point to vehicles in unauthorized locations. The GPS vehicle tracking unit can have a wireless modem that is able to communicate with global tracking systems³⁰ (image 14.6).

30 Information in this section is drawn from <http://gpstrackit.com/faq> and Dykstra et al. 2003.

IMAGE 14.6. Tracking through Barcodes, RFID, GPS, and Other Technologies Improves the Chain of Custody



Source: Tuukka Castrén.

More technologies and two examples of timber tracking are discussed in IPS “Ghana’s National Wood Tracking System” and IPS “Liberia: LiberFor Chain of Custody.”

Legal Information Management Systems: Global Legal Information Network

The Global Legal Information Network (GLIN)³¹ is an electronic online tool that gives access to authentic and updated official legal information at a low maintenance cost. The system was developed by the U.S. Library of Congress to improve access to original legal texts. In Gabon, GLIN has been used by the government to publish the primary sources of the law and all environmental legal information. The government chose to become a member of GLIN to provide the stakeholders (forest administrations, the private sector, donors, civil society, NGOs, and so on) with a modern legal archiving system. The system helps to strengthen the rule of law and to start a discussion among stakeholders. Experience in courts and government institutions has shown that the Internet was their only source of access to reliable, up-to-date legal information.

INNOVATIVE PRACTICE SUMMARY Ghana’s National Wood Tracking System

The Ghana National Wood Tracking System (WTS), developed by Helveta Ltd., provides a timber legality assurance system that is an important tool in reducing illegal logging—a key initiative under the EU–Ghana Voluntary Partnership Agreement. The system addresses the traceability of wood in on-reserve areas destined for export. However, a chain-of-custody system should track all wood and wood products in circulation in a given market. Otherwise the system makes it easy to “launder” illegal wood—that is, mix it with legitimate sources. The system uses hand-held computers in remote forest areas in conjunction with plastic barcoded tree and log tags to capture data such as species, diameter, length, and geospatial location. WTS is based on an existing

31 <http://www.glin.gov> and PROFOR (2010).

system from Helveta Ltd. called CI World. It consists of four main components:

- identification and tagging of individual products or consignments using barcoded labels or RFIDs
- incorporation of these tag numbers onto the statutory forms used for declarations, inspections, and other relevant records and reports
- use of electronic technology for data collection and transmission
- development of a database to receive, analyze, and report on all wood production and movements

WTS allows Ghana to demonstrate compliance and control across to their timber supply chains and secure access to premium markets in the European Union and the United States. Trees are numbered (engraved on the tree), and next to the numbering is a white tag that has a barcode with the corresponding number.

A PDA equipped with GPS, scanner, camera, and data input is handed out to the enumerators, who venture into the reserve with the field rangers and supervisors. The stock enumeration involves numbering and tagging the yet-to-be-harvested timber with a barcode near the base of the tree. When harvested, the timber will also have a replica number and barcode, allowing tracking of the timber through the process to export. Information collected includes the following:

- Allocation of reserves, compartments, and lots
- Consortium holding
- Consortium harvesting schedule and by whom
- Plant species and how harvesting is done
- Where to mill
- Due diligence on taxes
- GPS position of trees

The timber flows monitored and verified are standing trees in the lots or compartments in the forest reserves; the system has not yet proceeded to tracking the timber through logging and processing, import to processing, and local sales or export. WTS will enable the tracking of individual logs and consignments of processed products. It will include product labeling, physical inspections, and documentation checks electronically. The use of ICT in this case allows a more comprehensive review of all wood movements than paper-based systems alone can provide, which is the current method.³²

³² Information in this section drawn from the Ghana country report, available at <http://www.profor.info/profor/knowledge/information-management-and-forest-governance>.

INNOVATIVE PRACTICE SUMMARY

Liberia: LiberFor Chain of Custody

LiberFor is a public-private partnership developed in 2007 to implement a tracking system for the forest product supply chain. The chain extends from the stump to the point of export to prevent illegal timber from entering the supply chain and being exported. The system is currently managed by a private international company, but management will be gradually transferred to the Liberian Forest Development Authority.

The system will be able to monitor all timber flows in Liberia and ensure the integrity of regulatory documents and sampled field checks. It will also prepare all the timber sales and taxation invoices and monitor payments made by logging companies to the government. Ultimately, after checking that all requirements have been met and payments have been made, LiberFor issues an export permission for the timber.

Forests cover 45 percent of the total land area in Liberia, and they are an essential source of revenue and economic development for the country. After coming out of a 14-year civil war, the country needed to build a system to manage its forest resources professionally and in an sustainable way. Previously, illegal logging had been a key driver of corruption and financial, social, and legal problems. For example, in 2006 approximately US\$64 million of logging revenues were in arrears and only 14 percent of revenues were accounted for.

The new chain-of-custody system has been designed to ensure that there is no return to the past uncontrolled logging in the country. Like WTS in Ghana, LiberFor is based on the Helveta platform. Its main components are as follows:

- **CI Earth—mapping**
 - block maps
 - stock surveys
 - plantation compartment maps
- **TracElite—chain of custody**
 - tree felling
 - crosscutting, dressing, and log registration
 - transporting of logs and wood products
- **Performance management**
 - data reconciliations
 - data verifications
 - random samplings and inspections
- **Document management**
 - concession registrations
 - invoicing and regulatory document
 - management tag control

The system has tagged and located approximately 440,000 trees, verified approximately 180,000 trees in the system, and invoiced more than US\$11 million in revenue, mainly from areas fees.

With the new system, the Liberian Forest Development Authority will be able to do the following:

- Manage the supply chain for all wood products from the point of origin to the export gate or domestic markets.
- Manage the conditions for release of timber export permits.
- Ensure that taxes and fees related to timber production and trade are collected.
- Invoice and monitor payments by logging companies to the government through an information system involving the forest administration, Ministry of Forestry, and Central Bank.
- Strengthen the capacity of the Liberian Forest Development Authority.
- Help both the Forest Development Authority and private concession holders to better know the resource

base in the forest, which is a precondition for sustainable forest management.

The LiberFor chain-of-custody system is being operated on a build/operate/transfer basis by SGS Liberia. While the system is technically functioning and able to meet the requirements of law enforcement and revenue collection, there are severe concerns regarding the sustainability and feasibility of the system. Both public and private sector stakeholders have raised concerns that the system is extremely complicated, has increased transaction costs unnecessarily, and is inappropriate for the Liberian context. The main concerns were based on the need to have a 100 percent inventory (above a threshold size) of the logging sites (as opposed to only collection information on commercial species), inappropriate design of the tags, and dependence on LiberFor inspectors. One issue of concern is that the system runs on Helveta servers in the United Kingdom rather than in Liberia. Long distances and limited international bandwidth may lead to reliability issues.³³

Topic Note 14.4: PILLAR 4—ECONOMIC EFFICIENCY, EQUITY, AND INCENTIVES

TRENDS AND ISSUES

Timber sales and auctions and concession-allocation processes are prone to unfair practices, collusion, and nontransparent decision making. This ultimately has an impact on both state revenues and private sector competitiveness. In general, participatory design and proper enforcement of the law should result in more equity and economic efficiency. Thus, technologies aiding law enforcement could be considered tools for enhancing equity and efficiency as well.

Online Timber Sales, Licenses, and Auctions

There are examples of ICT applications that are designed to promote business transactions with the private sector. One such example is the online auction of public timber, or e-auction. Most forest agencies in developing countries do not have integrated and well-functioning forest management and information systems that would enable e-auctions. Even in developed countries there are only a few instances of fully online systems.

The Forestry Commission of the United Kingdom has an advanced online auction system (image 14.7). The auction process is fully online and integrated into the e-government service of the United Kingdom. This site is simple to use and

has a help feature that tackles most of the common problems faced by users. The site explains the different types of auctions and allows bidders and nonbidders to view sales events, which increases transparency. All terms and conditions are posted, so that bidders are fully informed before bidding. In addition, there are links and phone numbers to provide help. As a truly online auction, the sale closes automatically when the bidding closes and the winner is informed, with no further need for paperwork. Bidders cannot see other bidders' quotations, and losing bidders are only given the name of the winning bidder on request. The system has been operational since 2004, and about one-third of the Forestry Commission's annual production of about 6 million m³ is sold on the open market, indicating that electronic sales are an effective model. Cost-benefit analyses carried out by the commission reveal that approximately £100,000 is being saved annually as a result of electronic sales.³⁴

The commission also operates an online grants and licenses system that provides private forest and farmland owners an opportunity to apply for grants to plant trees or seek permission to fell trees on their lands. The system enhances transparency by displaying all applications on the website,

³³ Information within this section was provided by the LiberFor team.

³⁴ Pers. comm.

linking each application by a case number to the map, which shows the location of the proposed activity.

Logistics

Two examples from Finland demonstrate the use of tracking devices to improve efficiency and productivity. One project, called Indisputable Key, used RFIDs to reduce waste and increase the usable volume of wood from the harvest, while the Metka project was aimed at reducing transportation costs to increase productivity. Transportation costs are optimized when only those piles of bioenergy wood that have dried to the right moisture content are transported by the company. Both examples could be adapted to any wood-processing unit around the world.

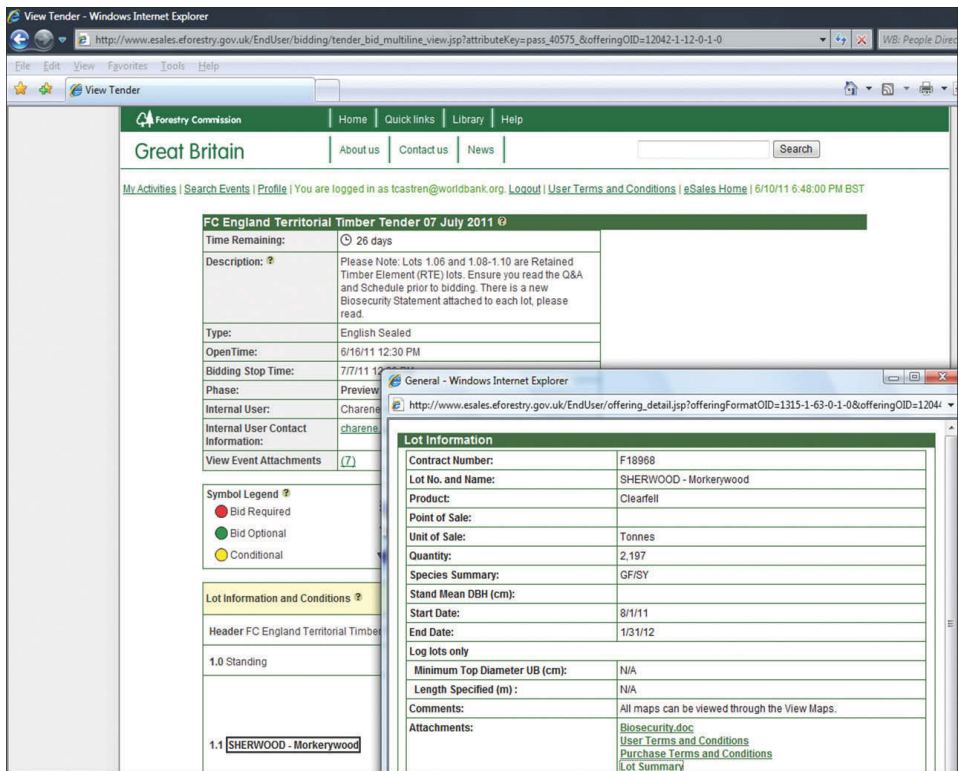
INNOVATIVE PRACTICE SUMMARY
RFID Chips for Efficient Wood Processing

The multinational development project Indisputable Key was a three-year, EU-funded endeavor with a total budget of €12 million. It was launched in 2006 and held its final seminar in March 2010. The primary objective of the project was to decrease the proportion of timber that is wasted or used for lower-value end products than the initial timber quality would have warranted. The data management is based on Individual Associated Data

methodology. According to this methodology, each felled tree has a unique code through an embedded microchip connected to a database. The chip or tag can also include information about the log parameters, felling location, and time of felling. This information is used in subsequent stages of the production chain to optimize process exploitation. Within the project, a new type of RFID tag was developed. By using new, pulping-compatible raw material, the tag does not affect any of the processing options. The project also resulted in the development of transponders that could read and modify tag data in harvesters and in tools such as large metallic saws, which had been problematic with the old transponders. The system was designed to be usable in all possible field conditions within the European Union, from the northern icy conditions to the southern warm and dry conditions.

The increased efficiency of the timber supply is achieved through the ability to source the raw material from the harvesting point all the way to the most profitable producing unit. Currently, the forest industry consumes timber in bulk without taking full advantage of the different characteristics of wood harvested from different origins. By being able to identify different sources, manufacturers can take into account the differences in timber quality in the processes. The quality aspect is noticed in market transactions through premiums for better timber quality. The methodology and technology behind the system are fully transferable to any geographical area.

IMAGE 14.7. Online Timber Sales in the UK



Source: UK Forest Commission.

Metka

Metka is a development project that uses an RFID tracking system. The project's objective is to develop an operational tracking system for local bioenergy supplier Vattenfall; the client benefits from increased profitability of wood-based bioenergy production. The software developer Protaccon built the information database, basing the system on existing Oracle-based stock management software. The tracking system is built on RFID tags attached to the bioenergy wood piles when harvested. The cost-efficiency of the system is achieved by using cheap, low-capacity bulk tags. This makes it possible to track low-value items as well. The tag allows the company to follow the chain of custody more carefully and to optimize the processes to reduce transportation costs. Another benefit of the information in the tags is the ability to optimize the drying time of harvested wood in order to minimize transportation costs and maximize the calorific value per transported unit. This has a remarkable effect on the chain's profitability. The system has been taken into operational use by Vattenfall. At the moment, the system is in use in the areas of two forest management associations and by two operators. The total number of vehicles and forest tractors using the system is about 10.³⁵

REFERENCES

When the source is a personal communication, website, or unpublished report, it is mentioned in the footnotes and not listed in the references.

Asia-Pacific Forestry Commission. 2010. *Forest Law Enforcement and Governance: Progress in Asia and the Pacific*. Bangkok: UN Food and Agriculture Organization.

Asner, G. P. 2009. "Tropical Forest Carbon Assessment: Integrating Satellite and Airborne Mapping Approaches." *Environment Research Letters* 4.

Asner, G. P., D. E. Knapp, A. Balaji, and G. Paez-Acosta. 2009. "Automated Mapping of Tropical Deforestation and Forest Degradation: CLASlite." *Journal of Applied Remote Sensing* 3: 1–11.

Collier Paul. 2007. *The Bottom Billion: Why the Poorest Countries Are Failing and What Can Be Done About It*. Oxford: Oxford University Press.

CyberTracker Conservation. 2007. "CyberTracker Monitoring Programme." CyberTracker Conservation, Cape Town. <http://www.cybertracker.org>.

Davies, D. K., S. Ilavajhala, M. M. Wong, and C. O. Justice. 2009. "Fire Information for Resource Management System: Archiving

and Distributing MODIS Active Fire Data." *IEEE Transactions on Geoscience and Remote Sensing* 47 (1): 72–79.

Dykstra, Dennis P., George Kuru, Rodney Taylor, Ruth Nussbaum, William B. Magrath, and Jane Story. 2003. "Technologies for Wood Tracking: Verifying and Monitoring the Chain of Custody and Legal Compliance in the Timber Industry." World Bank, Washington, DC.

European Commission. 2007. *FLEGT Briefing Notes: Forest Law Enforcement, Governance and Trade*. Briefing note number 01.

Fowler, M., P. Abbott, S. Akroyd, J. Channon, and S. Dodd. 2011. "Forest Sector Public Expenditure Reviews: Review and Guidance Note." Program in Forests (PROFOR).

Graham, M. D., C. Greenwood, G. Kahiro, and W. M. Adams. 2009. "The Use of 'Push to Talk' Mobile Phone Technology to Reduce Human Elephant Conflict, Laikipia District, Kenya." Working Paper 2, Laikipia Elephant Project, Nanyuki.

Gurovich, Luis A. 2006. "UC Virtual: A New Educational ICT Based Platform for Professional Updating of Knowledge and Abilities for Agricultural and Forestry Engineers in a Virtual University Campus." *Journal of Information Technology in Agriculture* 1 (1): 1–9.

ICT. 2004. *Update No. 16*, February. Wageningen: Technical Centre for Agriculture and Rural Cooperation.

Lawson, Sam. 2010. "Illegal Logging and Related Trade: Indicators of the Global Response." Chatham House briefing paper, Chatham House, London.

Magrath, William B., Richard Grandalski, Gerald L. Stuckey, Garry B. Vikanes, and Graham R. Wilkinson. 2007. *Timber Theft Prevention: Introduction to Security for Forest Managers*. Washington, DC: World Bank.

Myers, M. 2010. "Why Radio Matters." Developing Radio Partners, Washington, DC.

Peters-Guarin, Graciela, and Michael K. McCall. 2010. *Community Carbon Forestry (CCF) for REDD: Using CyberTracker for Mapping and Visualising of Community Forest Management in the Context of REDD*. Think Global, Act Local (K:TGAL) Report, Kyoto. <http://www.communitycarbonforestry.org>.

Program on Forests (PROFOR). 2010. *Rapport de Fin de Mission—GLIN Gabon*. <http://www.profor.info>.

USAID (U.S. Agency for International Development). 2005. *Women's Participation in Decision-Making at the Local Level Increased*. Final report. Washington, DC: USAID.

Vietnam Development Report 2011: *Natural Resources Management*.

World Bank. 2005. "Forest Institutions and Transition: Experiences and Lessons from Eastern Europe." ECSSD, World Bank, Washington, DC.

———. 2006. *Strengthening Forest Law Enforcement and Governance: Addressing a Systemic Constraint to Sustainable Development*. Washington, DC: World Bank.

———. 2008. *Forests Sourcebook*. Washington, DC: World Bank.

———. 2009. *Roots for Good Forest Outcomes: An Analytical Framework for Governance Reforms*. Washington, DC: World Bank.

³⁵ Information in this section is drawn from the Finland country study (available at <http://www.profor.info/profor/knowledge/information-management-and-forest-governance>) and <http://www.indisputablekey.com>).

Module 15 USING ICT FOR REMOTE SENSING, CROWDSOURCING, AND BIG DATA TO UNLOCK THE POTENTIAL OF AGRICULTURAL DATA

JOSH WOODARD (FHI 360), with contributions from MECHTELD ANDRIESSEN (eLEAF), COURTNEY COHEN (aWhere), CINDY COX (IFPRI), STEFFEN FRITZ (IIASA), DREW JOHNSON (TechnoServe), JAWOO KOO (IFPRI), MORVEN MCLEAN (ILSI Research Foundation), LINDA SEE (IIASA) TARAH SPECK (aWhere), and TOBIAS STURN (IIASA).

OVERVIEW

By 2050, the global population is projected to reach approximately 9 billion. Population growth will be concentrated in poorer countries, particularly the low-income countries of Sub-Saharan Africa. By some estimates, agricultural productivity will need to double to meet everyone's needs for food (Foley 2014). For instance, if current trends continue, yields of the world's foremost food crops—maize, rice, wheat, and soybeans, which supply roughly two-thirds of calories consumed globally—appear likely to grow significantly more slowly than required to meet the projected global demand in 2050 (Ray et al. 2013). Some productivity growth will come from using more of the world's arable land for agriculture, but most of the available arable land is unevenly distributed, and about half of it is found in only seven countries.

If agricultural productivity is to grow sufficiently to meet the world's expanding demand for food, producers must be able to increase yields and cropping intensity (Alexandratos et al. 2012), improve the productivity of their livestock, and quite possibly diversify their portfolio of economic activities on and off of the farm. At the same time, producers are only too aware of the challenges and risks presented by a changing climate and growing population pressure. Multiple approaches are needed to support their efforts, including those to improve natural resource and farm management, to develop better crop varieties and animal breeds, to devise and use innovations in crop and livestock production (such as technologies for precision agriculture or livestock identification and tracking), to generate and share knowledge, and to improve access to markets, among others.

This module was originally written in 2015, with minor revisions in early 2016. All content was accurate at the time of writing.

The reviewers of this module were Lyudmila Bujoreanu (World Bank Group), Terhi Elisa Havimo (World Bank Group), Holger Kray (World Bank Group), Trevor Monroe (World Bank Group), and Eija Pehu (World Bank Group).

Virtually all of these paths to offsetting current trends and increasing the growth of agricultural productivity can benefit from revolutionary changes in how data are collected, generated, shared, analyzed, and visualized. Agriculture is notoriously complex, characterized by wide variation across time and space in terms of producers, production systems, biophysical conditions, and myriad other variables, at scales smaller than the smallest plot or larger than multiple agroecologies. Advances in information and communication technology (ICT) over the past 20 years have enabled individuals to gather, analyze, and share data more effectively, as well as to visualize and understand, as never before, what this information means for agriculture. The capacity to capture and analyze data has been growing exponentially with the global spread of relevant ICT tools, including geospatial statistical methods.

Big data (the proliferating types and amounts of data being collected), together with advanced ICT capabilities (such as more sophisticated computer processors and algorithms), are providing a more accurate understanding of existing conditions and generating better predictions of future conditions, enabling more informed (often real-time) decision making. In agriculture, ICT and big data are helping to leverage the global engagement of development practitioners, researchers, scientists, and producers across borders. New approaches combining enhanced productivity with environmental sustainability are being developed.

For example, since the 1990s, commercial producers in high- and middle-income countries have increasingly taken advantage of precision farming technologies such as global positioning systems (GPS), geographic information systems (GIS), remote sensors, and satellite imagery to improve productivity (box 15.1). Such technologies are increasingly within reach in low-income economies. In 2005, the median price of a computer was US\$1,500 and a GPS device cost more than US\$2,000 (Martin et al. 2005); a decade later, a smartphone with a GPS receiver and more computing power than a computer available in 2005

cost less than US\$100. The array of sensors in smartphones has expanded to include barometers and thermometers that can collect hyperlocalized weather information. Small-scale producers with access to mobile phones are beginning to benefit from improved tools also for networking, decision making, and analysis based on these technologies.

The same big data sets are used by a wide array of stakeholders in distinctly different ways. With hyperlocalized weather data, for instance:

- Farmers can make better planting decisions based on more accurate weather predictions and better prepare themselves to adapt to changing conditions.
- The Ministry of Agriculture can use more accurate information on local weather patterns and disease and pest populations to tailor the extension messages it provides to producers.
- Government agencies responsible for disaster risk reduction and response can use this information to better allocate resources based on hyperlocalized weather events.
- Donors can use this data to design programs that are better attuned to local needs.
- The private sector can use these data to offer a whole range of services that it could not deliver previously, such as weather insurance for smallholder farmers. Two examples are the Agriculture and Climate Risk Enterprise Ltd. (ACRE) in East Africa and the weather-based crop insurance offered by private insurance providers in India (Greatrex et al. 2015).¹

Big data analytics makes it increasingly possible to combine multiple types of data in a single interface, often referred to as a mashup, which improves the prospects of gaining insights that would not have been accessible before. A growing community of scientists and agricultural development practitioners is able to perform more complex analyses using different types of data generated in very different ways and assembled in global data sets, which are increasingly available to the public (box 15.2). For example, analyses combining data from the World Bank's Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS–ISA) with satellite or aerial images could potentially help policy makers to develop a more robust picture of the challenges facing various types of producers than they could derive from either set of data alone.²

BOX 15.1. The Intersection of Remote Sensing, Crowdsourcing, and Big Data

In the United States, the agricultural firm John Deere exemplifies how remote sensing, crowdsourcing, and big data can be combined to offer farmers precise insights to increase efficiency and productivity. The company's online portal pulls in data from farmers' sensors. The aggregated data from thousands of farmers are combined with external data sets (such as weather data) and, powered by big data analytics, used to advise farmers on what to plant on certain areas of their land. The system can also predict when machinery is likely to break and notify a nearby parts distributor to stock that part. Despite the obvious benefits to farmers, some farmers have questioned whether they should be compensated for how John Deere uses their data to enhance its commercial services.^a This question needs to be addressed as similar types of services and the business models that support them are rolled out throughout the world, especially in middle- and low-income countries where producers have far more limited potential to pay for subscription services.

Source: Authors.
a. Marr 2015.

BOX 15.2. Visualizing Data Sets for Development

The World Bank's Spatial Agent app enables users to access global data sets in the public domain and to display the data in a graphic or other pictorial format that makes the implications easier to understand. The Spatial Agent app includes spatial and temporal data from a number of global institutions and is available for free for Android and iOS mobile operating systems.

Source: Authors.

Both the public and private sectors clearly recognize the potential value of investing in big data aggregation and analysis for agriculture. The agricultural technology sector, which includes the ICT applications highlighted in this module, received more than US\$2.3 billion in investments in 2014, surpassing investments in financial technology and clean technology in that same year. The level of investment in 2014 represented an increase of 170 percent over the previous year, and this strong growth trend appears likely to continue

¹ ACRE was previously known as Kilimo Salama.

² To learn more about LSMS–ISA, see <http://go.worldbank.org/BCLXW38HY0>.

BOX 15.3. Separating the Hype from Reality

It is easy to understand why some people are skeptical about the potential of remote sensing, crowdsourcing, and big data to improve the lives of the poorest producers. The reality is that even as global mobile phone penetration rates continue to grow, a significant number of poor producers, especially women, do not own a phone, much less any way of accessing the benefits of remote sensing and big data.

To some, these technologies represent a luxury reserved for high-income countries and affluent producers, rather than technologies with practical applications for less thriving economies and producers. There is some truth to that sentiment. The World Economic Forum's 2014 Networked Readiness Index identifies a number of countries, particularly in Sub-Saharan Africa, that are lagging in leveraging the potential of ICT.^a

Because advances in some technologies tend to move faster than many can imagine, they may become more readily available throughout the world over the next few years. Smallholders may not actually use remote sensors and big data analytics themselves, yet it is very likely that—at the very least—the institutions that support those producers will be able to access such technologies and use them to benefit the individuals they serve.

Policy makers and donors who ignore these factors and simply write off the technologies mentioned in this module as a pipe dream do so at the risk of exacerbating the digital divide. It is important to examine how smart investments can leverage these technologies over the short and long terms to benefit the agricultural sector as a whole and especially poorer producers, many of whom have yet to benefit. This module should be seen as the beginning, not the end, of examining the prospects for applying these technologies, given that their evolution and deployment are so dynamic.

Source: Authors.
a. Bilbao-Osorio et al. 2014.

(Leclerc and Tilney 2015). Notable investments since 2013 have included:

- Monsanto's US\$1 billion acquisition of the Climate Corporation, an agriculture analytics and crop insurance company that uses weather data (Tsotsis 2013).
- An investment of US\$95 million in Planet Labs, which operates a legion of Earth-imaging microsatellites used by several sectors, including agriculture (Lawler 2015).
- Qualcomm Ventures' US\$50 million investment into 3D Robotics, a drone manufacturer whose products are used, among other things, for precision agriculture (Burns 2015).
- Google Ventures' US\$15 million investment in the Farmers Business Network, a massive farming database and decision-making tool (Reader 2015).
- The £12 million invested by the UK government in the Centre for Agricultural Informatics and Metrics of Sustainability, which will focus on using big data analytics to support agricultural development (Crawford et al. 2015).
- Uruguay's investment of US\$55 million, with support from the World Bank, in the Sustainable Management of Natural Resources and Climate Change Project, which includes the development

of a National Agricultural Information System decision-support tool.³

- The Government of India's launching of the Digital India initiative. Although not specific to agriculture, it includes a crowdsourcing platform (mygov.in) to gather citizens' feedback.

A strong case can also be made for public investments in big data as a public good. These kinds of innovative investments have a strong history of success that includes Landsat, the Global Agricultural Monitoring system, the Famine Early Warning Systems Network, and ALEXI—and that belies skepticism that remote sensing, crowdsourcing, and big data analytics can benefit low-income economies and the poorest producers (box 15.3). Given the very large investment required to support some types of remote sensors and big data services, it may be some time before commercially available service providers find that it pays to target small-scale producers in Sub-Saharan Africa and Asia. Deeper analysis may reveal particular opportunities for public investment to yield positive returns for society—for example, investments in services that are highly likely to improve smallholders' productivity but relatively unlikely to be commercially viable.

3 Learn more here: <http://www.worldbank.org/projects/P124181/sustainable-management-natural-resources-climate-change?lang=en>.

Key Challenges and Enablers

The world currently produces a lot of data, and this amount will continue to grow exponentially over the coming decades. In 2013, the world's stock of digital data was estimated to be around 4.4 zettabytes.⁴ By 2020, that amount is expected to increase tenfold, to 44 zettabytes, with most of those data coming from emerging markets. Part of that growth is expected to come from data from embedded systems, as more and more devices begin communicating directly with each other.⁵ This phenomenon—referred to as the Internet of Things (IoT)—enables devices to share data directly, without a human intermediary, although by 2020 the vast majority of data (90 percent) will still come from humans (IDC 2014).

Access to data also remains a challenge. Many governments and organizations, including the World Bank, have promoted open data, yet much of the world's data remains proprietary or exists in inaccessible formats.⁶ Despite efforts to promote the opening of data for the public good, significant portions of the world's digital data are likely to stay outside the realm of public use for some time.

Agriculture is no stranger to this challenge. The collection and management of agricultural data is often fragmented among government agencies, development practitioners, and agribusinesses. Centralized and comprehensive agricultural databanks remain the exception rather than the rule. A recent commentary on data-driven agriculture in Nigeria notes that “the dearth of information is making it difficult to translate data into useful information for producers and other players in the value chain” (Essiet 2015).

While a reluctance to share data sometimes adds to this challenge, it is important to recognize that the problem stems largely from barriers related to data standards and the lack of interoperability. Hardware and software systems for collecting agriculture-related data are not all interoperable, meaning that they use incompatible formats. In some instances, standards that would facilitate interoperability between different systems are lacking as well. Public institutions can play a significant role, as they have already done, by promoting the use of open data sharing and standards. The Global Open Data for Agriculture and Nutrition (GODAN) initiative was launched in 2013 and

now has over 100 partners from the public and private sectors. GODAN advocates for open data and open access policies in the public and private sectors, as well as for the release and reuse of data for social, economic, governance, and environmental benefit.⁷ Another example is the Open Ag Data Alliance, launched in 2014 to help farmers access and control their data “by building an open source framework and a community of commercial vendors, farmers, academics, and developers upon which the emerging ag data market can rapidly grow.” Some of the world's largest agricultural companies support the Open Ag Data Alliance, which can potentially serve as a model for the types of collaboration required to overcome the challenges of fragmented and unusable data.⁸

Aside from the technical barriers to using data, there are significant skill barriers. Many organizations find it challenging to hire individuals with the right experience to fully harness the value of data. The information technology research firm Gartner has estimated that 4.4 million jobs would be created in 2015 to support big data, but that only one-third of those positions would actually be filled due to limited talent within the industry (Gartner 2012).

Both the public and private sectors have important roles in helping to bridge these gaps in human and technological resources. Public and private educational institutions, with encouragement from governments where necessary, need to be preparing more students to take on the development of next-generation remote sensors and build a robust big data analytics ecosystem (figure 15.1 provides more detail on the components of a big data ecosystem). Organizations and companies will need to provide on-the-job training to ensure that their employees are equipped to use the new systems and processes introduced as a result of the trends highlighted in this module.

Informed consent and fair compensation for data collection are two other significant challenges. The issue of informed consent is particularly thorny when data are collected without a human intermediary—for example, through a crowdsourcing platform or via a short messaging service (SMS) survey in which participating individuals may not fully read the lengthy terms of service that convey this information. The development community is only just beginning to explore these issues seriously. In late 2014 in Nairobi, for instance, the Responsible Data Forum hosted an event in partnership with Amnesty International on “Consent and Crowdsourcing.”

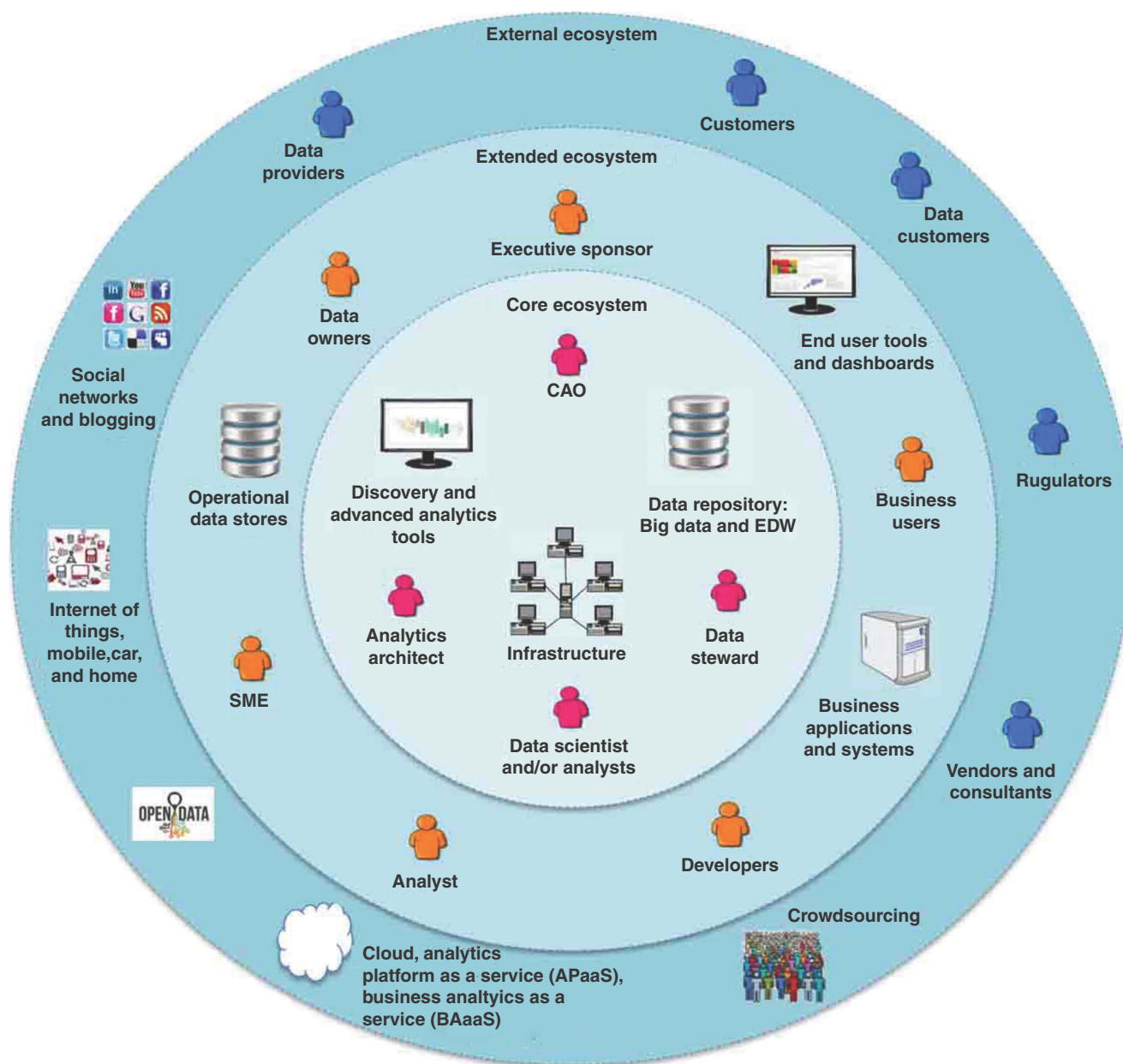
4 One zettabyte is the equivalent of just under 1 trillion gigabytes.

5 Embedded systems are computing systems within a device, such as a computing system within a refrigerator.

6 Open data are defined as data that are made freely available for use, reuse, and distribution, for any purpose, without restriction. The World Bank's Open Government Data Toolkit is a good starting point for learning more about open data in practice. It is available for free online at <http://opendatatoolkit.worldbank.org/en/>.

7 To learn more about GODAN, see <http://www.godan.info/about/statement-of-purpose/>.

8 To learn more about the Open Ag Data Alliance, see <http://openag.io>.

FIGURE 15.1. Example of a Big Data Analytics Ecosystem

Source: IBM Big Data & Analytics Hub.¹⁰

Note: Used with permission. Further permission required for reuse.

In examining that topic, participants attempted to address some of the following questions:⁹

- Do organizations that collect and use crowdsourced information have a responsibility to disclose those facts to users? If so, might disclosure affect the quality and quantity of information collected?

- Can ethics-based and consent requirements be built right into software, or do these responsibilities always lie with the organization using the software?
- Is consent more appropriate as a precondition for data collected for “research” versus other purposes?

Not all companies or organizations that offer data-enabled services to farmers are explicit about how they seek informed

9 For details on this event, see <https://responsibledata.io/forums/consent-and-crowdsourcing/>. The outputs of the event should eventually appear at https://wiki.responsibledata.io/RDF_Nairobi.

10 This graphic originally appeared in the article “Going Beyond Data Science toward an Analytics Ecosystem: Part 2” by Ahmed

Fattah, which was published on the IBM Big Data & Analytics Hub Blog on March 14, 2014.

BOX 15.4. Monitoring and Evaluating Investments in Remote Sensing, Crowdsourcing, and Big Data for Analytics

The monitoring and evaluation of investments in any of the three big data trends covered in this module will vary, depending on the extent of the investment and anticipated outcomes. Even so, the following common indicators of outputs and outcomes are likely to be useful:

- **Remote sensing**

- *Outputs:* Amount of data collected.
- *Outcomes:* Impact of remote sensing on productivity and/or cost.

- **Crowdsourcing**

- *Outputs:* Number of people engaged; number of contributions; amount of data collected.
- *Outcomes:* Impact of contributions on overall outcome being tracked; cost-benefit comparison between crowdsourcing and traditional methods.

- **Big data for analytics**

- *Outputs:* Number of insights gained; number of insights deemed accurate.
- *Outcomes:* Impact of insights on efficiency or cost of overall outcome; changes in policy.

Source: Authors.

consent from farmers to use their data. Plans for using individuals' data might be contained in a service agreement that marginally literate farmers cannot read or understand. It behooves any development practitioner who promotes the use of ICT by farmers to understand exactly how farmers' data will be used and who owns their data, and in turn to clearly explain these issues to farmers so that they can give their truly informed consent.

The related question is what rights individuals have to receive some portion of the value generated from their data. For instance, a hypothetical weather service could generate millions of dollars in revenue from the sale of its hyperlocalized weather data. The data that were fed into the service's algorithms were crowdsourced from local farmers, who received free weather information in exchange for their participation. Should those farmers also have some right to compensation for the revenue generated by the service, or is the value of free weather information a fair exchange?

Resolving these and other questions related to informed consent, privacy, and ownership rights must be at the center of organizational policy discussions in relation to data collection from crowdsourcing and remote sensors.¹¹

As the emphasis on using data and evidence on crafting development interventions is relatively recent but growing, we have pooled together a few key questions to support the monitoring and evaluation of data-centered approaches in box 15.4.

ORGANIZATION OF THIS MODULE

The topic notes that follow cover three ICT trends that are enabling producers, agribusinesses, policy makers, researchers, and agricultural development practitioners to optimize resources, connect people, and overcome data fragmentation: (1) remote sensing, (2) crowdsourcing and crowdmapping, and (3) big data for analytics. Although discussed separately, these trends are interrelated. The first two trends are driving the production of massive amounts of raw agricultural data, and big data analytics is the process through which these data is meshed, refined, and analyzed. Each topic note is followed by one or more innovative practice summaries highlighting a particular application or aspect of the topic at hand. Box 15.5 defines some key terms covered in this module.

Topic Note 15.1, "Remote Sensing for Sustainable Agriculture," focuses on the different types of geographical solutions that producers and others in agricultural value chains can use to increase efficiency, reduce waste, and ultimately bring about more sustainable agricultural practices.

¹¹ The book *Ways to Practise Responsible Development Data* is a great resource for learning more about responsible data practices. Download it for free at <https://responsibledata.io/ways-to-practise-responsible-development-data/>.

BOX 15.5. Key Terms Used in This Module

Remote sensing technologies are used to collect both spatial and temporal data. For comprehensive definitions of the most common types of remote sensing technologies, see Module 5.

Crowdsourcing is the process of obtaining data from a large group of people over a digital connection—for example, by broadcasting a call on the radio for farmers to send an SMS to report whether they have experienced any crop failure that season.

Crowdmapping is a subset of crowdsourcing. Data collected from a crowd are plotted onto a map using georeferencing, meaning that the data are associated with a particular point on a map. For example, farmers participating in the crowdsourcing example mentioned above could be asked to include their location in their response so their location can be associated with their response on a map. If farmers respond by SMS, this georeferencing may have to be done manually. If respondents use a mobile app or website combined with the GPS receiver on their phones, their geographical information can be collected automatically and tagged to the information they supply with a fairly high degree of accuracy (often within a few meters). GPS receivers are available primarily on smartphones and newer feature phones; georeferencing is not possible on basic and older feature phones.

Big data analytics has an evolving definition but generally refers to mining and analyzing data for improved decision making using software and hardware (using complex algorithms and artificial intelligence, for instance) that are much more sophisticated than those used by traditional databases. Some of the techniques used to process big data are defined in Module 5.

Source: Authors.

Topic Note 15.2, “Crowdsourcing and Crowdmapping: The Power of Volunteers,” focuses on how advances in social networking and data collection are enabling individuals to share hyperlocalized data in ways that have the potential to benefit society more broadly.

Topic Note 15.3, “Big Data for Analytics,” focuses on how all of these agriculture-related data collected globally can be mined and analyzed in ways that lead to meaningful insights about how agriculture can be made more sustainable and productive.

Topic Note 15.1: REMOTE SENSING FOR SUSTAINABLE AGRICULTURE

TRENDS AND ISSUES

Remote sensing covers a range of technologies, many of which are described in detail in Module 5. This topic note focuses on the types of data collected by remote sensing devices and on how such data can be used to assist producers, policy makers, and researchers. In simplest terms, remote sensing refers to the use of devices to remotely monitor information from fields, grazing areas, storage containers, irrigation plots and alike, and in some cases to remotely take specific actions. For example, remote sensors are integral to precision agriculture, which aims to maximize farming efficiency and minimize waste through data to guide hyper-localized agricultural practices.

Since most remote sensors are digital devices, they collect a lot of data, and the potential impact of their data can be enhanced significantly through integration with big data analytics (see Topic Note 16.3). While remote sensors can (for instance) be used to monitor crop growth and identify anomalies, the technologies are even more powerful when they are paired with systems that can identify issues automatically and offer advice on actions to mitigate them.

Generally speaking, remote sensing devices can be classified into three types: ground, air, and space.

Ground sensors capture data based on circumstances on the ground. They can be embedded in farm equipment, such

as sensors that track yield data, or they can be stand-alone devices, such as soil and water monitors, normalized difference vegetation index (NDVI) sensors, and weather stations. Some of these sensors are controlled by producers themselves, although others (portable soil sensors, terrestrial laser scanners, or weather stations) are managed by a third party. As mentioned in the overview, farmers also increasingly use smartphones as on-the-ground sensors. The sensors and GPS receivers embedded in smartphones are making it easier to collect certain types of climatic and location data.

Scientists, including breeders, are also benefiting from a new wave of ground sensors. High-throughput plant phenotyping, for example, uses a combination of spectral imaging cameras and other sensors to provide data for developing improved crop varieties (Fahlgren, Gehan and Baxter 2015; Thomasson 2015).

Aerial sensors consisted until recently of small aircraft armed with tools such as GPS, light detection and ranging (LiDAR) laser sensors, and digital still, multispectral, and thermal-imaging cameras. Flying low over a field, aerial sensors could obtain high-resolution images capable of providing farmers with information about weed growth, water stress, and even the locations of anthills (USDA 2005). This type of sensing is out of reach of the majority of the world's farmers, although it has applications for governments and larger agribusinesses. The commercial availability of unmanned aerial vehicles (UAVs, or drones) is removing some of the limitations on using aerial sensors and may eventually give many more producers, including those in middle- and low-income countries, a cheaper alternative to aircraft (box 15.6).

Even more removed from the field are **space-based satellites**. Any ground or aerial sensor that uses GPS relies on satellites to calculate its positioning. Satellites also have a range of other imagers and sensors. Different spectral bands can capture different types of information. For instance, thermal infrared can measure surface temperatures, whereas green can be used to assess plant vigor. Spectral bands also provide different levels of information about specific physical objects that are seen. Image 15.1 illustrates how different spectral bands provide different levels of granularity about trees, ranging from identifying an object as a tree with panchromatic (black-and-white) imagery to indicating what class of tree it is and even identifying the specific species with short wave infrared (SWIR) imagery.

Not all satellites capture data across all spectral bands, and only some satellite data are made publicly available (for instance,

BOX 15.6. The Future of Drones for Smallholders

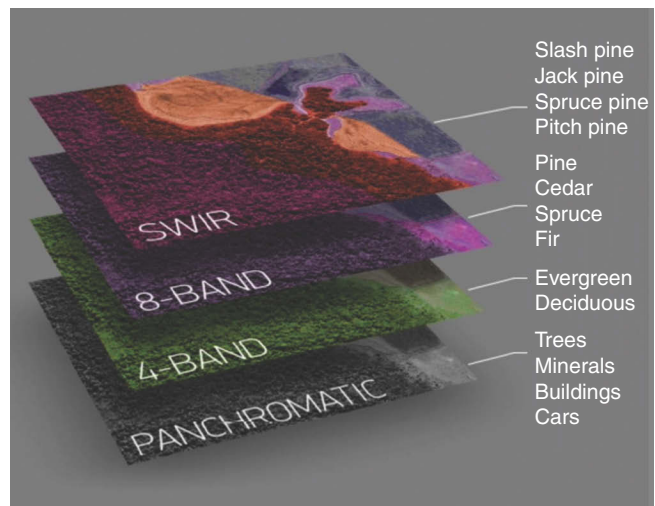
Will drones enable remote sensing to become a less remote prospect for smallholders? The International Potato Center received a grant from the Bill & Melinda Gates Foundation in late 2014 for local institutions to pilot the use of drones for remote monitoring of sweet potato fields planted by smallholders in Tanzania and Uganda.^a In addition, new firms such as Raptor Maps in the United States and CI-Agriculture in Indonesia are combining big data analytics with data from drones and other remote sensors to provide farmers with precise information on their farms. It is too soon to tell whether either firm will succeed, but they are a bellwether of what is to come.^b

Source: Authors.

a. Quinn 2014.

b. Lavars 2015; Freischlad 2015.

IMAGE 15.1. Different Spectral Bands for Satellite Imagery



Source: DigitalGlobe.

Landsat data). A satellite or a constellation of satellites will also vary in the frequency with which complete coverage of the globe can be provided, which in turn affects how frequently they capture new data on a specific location. For example, Landsat 8 and Landsat 7 take 16 days to cover the globe. Microsatellite firms, such as Planet Labs, on the other hand, aim to provide daily coverage of the world's entire landmass.

In many cases, certain levels of skill and expertise are still required to analyze and make sense of satellite data. This situation is changing, however. Advances in satellite technologies and increased competition are making it possible for

even small-scale producers to receive insights from satellite sensors that are pertinent to their farms, or at least to their general geographic area, directly on their mobile phones. Farmers generally do not access the satellite data directly; they subscribe to a mobile service that makes use of it.

For example, coffee farmers in Rwanda can use the WeatherSafe app, which combines satellite and farm-specific data, to receive localized weather information and farming recommendations (European Space Agency 2014). While eLEAF, which is based in the Netherlands, uses a combination of meteorological and remote sensing data to monitor crop growth and water use on farms in real time (see the innovative practice summary below). Another interesting example of expanding access to satellite information is the partnership between the Food and Agriculture Organization (FAO) and Google to increase the accessibility of its geo-spatial tracking and mapping products (Graziano da Silva 2016). One recent output from this partnership is the Water Productivity Open-access Portal (WaPOR), which currently has 250m spatial resolution data on agricultural water productivity for all of Africa and the Near East.¹²

The trend toward increasingly sophisticated and in some cases miniaturized remote sensors will undoubtedly continue in the coming decades, and prices for many of them will almost certainly continue to fall. It is estimated that the precision farming market will see a compound annual growth rate of over 13 percent from 2015 through 2022 (BIS Research 2014).

It is important to understand that even though remote sensing technologies are becoming more accessible, access to those technologies will not be distributed evenly. The majority of producers, especially smallholders, are likely to benefit from remote sensors that are built into or are accessible via mobile phones, although their use will depend partly on whether producers have access to smartphones capable of using the technology. GSMA Intelligence calculated that 43 percent of people in developing countries owned a mobile phone in 2014, a figure that they expect to grow to only 55 percent by 2020. Over that same period, however, GSMA anticipates that smartphone ownership will grow from around 25 percent to over 60 percent.¹³ Those trends are both positive but clearly show that significant portions of the population will remain without direct mobile access.

¹² WaPOR can be accessed online at <http://www.fao.org/in-action/remote-sensing-for-water-productivity/database/database-dissemination-wapor/en/>.

¹³ Accessed on <https://gsmaintelligence.com/>. All data © GSMA Intelligence 2015.

Possibly other types of basic ground sensors and potentially even small drones could find their way into the hands of poor, small-scale producers. In the short term, however, it remains likely that most of the world's farmers will have access to these types of devices at best through an intermediary.

Researchers and policy makers potentially have much to gain from advances in remote sensing, which should significantly increase the amount of precise agricultural data available to them (box 15.7). These data, combined with big data analytics (discussed in Topic Note 15.3), could drive the future of agricultural research and also guide the design of more precise interventions by governments and development organizations seeking to support specific subsets of producers (poor smallholders, transhumant livestock producers, women diversifying into horticultural crop production, and so on). The potential for increased precision at the farm level to improve the efficiency of resource use will be particularly important for the ability of all producers and for all types of agriculture to adapt to climate change.

Of course, the policy implications of some of these technologies must be addressed first to ensure that benefits can be gained from them without undermining broader public interests. For instance, many countries have yet to resolve legal issues related to the use of personal drones for agriculture. Some have opted to control personal drone use from a public nuisance perspective, while others approach the issue from a national security perspective. Many governments also restrict the use of satellite imagery. Until recently, the U.S. government restricted the sale of satellite images at resolutions sharper than 50 centimeters. Those restrictions have been eased somewhat, and now black-and-white images up to 25 centimeters in resolution and color images up to

BOX 15.7. Advances in Remote Sensing

At the ICT for Ag conference in Washington, DC, in 2015, presenters noted that a couple of trends in remote sensing for agriculture could greatly unlock the value of their data (Zoltner 2015):

- Free and open source platforms for interpreting the data are becoming more available.
- High numbers of low-cost sensors can match the accuracy of high-end sensors through a greater number of data points.

Source: Authors.

1 meter in resolution may be sold to non-U.S. customers (Ferster 2014).

Measuring the impact of remote sensing for sustainable agriculture depends entirely on the type of sensing that is used and its purpose. Broadly speaking, though, farmers using remote sensors are anticipating seeing improvements in productivity and/or reductions in costs, not to mention a reduction in negative effects on the environment.

LESSONS LEARNED

Until recently, even in high-income economies, full use of the spectrum of remote sensing technology required tens of thousands of dollars in investment, meaning that large numbers of farmers often could not benefit. In low-income countries, producers' use of remote sensing remains in an extremely nascent phase. The world is embarking on a new era of more affordable remote sensing, however. In moving forward, policy makers, researchers, and practitioners can benefit from applying some lessons gained from using these technologies to date.

Clarify Legal Limbos

Precision agriculture technologies, including remote sensing, will remain on the cutting edge of technological capabilities for some time. As new technologies emerge or previously restricted technologies are made commercially available, governments will need to move quickly to address any legal issues that could impede their use. The legal uncertainty surrounding drones is the current case in point, although undoubtedly other technologies will find themselves in the same situation.

Expand Digital Literacy

Remote sensing relies on a variety of digital hardware and software. Producers, especially poor producers, will benefit from these tools only if they understand how to use them. Fostering digital literacy is potentially no small feat, and may require continuous training and support for some groups of producers. In the short term, since many producers will not have direct access to remote sensing tools, there is an opportunity to acquaint them with these tools via an intermediary, such as an extension agent or lead farmer. One such example of strengthening intermediary capacity comes from the partnership between FAO and Google mentioned earlier. As part of that partnership, 1,200 FAO staff and partners will receive trusted tester credentials on the Google Earth Engine, as well as receiving training on how to

use it. In turn, FAO will train its staff and technical experts in member countries on how to use this technology (Graziano da Silva 2016).

Expand the Capacity to Interpret Data

The next step beyond understanding how to use remote sensing tools is to understand how to interpret the resulting data and translate those insights into action. The data tend to be highly technical and potentially difficult for someone with a basic level of education to understand. Any remote sensing tool that aims to benefit such producers will need to closely consider this reality during its design.

Ensure Interoperability and the Adoption of Standards

A major impetus for creating the Open Ag Data Alliance was the lack of interoperability between precision agriculture technologies and data standards. The Open Ag Data Alliance was particularly concerned with the fragmentation of data across the different devices and platforms used by a typical U.S. farmer.¹⁴ The lack of application program interfaces (APIs) connecting different software applications prevented producers from easily seeing all of their data in one place. As development organizations begin to promote the use of remote sensing technology among producers, especially disadvantaged producers, it is crucial to avoid these pitfalls by partnering with providers that adhere to open standards and interoperability—or to encourage providers that do not adhere to open standards to do so.

Strike an Appropriate Balance between Privacy and the Public Interest

This lesson is explored in more detail in the Lessons Learned section of Topic Note 16.3 on big data. In short, while access to all of the hyperlocalized data generated by ground and aerial sensors could be of huge value to researchers, it may not be in producers' best interest to share those data. While providers of remote sensor software may embed their right to sell user data to third parties in their terms and conditions, practitioners should ensure that producers are asked for explicit informed consent to do so. In some cases, this approach will mean resisting the temptation to enable individuals to opt in by default in order to ensure a rich data set. At the same time, researchers, practitioners, and policy makers should promote strong data privacy standards to

¹⁴ Two figures on the Open Ag Data Alliance website clearly illustrate the current disconnectedness of remote sensing systems and the envisioned future interoperable state; see <http://openag.io/about-us/principals-use-cases/>.

protect the personal data of producers, including their farm- or enterprise-specific data. In some instances, it may be necessary to explore standards that promote unlinking farm-related data from exact geographic coordinates—providing them at the village or district level instead—to balance producers' interests in protecting their specific farm data with researchers' and policy makers' desires for access to some level of aggregate information to use in their research and decision making.

INNOVATIVE PRACTICE SUMMARY

Using Multispectral Satellite Images and Energy Surface Balance Models to Calculate Crop and Water Productivity

The Netherlands-based firm eLEAF has developed a series of algorithms that use a combination of meteorological and remote sensing data to monitor crop growth and water use on farms in real time. A technology called Pixel Intelligence Mapping (PiMapping) delivers data at a range of spatial resolutions (image 15.2). Widely used are 250-meter data and 20–30-meter data; however, with the launch of the European

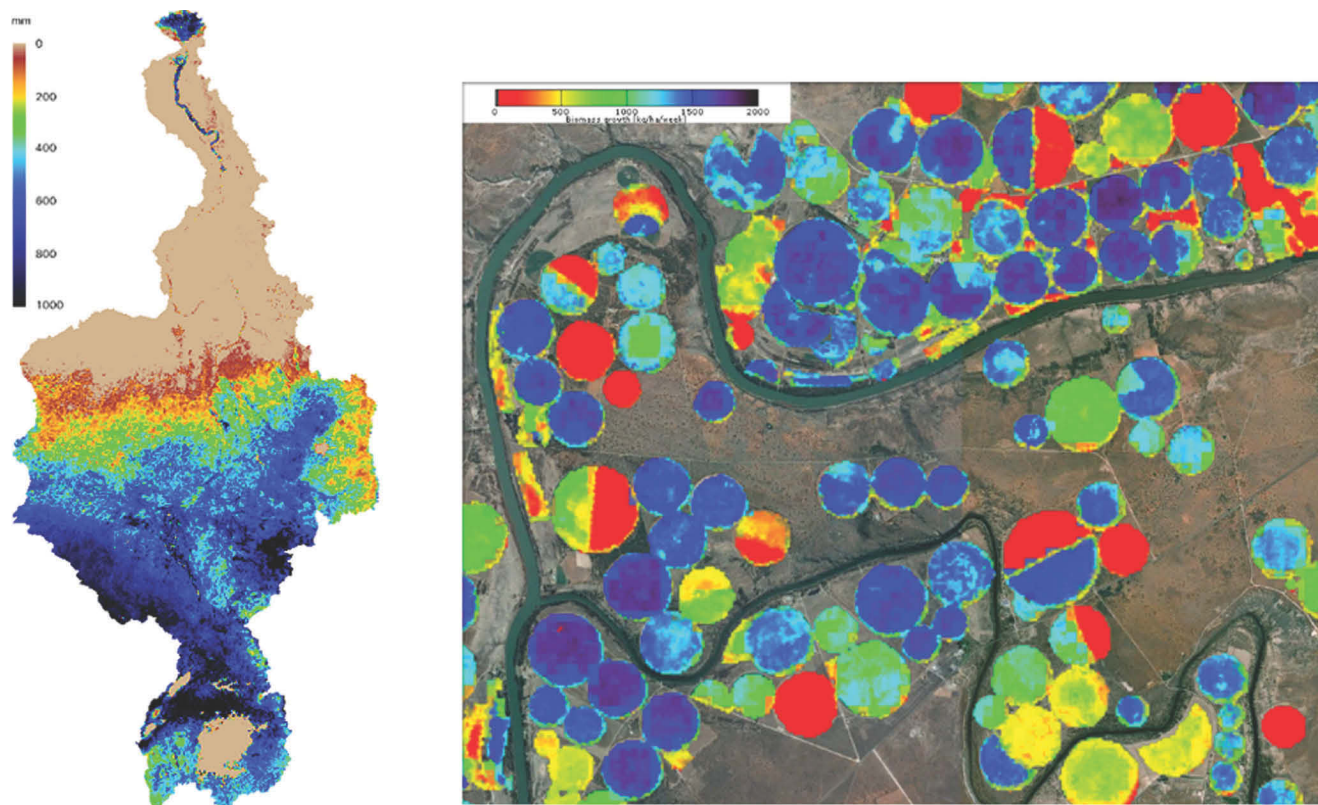
Union Sentinel satellites in 2015, resolutions as high as 10 meters are within reach. The lower-resolution data can be used for monitoring large areas at a regional or national scale, such as entire river basins. The higher-resolution data allow identification of individual fields to monitor crop growth changes on individual farms.

Using eLEAF's FieldLook-platform, individuals can access a range of PiMapping data, including biomass production, evapotranspiration, transpiration, evaporation, biomass water productivity, leaf area index (LAI), NDVI, and fractional vegetation cover (FVC). In addition, by delivering both historical and real-time data, users can use PiMapping data to monitor changes over time as well as to check on current conditions.¹⁵

In Sudan, the Hydraulics Research Center (HRC), with funding from CTA, used eLEAF's technology to monitor the Gezira Irrigation Scheme, which is one of the world's largest

15 Information taken from eLEAF's Company Profile on its website (<http://www.eleaf.com/>) and confirmed by eLeaf staff.

IMAGE 15.2. Examples of Low- and High-Resolution PiMapping Data



Source: eLEAF.

Note: Images are used with permission; further permission required for reuse. On the left: Evapotranspiration in mm/year for the entire Nile Basin at a resolution of 250m; on the right: 30m resolution biomass production makes growth variations within individual grain fields visible in South Africa.

irrigation schemes. Specialists from HRC used the data to send registered farmers SMS notifications to let them know the best time to irrigate their fields and to apply fertilizer. The service was piloted with 44 farmers during the 2014/15 planting season. All of the farmers increased their productivity as a result of participating in the pilot. One farmer, for instance, saw wheat production increase to 12 sacks per acre, up from 3 sacks per acre in the previous year (CTA 2015).

Helpful resources

- Remote Sensing Technology Trends and Agriculture, <https://dg-cms-uploads-production.s3.amazonaws.com/uploads/document/file/31/DG-RemoteSensing-WP.pdf>.
- International Society of Precision Agriculture, <https://www.ispag.org/>.

Topic Note 15.2: CROWDSOURCING AND CROWDMAPPING: THE POWER OF VOLUNTEERS

TRENDS AND ISSUES

This topic note explores how volunteers are contributing agricultural data to larger and broader data sets, as well as helping to ground truth the accuracy of maps and underlying data sets. It explores the implications of this practice for individual producers as well as for implementers, researchers, and policy makers. In particular, it provides a perspective on how organizations are capitalizing on ICT-enabled approaches to collect data from a wider population than would have been feasible using traditional data collection methods, such as surveys conducted by enumerators. The note also examines how organizations are using those same ICT applications to share insights gleaned from analysis of the raw data with the respondents who provided that data.

The term “crowdsourcing” was coined in *Wired* magazine in 2006 but its origins may date as far back as the early 18th century, when the British government put out an open call to find a reliable method to calculate the longitude of a ship (Dawson and Bynghall 2012). Crowdsourcing in the modern sense of the word tends to refer to information that is collected or tasks that are performed by a large group of people, often in different locations, via some form of digital device (such as a computer or mobile phone). Crowdsourced data are collected primarily via SMS, websites, mobile apps, social media, email, and voice calls. In the context of development, crowdsourcing’s rise to global prominence can perhaps be dated to early 2008, when a group of technologists and activists developed a platform, dubbed Ushahidi, to track outbreaks of violence in postelection Kenya. Ushahidi was not the first use of crowdsourcing in development, but the international attention it garnered helped many more people to realize the potential of this approach.

From a data collection perspective, crowdsourcing can be combined with georeferenced data (often referred to as crowdmapping), which often come from GPS coordinates collected via a mobile phone—although, in some cases, the location is reported by the respondent. Through this pairing, an individual with access to the data can see exactly where in the world these data came from. Another advantage is that because these data can be processed in real time by data collection platforms, the parties collecting the data can access them almost immediately. The only delay occurs when data are input into a mobile data collection tool in offline mode, when the phone is out of network range. In those instances, the data will not be synchronized to the main database until the phone is connected to the Internet again.

Crowdsourcing can also be used in combination with geospatial images, calling on the power of the crowd to help identify changes to a specific location. For example, DigitalGlobe released images before and after Typhoon Haiyan struck the Philippines in 2013. The images covered 100,000 kilometers. More than 4,600 individuals tagged over 400,000 items, including 143,155 damaged buildings and residences.¹⁶ This example is not specifically related to agriculture, but it clearly demonstrates the power of crowdsourcing and crowdmapping.

It is easy to see why this approach would appeal to anyone who needs data from a wide geographic range. Unlike traditional data collection methods that require enumerators,

¹⁶ To learn more, see <https://www.digitalglobe.com/sites/default/files/Crowdsourcing-DS-CROWD.pdf>.

often using paper forms, to be on the ground, crowdsourcing enables the collection of data from a significantly larger number of individuals, across a broader geographic area, in much less time and for less money. Crowdsourcing services can also be designed to be bidirectional, giving individuals, even if they have not contributed data, near-instantaneous access to the aggregate data and analysis. This immediacy is a positive shift from traditional methods of data collection, whereby it took months for data collected from communities to make it back to those communities, if at all.

Crowdsourcing is predicated on the fact that the target population has some form of digital connection—most likely via a mobile phone. As discussed in the overview, the reality is that only slightly more than two-thirds of the world's adult population owns a mobile phone.¹⁷ Nor does simply owning a phone mean that an individual will use it to provide information to a crowdsourcing initiative. Differences in literacy, numeracy, and digital literacy all affect the ability to use a mobile phone effectively. Users also need access to sufficient electricity¹⁸ to keep a phone charged and sufficient income to purchase airtime to keep the phone number active.

Given these variables, the feasibility of crowdsourcing will depend on the local context. It is also important to be mindful of those without access to ensure that their opinions or inputs are included—or that if they are excluded, those limitations of the data are clearly stated.

Assuming that the local context is conducive to crowdsourcing, the approach can be used in agriculture in a number of ways. Some of the most likely uses are as follows:

- **Tracking pest and disease outbreaks.** Delays in traditional pest and disease reporting often prevent the authorities from taking decisive action to contain outbreaks. By crowdsourcing information on the incidence of pests and diseases, governments and researchers may identify outbreaks before they

spread and take action accordingly. In 2012, Zambia's Disaster Management and Mitigation Unit created a crowdmap to track armyworm sightings, which could be submitted by SMS or voice calls using a short code. Given this information, the government was able to target resources and contain the outbreak (Silversmith and Tulchin 2013).¹⁹ A similar approach was used in Uganda to monitor banana bacterial wilt using Ureport, an SMS-based polling service (Bujoreanu 2013).

- **Collecting local weather information.** For weather forecasts to be useful to producers, they need to be hyperlocalized to their farms. Traditional weather forecasts, based on a blend of satellite data and ground-based weather stations, generally cannot provide that level of specificity. The next generation of weather forecasts is taking advantage of sensors built into smartphones to collect extremely localized weather information. Apps such as PressureNet, Sunshine, and WeatherSignal all provide such services, although primarily for urban users. Eventually, these types of services will be practical for most smallholders.
- **Collecting market prices.** Market information services (MIS) have long relied on enumerators reporting daily prices for select markets. Services like AGROAM are experimenting with the possibility of indirectly crowdsourcing market prices by offering a buyer-seller matching service. By taking an average of what prices are paid for specific crops in specific areas, they are able to provide a snapshot of actual market prices. This method is highly dependent on volume, since low volumes of transactions for certain crops or in certain areas could skew the actual market price average. Esoko is doing something similar with its MarketPlace app, taking price data from purchases made through the system to show price trends over time.
- **Facilitating access to markets.** Among a number of other mobile services, the Connected Farmer Alliance, highlighted in the innovative practice summary below, is using mobile phones to enable smallholder farmers to market their produce to prospective buyers in Kenya, Tanzania, and Mozambique.
- **Agriculture knowledge sharing.** Agricultural knowledge has actually been crowdsourced for decades,

17 This figure was roughly calculated at 69 percent as of June 1, 2015, based on total unique mobile subscribers from GSMA Intelligence divided by the total global population over the age of 15, which was calculated from the Population Reference Bureau's 2012 data and U.S. Census Bureau data. As young people under the age of 15 do own mobile phones, this estimate is likely to be higher than the real number of adults with mobile phones.

18 Some estimates state that by 2030, almost 900 million people globally will still lack access to electricity (Practical Action 2012).

19 The crowdmap from that outbreak can be found at https://armyworms.crowdmap.com/main?!=en_US.

in the form of radio call-in programs on which farmers direct their questions to experts. With mobile phones and social media, new channels are available for individual producers to pose questions and receive responses from experts as well as their peers. One example is the Awaaz.De interactive voice response platform, which has been used by organizations in India to provide agricultural information to farmers. The service allows callers to record questions for experts to respond to, listen to questions and answers from others, and also to record their own responses to questions.

- **Facilitating land administration.** Indigenous communities in some parts of the world have fallen victim to land grabs by outsiders because they have not been able to demarcate their traditional rights to land on a map. The Rainforest Foundation UK has been helping communities in the Congo River Basin use GPS-enabled mobile phones to map the land that they use for hunting and gathering. Module 14 contains more information on crowdsourcing for land administration.
- **Crop and livestock monitoring.** One method for crowdsourcing crop and livestock data is to ask producers to submit information about the crops that they are growing and their livestock numbers. Results of such efforts have been uneven. For instance, the Mauritius Breadfruit Sector Consortium tried to map all of the island's breadfruit trees with less than impressive results—fewer than 70 out of an estimated 3,000 trees were mapped (Hosenally 2012). A more globally focused example, highlighted in the innovative practice summary below, is Cropland Capture, a game developed by Geo-Wiki that shows players a satellite image and asks them whether they see any cropland (Gustafson 2013).
- **Conducting research.** As noted, the proliferation of mobile phones offer researchers opportunities to survey farmers without sending enumerators to meet them in person. Short polls can be conducted via SMS, while voice, mobile apps, and websites can be used for longer polls, particularly those requiring qualitative responses. GeoPoll's Food Security Service is one example of a service that crowdsources data for research. The service has a database of 200 million users in roughly a dozen countries and currently offers surveys to capture data on two indicators: Food Consumption Score (FCS) and Reduced Coping Strategies Index (rCSI).

- **Monitoring food security.** The UN Global Pulse has used numbers of tweets to track inflation in the rice price (Crimson Hexagon 2011). Although this type of social media sentiment analysis may not always be effective for determining whether changes in food security are occurring, it is an area worth further exploration.

How the success of a crowdsourcing initiative is measured will vary depending on how and why crowdsourcing is being used. At the output level, the number of people engaged in the crowdsourcing effort and the total number of contributions made can be tracked. At the outcome level, two key indicators can help to measure the success of a crowdsourcing initiative. The first is the impact of crowdsourced contributions on the overall outcome being tracked. For instance, if the overall project aims to increase farmers' knowledge of a particular topic, what, if any, changes to that indicator can be attributed to farmers' access to crowdsourced resources? Another method of measuring outcomes is to compare the cost versus benefit of crowdsourcing and traditional methods. When using crowdsourcing to conduct research, ask how the cost of crowdsourcing and the benefit derived from it compare to the costs and benefits of traditional methods of conducting research.

LESSONS LEARNED

It is easy to get excited about crowdsourcing. This approach potentially facilitates engagement with a large and dispersed audience, often at a fraction of the cost of traditional methods of engagement, and can deliver information in near-real time.

As great as all of this sounds, experience from the field reveals some challenges in using crowdsourcing effectively. Thankfully, good practices are emerging from the experiences of practitioners, including lessons on specific challenges and specific actions that can be taken to mitigate them.

Data Quality

Since crowdsourcing tends to entail the collection of information from people who are not experts on the subject, the likelihood of error is perhaps higher than what one might expect from data that are input by trained enumerators. Sometimes participants can be intentionally misleading; for example, AGROAM, which shares market price information, encountered individuals who

were deliberately trying to game the system for their own benefit (Conor 2014).

One approach to reducing data input errors is to design and test the platform rigorously with the target audience to ensure that the platform is intuitive and easy for them to use. Methods such as user-centered design can be helpful for doing this. IDEO.org's *Field Guide to Human-Centered Design* is a great resource for learning how to employ this approach.

It is a bit more complicated to protect against people who are gaming the system or simply sharing incorrect information that they believe to be true. This issue is truly a challenge only when the number of contributors is small. With a large enough pool of contributors, such outliers can be identified and discarded—assuming that there are no large group biases. For that reason, the best protection against gaming is to have a large pool of contributors who can validate and crosscheck each other. Some technology providers have also developed algorithms to determine the reliability of contributors in order to weight inputs, such as DigitalGlobe's CrowdRank.

During the design phase, it is advisable to think about all of the reasons why someone would submit false or incorrect data so that checks can be devised for them. Devising a clear data verification process will also help to mitigate data quality issues.

Accessibility

Because not everyone has access to mobile phones or the Internet, a subset of the population will probably be excluded from any crowdsourcing initiative. The issue of limited accessibility is not one that any single project will be able to fix. At a minimum, however, it should be possible to learn about and understand the access of the target audience. Remember to ask such questions as: What groups of people have less access than others? How dependable is people's access (to electricity, network coverage, airtime)? How can access be extended to those without it (e.g., can the project promote device sharing)?

User Capacity

Participants need to know how to use the crowdsourcing platform or service properly to input data. In the Mauritius breadfruit mapping initiative mentioned earlier, one of the main reasons for people's failure to contribute was their limited ICT skills. Limited skills also reduced data quality, as

users placed some trees in the sea or in the middle of the street (Hosenally 2012).

Understanding users in advance will help to mitigate this challenge to some extent. Designing a platform or service aligned to users' current capacity, as opposed to one that depends on massive amounts of user training, is always preferable. It will rarely be possible or cost-effective to train large amounts of people to use the platform. It also helps to design checks into the platform to catch errors and notify users of the correct way to do something.

User Interest/Incentive

Crowdsourcing initiatives can succeed only if they attract a sufficient number of people to participate. Limited participation will likely yield data of limited value for analysis. If users see no value in contributing, they are less likely to do so. In some cases, users may have an inherent interest to contribute. In other cases, some level of incentivization may be necessary. The incentive can be something as basic as offering points and badges in some cases, although it may also extend to small financial rewards, particularly if contributors need to use their own airtime to participate. Younger, more tech-savvy producers may also be more likely to participate than older producers.

Again, start by developing an understanding of the target users. What are their interests? What are their needs? What might incentivize them to participate? The *Field Guide to Human-Centered Design* has good activities for learning about users, both in the mainstream and at the extremes, to design incentive systems and marketing campaigns appropriately.

Protecting Privacy

Since individuals will be asked to share information, it is important to consider how their privacy will be protected. Privacy becomes an even more important issue when crowdsourced data are georeferenced and can reveal where people live. When using a third-party provider, be clear on how they use the data as well.

The U.S. Federal Trade Commission report, "Protecting Consumer Privacy in an Era of Rapid Change: Recommendations for Businesses and Policy Makers," is a useful resource for starting to consider these challenges. Questions to ask, particularly when working with third-party providers, include: How will the provider secure disaggregated data? Will the provider sell data to other parties? If so, how will the provider

notify users that their data are being sold, and will users be compensated in some way?

Unintended Consequences

One of the benefits of crowdsourcing is its potential to democratize data and increase transparency, yet it is also possible that the data can be used for nefarious purposes. For example, an unscrupulous government or company armed with detailed information about a marginalized community might be able to use that information to take advantage of them. It is not farfetched to imagine a scenario in which smallholder farmers who have reported higher-than-normal productivity via a georeferenced crowdsourcing campaign find themselves in the sights of land grabbers (McLaren 2015).

It is difficult to think about what types of unintended consequences might arise. That said, it is important to try to identify potential risks, such as the misuse of any data that are made available, and to develop mitigation strategies based on the likelihood of those risks occurring.

Helpful resources

- Ushahidi Toolkits include a wealth of advice and guidance, including 10 questions to ask before starting a crowdsourcing initiative see <https://wiki.ushahidi.com/display/WIKI/Ushahidi+Toolkits>
- Crowdsourcing Applications for Agricultural Development in Africa, http://pdf.usaid.gov/pdf_docs/PA00J7P7.pdf
- ICT Update: Crowdsourcing and engagement, [http://wayback.archive-it.org/3908/20150511072324/http://ictupdate.cta.int/\(issue\)/69](http://wayback.archive-it.org/3908/20150511072324/http://ictupdate.cta.int/(issue)/69)

INNOVATIVE PRACTICE SUMMARY

Crowdsourcing Supplier Data via Mobile Phone

The Connected Farmer Alliance is a public-private partnership between Vodafone, the U.S. Agency for International Development (USAID), and TechnoServe focused on promoting commercially sustainable mobile agriculture services for smallholder farmers in Kenya, Tanzania, and Mozambique.²⁰ The Alliance pilots initiatives aiming to

create a better ecosystem for mobile services in the agricultural sector, affecting production throughout the supply chain.

Data Generation

One of the main focus areas of the Connected Farmer Alliance involves enterprise solutions that enable enterprises to better source from small farmers and allow farmers better access to markets. The data are gathered and distributed through a suite of modules, including a registration module allowing an agent of an enterprise to register a farmer who supplies a particular type of produce. Farmers may also register themselves as suppliers. In this way, the service enables the remote gathering of crowdsourced data to identify who and where farmers are and what types of crops they produce. The data are highly structured. They are referenced temporally and spatially and clearly identify individuals so that participating enterprises can distinguish specific farmers and their products. The typical participating enterprise is a mid-sized national company that sources produce from small farmers and seeks more detailed data and interaction with available suppliers.

Building upon the crowdsourced supplier data are a series of additional modules, including two-way communication that enables enterprises to share information with, or survey, farmers. A receipting module, integrated with M-PESA (a mobile money service), allows enterprises to send receipts and pay farmers at the point of sale, identifying the time, price, and volume of the purchase, which increases transparency. Another module allows enterprises to offer short-term loans through M-PESA, enabling cash advances that are later deducted from payments for produce. The enterprise can use the data generated through the registration and receipting modules to assess farmers' creditworthiness, something that was not previously possible for the majority of agribusinesses. A tracking module enables enterprises to better track collection processes and points to streamlined product collection. At this time, the size of the crowdsourced data set does not yet approach big data, but Vodafone is bringing this first suite of modules to commercial markets for much broader deployment.

Data Interpretation

Vodafone works with its subsidiary, Mezzanine, on the development and management of the data collection platform, which is locally hosted in the Kenyan, Tanzanian, and

²⁰ This innovative practice summary originally appeared in the World Bank's report *Big Data in Action for Development*. The original case study can be found on pages 39–41 of that report, which is available at http://live.worldbank.org/sites/default/files/Big%20Data%20for%20Development%20Report_final%20version.pdf. It was slightly updated for this module based on inputs from Drew Johnson, interim regional program director of the Connected Farmer Alliance, which were provided in February 2016.

Mozambican markets and protected by high-level security mechanisms. Data are available only to the enterprise and participating farmers. For the surveys, enterprises receive only aggregated responses, not individual records. Vodafone is working with enterprise customers on the most convenient way for farmers to submit data while ensuring confidentiality for them and for businesses. The details of data privacy will be governed by Vodafone's data privacy policies to ensure ongoing protection.

Within the Connected Farmer Alliance partnership, TechnoServe is charged with analysis and interpretation of how the modules are performing for the enterprises and farmers. Insights are currently being gathered through traditional survey methods. Those methods include assessing goals for the participants at the outset of the project, determining areas of measurement, and collecting input through questionnaires during the process. Additionally, the Connected Farmer Alliance supports enterprise partners in their own data analyses of information and outcomes.

Insights for Action

Although enterprises are just starting to adopt the technology, some insights are emerging into the benefits of the modules. Farmers who receive M-PESA for loans and payments reduced their costs by avoiding expensive, time-consuming, and risky trips to the enterprise office to collect cash. The receipting module has reduced the costs of enterprises by increasing their operational efficiency and transparency. A key benefit of mobile solutions for farmers is the increased access to information. It is difficult to make generic content services meaningful to small farmers whose local realities may vary significantly within a distance of just a few kilometers. The targeted information flow permitted by the two-way information module appears to provide information that is particularly relevant to the stakeholder farmers and to enhance the face-to-face interactions among farmers and enterprises.

INNOVATIVE PRACTICE SUMMARY

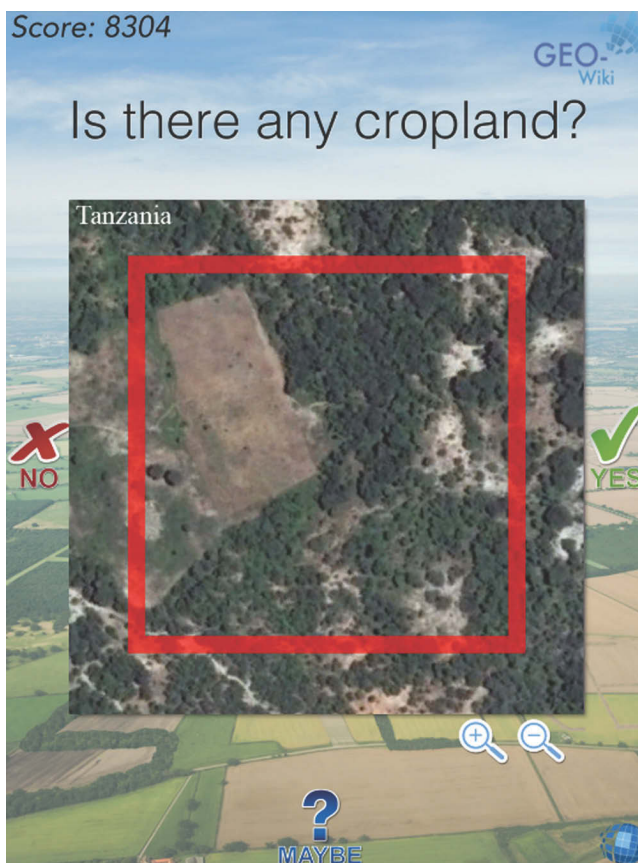
Combining Gaming and Crowdsourcing to Identify and Monitor Cropland

The Geo-Wiki project was established by the International Institute for Applied Systems Analysis (IIASA), the University of Applied Sciences Wiener Neustadt, and the University of Freiburg (Germany) in 2009 to try to address

one of the main challenges with current global land cover data sets—the large discrepancies between them. The project asks a network of volunteers to help identify, among other things, human impact in satellite imagery of land cover (see image 15.3).

A good understanding of the location of the world's cropland is important for a number of reasons, including identifying where the best investments could be made to increase production (Gustafson 2013). The good news is that experts are not needed to identify cropland accurately, as research by IIASA has revealed. A comparison of 53,000 data points input by experts and nonexperts found that the nonexperts were just as good as experts at identifying human impact (specifically, cropland) in satellite images (See 2013). A comparison of the accuracy of crowdsourced cropland maps to three major cropland maps (GLC [Global Land Cover]-2000; Moderate Resolution Imaging Spectroradiometer, MODIS; and GlobCover) in Ethiopia found the crowdsourced data to be the most accurate (See et al. 2013).

IMAGE 15.3. Screenshot of Cropland Capture



Source: Geo-Wiki Project.

Note: Used with permission. New request for permission is required if image is reused.

With this information in hand, Geo-Wiki launched a mobile and Web-based game called Cropland Capture that transforms anyone in the world into a citizen scientist. The concept is quite simple. Players of the game are shown an image and asked if it shows cropland at a certain site (answering “yes,” “no,” or “maybe”) (figure 16.4). Images contested by players are sent to an expert to make the determination. The resulting crowdsourced data have been used to create a new global cropland map that Geo-Wiki hopes will be more accurate than other available sources.

The game was launched in 2013, followed by 25 weeks of competition rewarding the top three players of the week with prizes to incentivize participation. Although the game is still available for download, the lessons learned from the game have been used to develop a more generic version of Cropland Capture called Picture Pile, which is being used to gather information on evidence of deforestation.²¹

²¹ More information on Cropland Capture is available at <http://www.geo-wiki.org/oldgames/croplandcapture/>. Picture Pile can be found at <http://geo-wiki.org/games/picturepile>.

Topic Note 15.3: BIG DATA FOR ANALYTICS

TRENDS AND ISSUES

It is perhaps only mildly hyperbolic to state that big data will have a dramatic impact on the 21st century economy. In 2014, the big data market generated more than US\$27 billion in revenue from the sale of hardware, software, and professional services. Within the next 10 years, it may generate more than US\$80 billion in global revenues (Kelly 2015). Even that figure pales in comparison to the potential revenue that might be generated and costs saved from the application of big data. The McKinsey Global Institute, for instance, estimated in 2011 that big data could have a value of more than US\$1 trillion annually from just three sectors: the U.S. health care system, European public sector administration, and personal location data (McKinsey Global Institute 2011).

Within the next five years, big data will become the norm, enabling a new horizon of personalization for both products and services. Wise leaders will soon embrace the game-changing opportunities that big data affords for their societies and organizations, and will provide the necessary sponsorship to realize this potential. Skeptics and laggards, meanwhile, look set to pay a heavy price.

—“Big Data Maturity: An Action Plan for Policy Makers and Executives.” Chapter 1.3 in *The Global Information Technology Report 2014* (World Economic Forum and INSEAD).

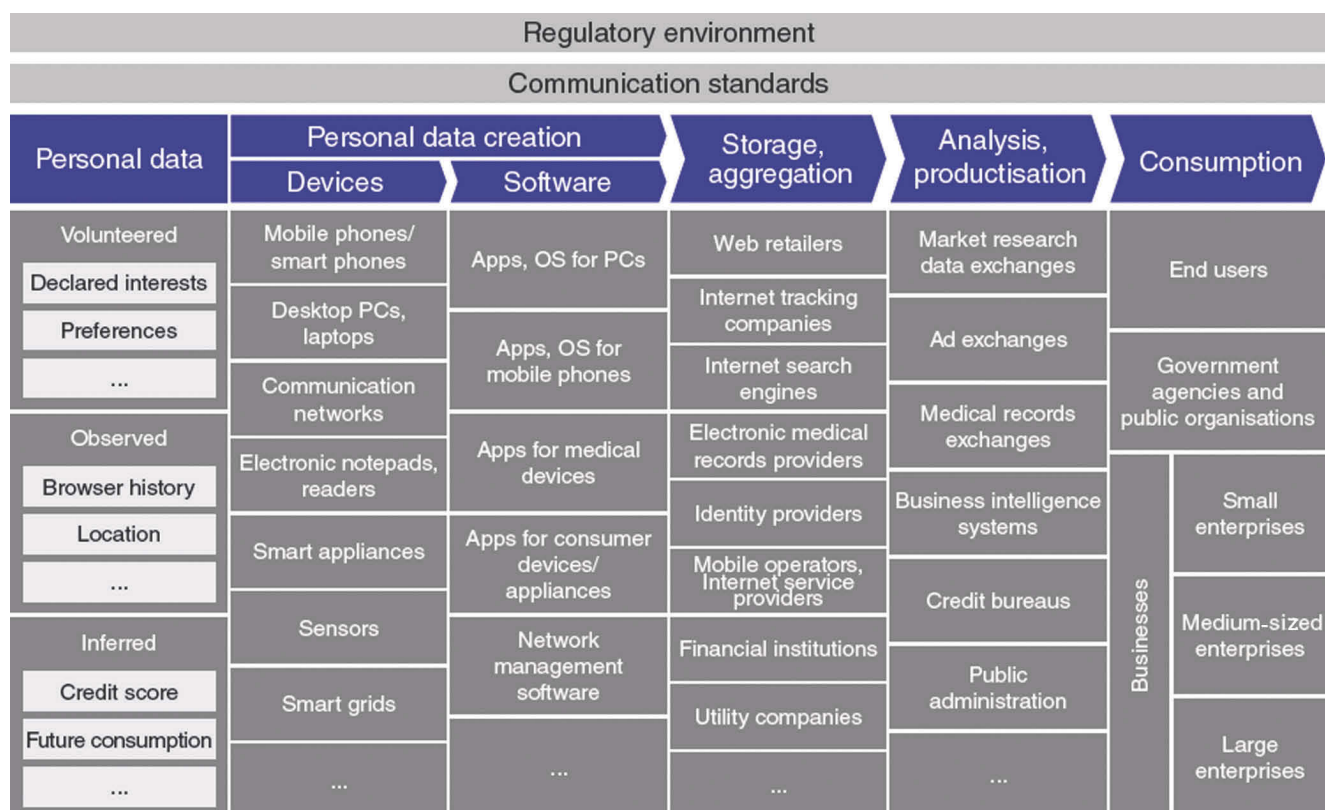
This topic note examines how agriculture could make use of big data and discusses what has been learned so far. Topic Notes 16.1 and 16.2 focus on sources of data—remote sensors and crowdsourcing—whereas this topic note focuses on how all of these data can be more effectively analyzed and acted upon.

As mentioned in the overview, no widely accepted standard definition of big data exists, although many people talk about big data as having the following characteristics, referred to as the “3 Vs,” defined in 2001 by analyst Doug Laney (Laney 2001):

- **Volume** refers to the sheer volume of digital data being produced globally.
- **Velocity** refers to the speed at which data can be captured and analyzed.
- **Variety** refers to all of the different types and formats of data being produced.

Since then, some people have opted for additional Vs. For instance, SAP Business Innovations has added **veracity**, which refers to the quality of the data, and **value**, which refers to the potential business value derived from it (Saporito 2014).

Figure 15.2 shows the full life cycle of data from creation to consumption. Numerous types of digital devices and software amass data from a variety of places, including individuals, the public sector, and the private sector. Data can be volunteered (explicitly shared), observed (captured by recording actions, such as Web browsing history or call detail records, CDRs), or inferred (based on an analysis of volunteered and/or observed data) (World Economic Forum 2011). The data are stored and aggregated by a range of entities, including websites, mobile network operators, and development organizations. The next step is analysis, which is sometimes done by the same entities that store and aggregate the data and sometimes by third parties. A growing number of companies offer what is known as BDaaS (Big Data as a Service). These providers offer access to analytics tools and services for a fee, as opposed to firms that sell insights based on analysis they conduct.

FIGURE 15.2. Life Cycle of Digital Data

Source: Bain & Company.²²

Note: Used with permission. New request for permission is required if image is reused.

The last step in the chain is the consumption of the insights and intelligence gleaned from big data analytics; the consumers can include governments, businesses, researchers, and sometimes even individuals.

Broadly speaking, big data can be used to support six areas with potential applications in agriculture:

- **Awareness**—learning that something is happening by using sentiment analysis to identify potential trends in people's opinions or concerns. For example, as mentioned, the UN Global Pulse roughly tracked the inflation of the price of rice in Indonesia by analyzing tweets on Twitter.
- **Understanding**—learning why something is happening, such as why food prices have risen or why water shortages have arisen.
- **Advice**—providing targeted and specific advice, based on big data, to individual farmers based on their circumstances, or to decision makers based on a wider geographic area to enable them to make more data-driven decisions.
- **Early warning**—analyzing data in order to, for example, identify disease or pest outbreaks before they spread.
- **Forecasting**—using big data tools to predict future trends, such as prices for specific crops in specific areas.
- **Financial services**—using big data to overcome barriers to providing credit and insurance to people who lack access to such financial services (for instance, small-scale producers with no credit history and limited collateral). Big data could potentially transform credit and insurance models by drawing in many more data sources about producers, their farm or other enterprise, the climate, and other factors. For example, GroVentures has aggregated and analyzed dispersed data sets from several dozen countries, enabling businesses to evaluate risk more effectively, resulting in more affordable crop insurance (World Bank 2015).

²² This figure originally appeared in the report "Personal Data: The Emergence of a New Asset Class," which was prepared by the World Economic Forum and Bain & Company in January 2011.

Some of these applications of big data will benefit producers directly, while others have the potential to help researchers and policy makers form recommendations and policies that will shape the future of farming in the face of climate change, increasing population, yield lags, demographic shifts, and depleting natural resources, among other challenges. Box 15.8 describes studies of prospective applications for big data in Senegalese agriculture.

Making sense of the data for these purposes requires specific analytical tools and methods. The five most common types of big data analytics are²³:

- **Descriptive** analytics, the most common and widely used form of analytics, tells what has happened in the past and what is happening now. An example in agriculture is Esoko's MarketPlace service, which provides historical price trends of crops.
- **Diagnostic** analytics help explain why something has happened. This form of analytics includes the analysis of correlations and relationships in data to better understand causation. For example,

BOX 15.8. Big Data for Agriculture in Action

In 2014, Sonatel and Orange Group made anonymized call detail records of mobile subscribers in Senegal available to researchers as part of a Data for Development Challenge. Agriculture, one of the five priority areas, was the subject of four research papers analyzing whether mobile network data could be used for:

- Developing mobility profiles and calendars for food security and livelihood analysis.
- Understanding the genesis of millet prices in Senegal (including the roles of production, markets, and their failures).
- Improving disaster resilience through a visual analysis of call data records.
- Unraveling correlations between agricultural events and phone traffic.

The papers are available in the *Data for Development Challenge Senegal Book of Abstracts: Scientific Papers*, available at http://www.d4d.orange.com/fr/content/download/43453/406503/version/1/file/D4DChallengeSenegal_Book_of_Abstracts_Scientific_Papers.pdf.

Source: Authors.

Grameen Foundation's Community Knowledge Worker program, in partnership with Palantir, developed a platform that enables them, among other things, to understand the link between the application of good agronomic practices (GAP) and farm productivity (World Bank 2015).

- **Predictive** analytics uses predictive modeling to anticipate what will happen next based on past and current data. Back in 2007 agricultural consultancy firm Lanworth, now part of Thomson Reuters, was able to predict the volume of the U.S. corn crop with relative accuracy, using a mix of data including satellite images, weather forecasts, soil maps, crop conditions, and rotation patterns. In contrast, the U.S. Department of Agriculture, which used old-fashioned farmer surveys, overestimated that year's crop (Paynter 2008).
- **Prescriptive** analytics takes the trends identified in predictive analytics and recommends potential courses of action and their likely outcomes. It uses simulations, localized rules, and decision logic to identify options. For example, in Colombia, the International Center for Tropical Agriculture (CIAT) and the Colombian Rice Growers Federation (FEDEARROZ) developed a computer model including an artificial neural network²⁴ that incorporated 10 years of agricultural data, seasonal forecasts, and climate data. They predicted that a drought would occur and advised farmers against planting crops, saving those who adhered to their advice US\$3.8 million (Clark 2014). The initiative received a UN Big Data Climate Challenge award and has plans to scale up over the next one to three years to include other crops and to expand into other countries in Latin America and Africa.
- **Cognitive** analytics uses a mix of artificial intelligence, machine learning algorithms, and in some case natural language processing to, in essence, mimic the cognitive capacity of humans. Although in many ways experimental and not yet widely available, cognitive analytics has the potential to completely change our ability to make sense of massive amounts of data in ways that our unaided minds are simply not capable of handling (Ronanki and Steier 2014).

The best way to measure the effectiveness of big data analytics in agriculture may be to determine how the insights revealed by the service have contributed to changes in efficiency and in

23 The five types of analytics cited here are based on IBM's classifications (see <http://www.ibm.com/analytics/us/en/analytics-technology/>).

24 An artificial neural network is a type of machine learning algorithm that mirrors the interconnectedness of neurons in the human brain. These networks, which are helpful for analyzing complex and often incomplete data, are used for such things as detecting potential credit card fraud or the presence of explosives in airports (Kay 2001).

the cost of the overall outcomes that the service was intended to deliver. The capacity for realizing any benefit from big data is predicated on two factors at the output level. The first is that the analytic tools being used actually generate insights based on the data available, so (at a very basic level) one output that can be tracked is the number of insights generated. The second, and more important, output is the number of insights generated that are deemed to be accurate or worth acting upon.

The next section of this note highlights lessons and issues surrounding big data, and the three innovative practice summaries that follow present more detailed examples of how big data analytics is coming into its own in agriculture. The first two summaries describe open access resources: HarvestChoice, with spatially explicit, harmonized data layers on numerous major indicators for Sub-Saharan Africa, and the Crop Composition Database (CCDB), with rigorously vetted data on the nutritional composition of specific crop species. The third summary describes aWhere, a service that collects global meteorological data and matches them with information from farmers; the resulting data can be analyzed not only to develop personalized agronomic recommendations for farmers but also to contribute significantly to development policy, especially with respect to climate change.

LESSONS LEARNED

The case for using big data for analytics is pretty clear. The world is increasingly interconnected, volatile, and complex. The sheer volume of data that the world produces makes it simply impossible for humans to make sense of it all and react in real time. An added consideration is the inherent cognitive biases in human brains, which can lead to illogical conclusions or associations (Kahneman 2011).

Given these trends and concerns, it is not hard to see why such excitement surrounds the potential for big data to play a major role in contributing to the agricultural productivity gains that are needed to meet the world's food needs by 2050. Of course, realizing this potential is not as easy as simply turning on a switch. To maximize the impact of big data on agriculture, policymakers and practitioners will need to consider and address a number of issues, outlined here. In broad terms, these issues can be clustered into three groups: issues related to data ownership, access, and quality; issues related to analysis and interpretation; and issues related to implementation capacity.

Data Ownership, Access, and Quality

Determining who owns the collected data and how those data sets are protected are issues worthy of serious consideration.

They have always been present to some degree in development—data collection is nothing new. With the advent of big data, what has changed is the role of third parties. Given the complexity of the computer systems needed for big data analytics, third parties increasingly store and analyze the data that organizations collect. Policymakers and practitioners need to think seriously about protections for these data, particularly data related to individuals, and implement them.

One example (mentioned earlier) of the risks involved in failing to protect data is the potential for individuals to be displaced from their land. In a context where land grabs are prevalent and rights to land are protected ineffectively, failure to prevent detailed information about the quality of farmers' soil and production capacity from falling into the wrong hands could put producers with high-quality land at greater risk. Anecdotal reports note that farmers in high-income countries have already expressed concern that they might be penalized if the government or environmental activists discover that they have applied fertilizer incorrectly (Gilpin 2014) or that traders might manipulate market prices based on access to information about what farmers are planting (Banham 2014). If producers perceive that their data are not secure or might be used against them, they may resist using tools that ultimately could help them.

Crowdsourced data are particularly affected by the potential of people to report incorrect information based on their perceptions rather than fact. It turns out, for example, that Google Flu Trends was not actually that good at predicting the occurrence of influenza; instead, it reflected the incidence of illnesses with flu-like symptoms (Fung 2014). If this tool had been applied to agriculture and used, for instance, to predict outbreaks of avian influenza, policy and commercial decisions based on such predictions could have mobilized resources to cope with an outbreak that did not exist.

Limitations in data sharing, compatibility, and availability also constitute barriers to fully realizing the potential of big data in agriculture. In a number of countries, for example, censuses and farm surveys are sporadic, incomplete, and often exclude smallholder farmers. The FAO's Global Strategy to Improve Agricultural and Rural Statistics is attempting to address this challenge through the introduction of an integrated survey system that countries can use to regularly collect and produce comprehensive agricultural data (Graziano da Silva 2016).

For the most part, structures and standards for sharing proprietary data are also lacking. Unlocking those data will require public-private partnerships; it will also require stakeholders to

understand how they will benefit, both individually and collectively, from doing so (World Economic Forum 2015).

A strong open data movement, which the World Bank and others are promoting, seeks to bring more of the world's data into the public domain, including agricultural data (see box 15.9 and the innovative practice summary below). A vast share of these data remain closed to the public, however. Of the 1,290 data sets of public records surveyed from 86 countries by the Open Data Barometer in 2014, only slightly more than 10 percent met the definition of open data by being “published in bulk, machine-readable formats, and under an open license” (World Wide Web Foundation 2015).

Even members of the development community, which should have many incentives to share data with each other, have responded unevenly to the call for open data. Part of the challenge in making data public is to develop internal processes for managing data and to compile data sets that may be sitting on hundreds of different hard drives around the organization. Another part of the challenge is to overcome resistance to change among individuals who are simply used to handling their data in one way, and have yet to adjust to new data management processes. Both of these issues speak to the need for organizations in the development community to put forward very clear guidance on open data set requirements and to implement clear data management processes that are effectively communicated to all employees.

Not surprisingly, gaining access to data in the private domain is even more complicated. Many private businesses are reluctant to share data with third parties without either selling the data to them and/or requiring legal agreements, such as non-disclosure agreements. CDRs are a good example. CDRs collected by mobile network operators indicate the approximate

location of all calls made on their network. The analysis of CDRs has been suggested as a way to track population movements during times of conflict or disease outbreaks, but the network operators' limited commercial interest in sharing such data is often overlooked. The analysis of CDRs also generally ignores principles of informed consent, since individual callers have not consented to having their data analyzed for those purposes (Letouzé and Vinck 2014).

Analysis and Interpretation

The challenges related to analysis and interpretation can be broadly classified into three types of limitations: data, human, and machine. Data limitations refer to shortcomings in data sets that prevent their meaningful analysis, such as an insufficient amount of data, erroneous data, or unreadable data.

Many of the human limitations relate to cognitive biases and poor interpretation of the data or of their implications.²⁵ Even in the case of cognitive analytics, which aims to reduce the potential effect of such limitations, ultimately it is still humans who will make decisions based on the outputs from the analytic tools. At least in the near future, human judgment will retain a significant role in benefiting from analytic insights, because most big data analytics will remain outside the realm of cognitive analytics.

The supply/demand gap between the number of professionals with the requisite skills to analyze and make decisions from big data, and the number of professionals needed across all industries with an interest in big data, has been reported by a number of sources over the past few years. Governments, academic institutions, and development organizations, in addition to the private sector, need to address this talent gap in the agricultural sector through capacity building and education. Skills must be developed at the farm level as well as among development practitioners and researchers, all of whom will benefit from better understanding how to make sense of data and act upon that knowledge.

Although, one day, artificial intelligence, driven by machine learning algorithms, may be virtually indistinguishable from human intelligence, machines—at least for the present—also have limitations. Even Watson, IBM's supercomputer—a system much more powerful by far than anything the reader is likely to access in the near future—made very basic mistakes in common sense during its triumphant run on the U.S. television show *Jeopardy!* several years back (Hamm 2011).

BOX 15.9. Suggestions for Unleashing the Power of Data for Agriculture

Participants in the 2015 International Open Data Conference (Canada) identified seven ways that data can be made more effective in agriculture: (1) open up data, (2) identify data users, (3) bring intermediaries into the game, (4) develop new tools for data collection, (5) look beyond technology, (6) foster cross-sector collaboration, and (7) address the need for disaggregated data. More detailed information can be found online here.^a

Source: Authors.

a. Halais 2015 (<https://www.devex.com/news/7-challenges-the-agriculture-sector-must-address-to-unleash-its-data-revolution-86310>).

25 The UN Global Pulse's Big Data for Development: Challenges & Opportunities has a thorough section on challenges in the analysis of big data, mostly related to human limitations.

Implementation Capacity

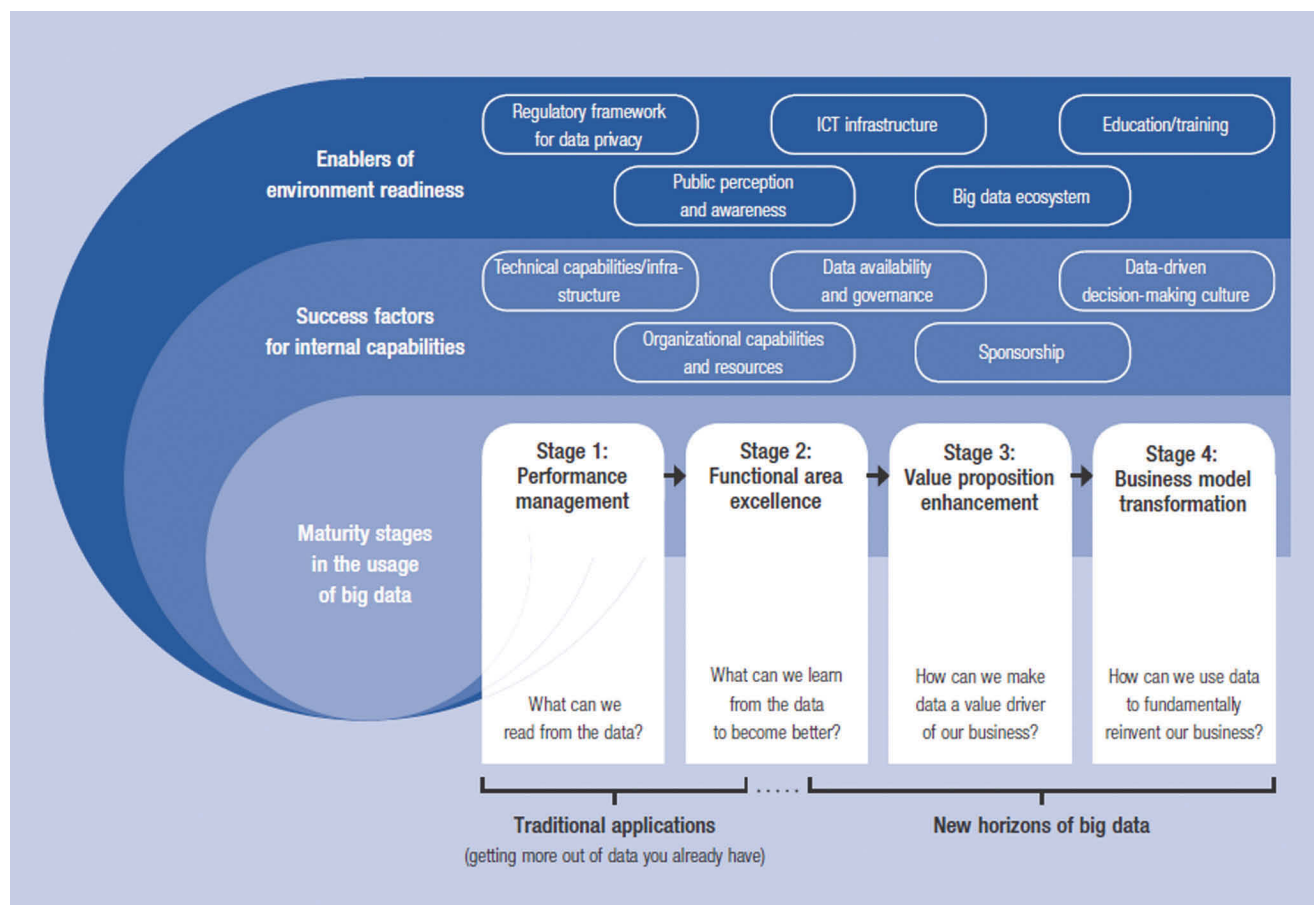
A 2013 worldwide survey by Gartner found that 64 percent of organizations had invested in or were planning to invest in big data systems (Gartner 2013). Over the next few years, this figure is likely to continue to grow rapidly, as an increasing number of medium-sized and large agribusinesses in high- to low-income countries will probably invest in some form of big data solution. A good portion of those firms will also probably fall victim to at least one of the eight implementation challenges identified by Svetlana Sicilar at Gartner (Sicilar 2014): (1) management inertia, (2) selecting wrong use cases, (3) asking wrong questions, (4) lacking the right skills, (5) unanticipated problems that are wider than just a big data technology, (6) disagreement on the enterprise strategy, (7) siloed big data, and (8) solution avoidance.

For governments seeking to implement big data systems to support agricultural development, the challenges are likely to be even greater, given the scale. In an examination of the sources of the initial failure of the U.S. healthcare.gov website, Clifford Winston of the Brookings Institution identified four primary contributors: (1) limited technical expertise and an overreliance on contractors; (2) little, if any, rigorous and transparent ongoing assessment because of a fear of exposing problems; (3) a status-quo bias and an inflexibility and inability to make important changes in managing a project; and (4) constraints that may affect budgeting and adoption of state-of-the-art technology (Winston 2013).

All such factors should be considered and taken into account in supporting and deploying any big data system. The relevance of each factor depends somewhat on how much the use of big data has advanced in a particular country or organization. Figure 15.3 provides a useful framework for understanding the different stages of big data use in an organization, as well as the internal capabilities and ecosystem enablers that need to be in place first.

26 This figure originally appeared in the chapter “Big Data Maturity: An Action Plan for Policymakers and Executives” within The Global Information Technology Report 2014.

FIGURE 15.3. Big Data Maturity Framework



Source: Strategy& (formerly Booz & Company), part of the PwC network of firms.²⁶

Note: Used with permission. New request for permission is required if image is reused.

Helpful resources

- Big Data in Action for Development, <http://live.worldbank.org/big-data-in-action-for-development>.
- Big Data, Big Impact: New Possibilities for International Development, <https://www.weforum.org/reports/big-data-big-impact-new-possibilities-international-development>.
- Big Data for Development: Challenges & Opportunities, <http://www.unglobalpulse.org/sites/default/files/BigDataforDevelopment-UNGlobalPulseJune2012.pdf>.

INNOVATIVE PRACTICE SUMMARY

Generating Open Access, Spatially Explicit Data Sets, and Analyses for More Productive Farming and Better Livelihoods in Africa

A growing community of scientists is taking advantage of publicly available global data sets remote sensing imagery, GIS, computer modeling, and georeferenced data pooled from the bottom up (or crowdsourced) to capture the heterogeneity of humans and agriculture and gain a better understanding of the complex spatial relationships between agriculture, the environment, climate change, and social well-being.²⁷ A problem in many settings, but especially in low-income countries and among low-income and vulnerable populations, is that critical data are difficult to obtain from administrative offices or to generate through experiments and observations on the ground. The growing availability of cross-harmonized data and geospatial tools is helping to alleviate some of those constraints.

HarvestChoice is hub to a large number (more than 750 and growing) of spatially explicit, harmonized data layers for Sub-Saharan Africa, including indicators of health and poverty variables, agricultural production and area, climate and soil, and access to markets (box 15.10). Web-based data analytics tools, such as HarvestChoice's Mappr, allow development practitioners and analysts to dip into HarvestChoice's core data holdings and visualize geographical impacts for investment and policy design at scale (HarvestChoice 2012). More advanced users can plug directly into HarvestChoice data through an open API²⁸ (HarvestChoice 2014b).

Data are harmonized across domains and country borders, allowing for complex spatial analyses and evidence-based investment strategies. For example, HarvestChoice's Spatial Production Allocation Model (SPAM) uses a cross-entropy approach on a variety of inputs, from subnational crop production statistics to market information, to generate plausible, disaggregated estimates of crop distribution for 42 crops and their performance around the globe (You et al. 2014). SPAM results are useful for understanding production and land-use patterns and for identifying geographical trends. They also provide a means for understanding the causalities of cropping outcomes within disaggregated units. SPAM data can be manipulated via Mappr or downloaded from www.mapspam.info.

Pooled data from georeferenced household surveys, such as Demographic and Health Surveys²⁹ (DHS) and the LSMS³⁰, are filling critical information gaps with respect to nutrition, health, gender-related variables, wealth (consumer durables, housing characteristics), education, and access to services (water, sanitation, health facilities, schools). When it comes to agricultural activities, income, and infrastructure, however, the survey data are weak (although improving). This is where the interoperability of harmonized data becomes important. By combining population data from household surveys with HarvestChoice spatial data on agriculture, biophysical characteristics, and market access, it is possible to produce a well-rounded set of variables and facilitate studies on nutrition and agriculture across or within countries.

HarvestChoice currently holds many spatial layers on nutrition and dietary outcomes based on crowdsourced surveys, allowing Mappr users to visualize the spatial distribution of diet quality and nutritional outcomes across subnational regions in Sub-Saharan Africa. Such data can support analyses of how diet and nutrition are related to market characteristics, the environment, and agricultural systems, and they can provide the context for understanding the scalability of research outcomes.

Economic and crop modelers are also increasingly taking advantage of granular data sets, especially those harmonized on high-resolution global grids in modeling analyses that explore future consequences of climate change (Nelson 2014; Rosegrant 2014). Crop models such as Decision Support System for Agrotechnology Transfer (DSSAT) make

27 This innovative practice summary was developed by Cindy Cox and Jawoo Koo at the International Food Policy Research Institute (IFPRI).

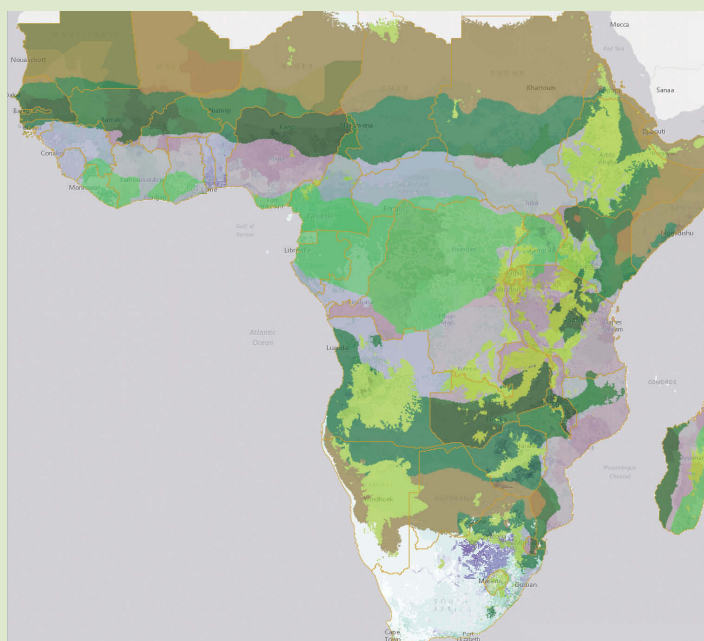
28 A publicly available application programming interface.

29 Available at <http://dhsprogram.com/data>.

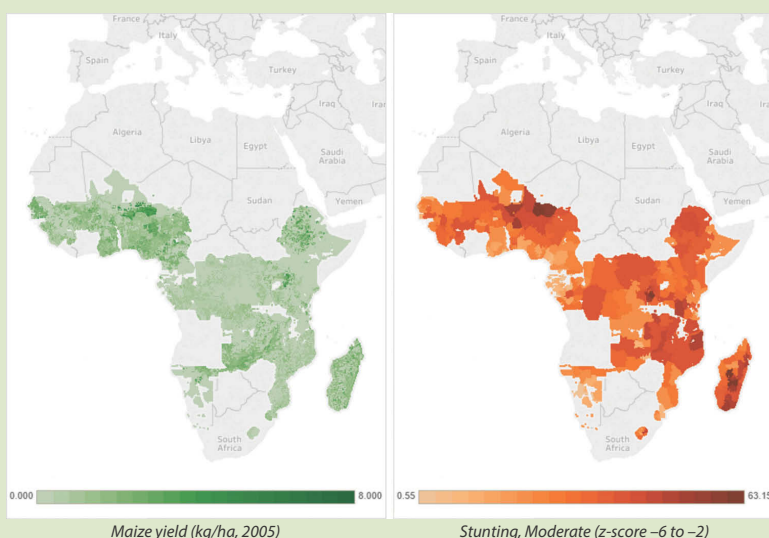
30 Available at <http://go.worldbank.org/BCLXW38HY0>.

BOX 15.10. Aggregating and Visualizing Data in Mappr

Mappr users can aggregate $\sim 10 \times 10$ kilometer pixels in meaningful ways, such as by farming system, watershed, or agro-ecological zone. HarvestChoice uses remote sensing, GIS, open source subnational data sets, crop and economic modeling (DSSAT and IMPACT), and georeferenced household surveys to generate over 750 layers of subnational socio-economic and biophysical data for Sub-Saharan Africa; see, for example, images B15.10.1 and B15.10.2.

IMAGE B15.10.1. HarvestChoice's Mappr

HarvestChoice's Mappr (<http://apps.harvestchoice.org/mappr>) allows users to easily explore +700 multi-disciplinary geospatial indicators across SSA without needing to use advanced GIS software or spatial analysis skills. Users can browse the data catalog, select multiple indicators of interest, visualize them on the map, and execute a set of spatial analysis. This screenshot shows an example of spatial domain analysis output generated from three user-selected indicators (rural poverty, maize harvest area, and growing period) presented on the map and a series of charts.

IMAGE B15.10.2. HarvestChoice's grid-based multi-disciplinary indicator database (CELL5M)

Learn more about CELL5M, which powers a suite of spatial targeting analyses and applications, at <http://dx.doi.org/10.12688/f1000research.9682.1>. This tool (available online at https://public.tableau.com/profile/ifpri.td.hc#!/vizhome/cell5m_a4nh_v2_ssa/CELL5M_A4NH) provides an easy-to-use, interactive indicator-level mapping and filtering interface to identify the areas meeting multiple search criteria of agriculture and nutrition baseline.

More than just pretty maps, georeferenced data can help development practitioners visualize where populations are most vulnerable, the farming systems they most depend on, the biological and geophysical constraints and risks that limit farm productivity, the investments and innovations that could raise farm productivity most sustainably, and the broader impacts of such change.

Source: Authors.

Note: Images used with permission. New request for permission is required if image is reused.

it possible to explore global changes in agricultural productivity (Jones et al. 2003). Results from crop models can be integrated with economic models (such as the IMPACT and DREAM models) to study alternative projections of global food supply, demand, trade, prices, and food security (HarvestChoice 1995; Rosegrant 2008). Agritech Toolbox, a geo-tool available from HarvestChoice, allows users to explore simulation results from those two types of models and visualize the impact of agricultural technologies around the globe (HarvestChoice 2014a). This analytical capacity is particularly important in regions of the world where the effects of global changes in the environment, including the effects of climate change, are most pressing and consequential.

INNOVATIVE PRACTICE SUMMARY **The ILSI Crop Composition Database**

The CCDB (<https://cropcomposition.org>), launched in 2003, is a curated, open resource that provides data on the natural variability in the nutritional composition of specific crop species (e.g., information on nutrients, anti-nutrients, and secondary metabolites) (Alba et al. 2010; Ridley et al. 2004).³¹ These data have multiple uses, although the CCDB was originally developed to provide information for risk assessors and regulators to undertake intraspecies comparative assessments of the nutritional content of conventional versus transgenic crops (CAC 2003). The non-profit International Life Sciences Institute (ILSI) Research Foundation maintains the CCDB, and criteria for accepting data are overseen by the CCDB Working Group, which comprises scientists from the public and private sectors. The most recent version of the CCDB was released in 2014 and includes more than 840,000 data points representing 3,150 compositional components.

Data in the CCDB are derived from numerous samples of hybrids and/or varieties cultivated in controlled field trials using standard commercial cultivation practices at various locations throughout the world. Representative plant samples are obtained from field-grown crops with known production locations and dates. The analytical methods used to generate the data must be indicated, validated, and use certified or historically verified standards. Data are uploaded in a standardized format by an authorized provider using a secure data provider tool. As the comma-delimited file is uploaded, it is checked for format and duplication at the file and sample level. The content of successfully uploaded data is then tested for validity and

consistency. Users can query the database to generate mean levels and ranges of nutritional components in various crop species. Environmental factors such as soil type and temperature can affect the levels of important nutrients in plants, and the moisture content can vary based on field conditions at harvest and when samples are handled. The database includes features that allow the user to retrieve a subset of data for samples produced in a specific year or location, and the analyst search filter can be applied to retrieve a predetermined subset of data.

The CCDB is accessible to scientists from academia, government agencies, and industry as well as to the general public, and it is a well-used resource. From July 2014 to July 2015, the CCDB logged 81,838 unique site visits from users in 122 countries around the world. It is referenced in peer-reviewed publications, regulatory guidance documents, and in many regulatory dossiers submitted in support of genetically engineered food safety assessments. This database complements existing food and nutrient databases, and it is an important but probably underused resource for food scientists, nutrition practitioners, and others interested in the interface between agriculture and nutrition.

One of the strengths of the CCDB—the completeness and quality of the data sets for each of the subject crops—is also potentially one of its limitations, however. The analytical rigor required for data submitted to the CCDB means that sample testing is expensive, so it is not surprising that most data has been provided (at no charge) by the private sector, and for a very limited range of crops (currently canola, field corn, sweet corn, cotton, rice, and soybeans). The ILSI Research Foundation and the CCDB Working Group are committed to including data for other crop species, particularly of important staple foods. For such data to become available, public sector breeding programs, as well as breeding programs run by small and medium-sized private firms, must be able to submit data, but it is also imperative to ensure that data for new crops are verifiable and robust. Resolving how to balance these imperatives remains a significant challenge.

INNOVATIVE PRACTICE SUMMARY **Using Big Data to Provide Localized Weather and Agronomic Information to Producers**

Throughout the world, a great number of producers use traditional knowledge of weather-related signs and conditions to make their agricultural choices. This knowledge—which has sustained countless generations of

31 This innovative practice summary was written by Morven McLean of the ILSI Research Foundation.

producers—has become a less reliable guide as more variable weather patterns have brought less predictability, higher risk, and a growing sense of uncertainty to farmers and to agriculture.³²

Uncertainty can affect behavior by making people even more averse to risk. Farmers who are more risk averse may be less likely to experiment with or adopt new approaches, including approaches that could increase agricultural and environmental sustainability in an era of climate change and less predictable weather. The connection between uncertainty and subsequent environmental degradation can create a vicious cycle in which the impact of increased weather variability on agriculture continues to grow. Services that tailor agricultural information to highly local settings can help farmers adjust to weather variability, increase the productivity and profitability of farming, and create an opportunity to improve sustainable food production.

By combining localized weather information with farmer-specific tips, aWhere is seeking to address these issues. Its predictive analytic platform collects over 1 billion data points daily on temperature, rainfall, humidity, solar radiation, and wind from satellites, weather aggregators, and drone operators, resulting in a global meteorological data set that covers all agricultural geographies. As a result, all weather data, from a 20-year history to 8-day forecasts, are consistently available globally. At the same time, the platform is quite localized, matching farmer-specific agricultural tips with growth stage models that are specific to each region.

While aWhere provides historical weather information, forecasts, and agronomic models, the platform relies on data inputs from partners for other types of information, such as cropping calendars and agronomic tips for each crop and variety. This information is generally acquired through local resources such as agricultural extension services, universities, and local knowledge. The combination of aWhere's agronomic models and a well-defined crop calendar effectively results in a personalized crop calendar for every farmer.

The relevance of the intelligence farmers receive from aWhere depends, in turn, on how much information they provide to the service. If the farmer provides the latitude

and longitude of his or her farm and the crops planted, the information can be more tailored to that farmer's circumstances. In practice, aWhere has found that farmers typically provide the name of a village, for which the coordinates can be identified. Given that many farmers do not have GPS-enabled phones or, if they do, may not know how to collect their coordinates, it may be necessary for someone else to collect that information on their behalf. Once their specific information is input into the platform, however, they can begin to receive crop-specific advice, localized weather forecasts, details on nearby input providers, and local market prices.

Key Lessons from aWhere

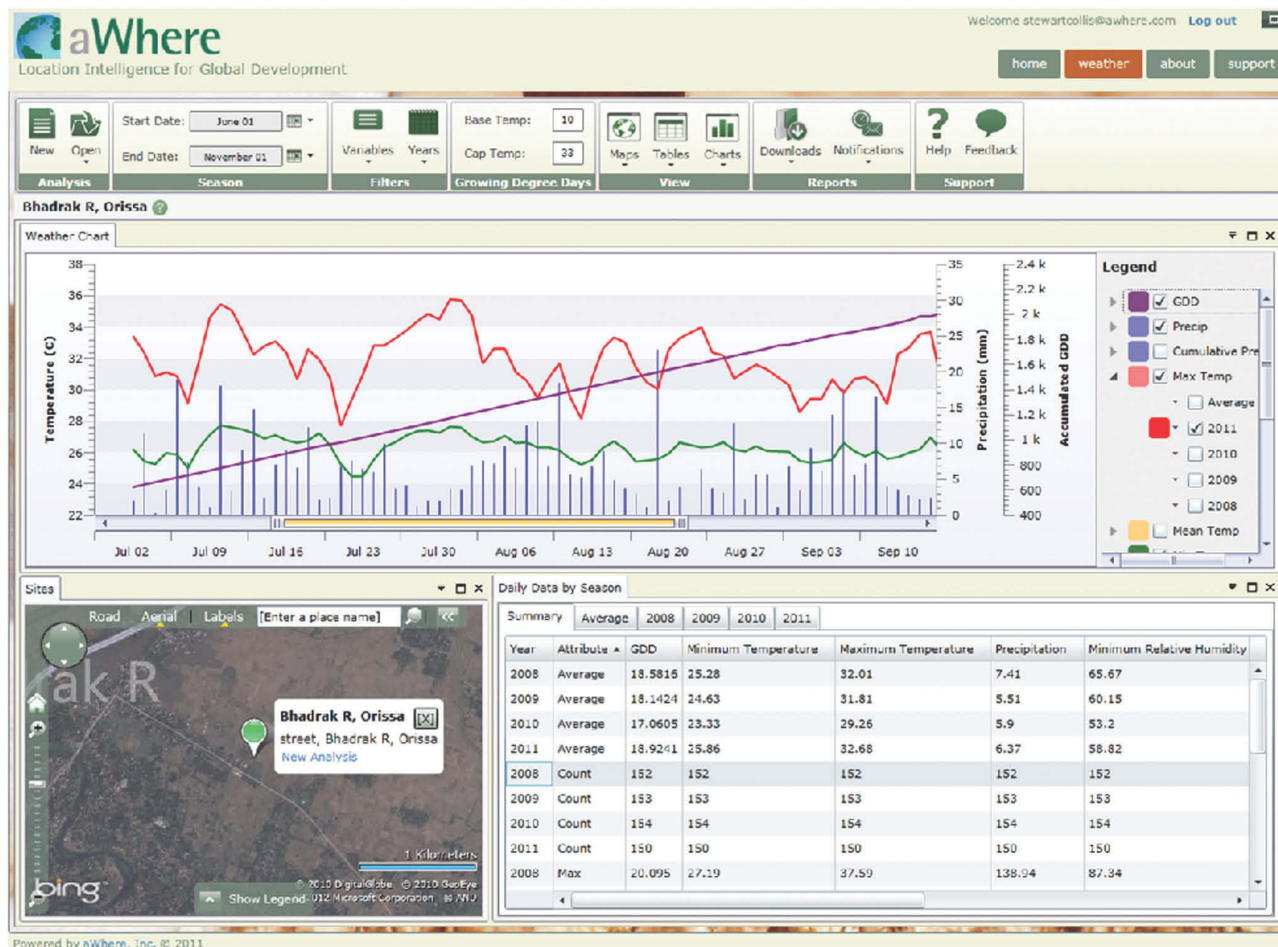
- Combining data from multiple sources provides a longitudinal view of climate effects and produces insights that can be extremely beneficial to farmers.
- Simply collecting the data and generating insights is not enough; the use of technology to make sure that the message reaches the right stakeholders at the right time is also important.

Most of aWhere clients are based in the United States, although the service is expanding into Africa, Asia, and the Caribbean, where it partners with agricultural information providers such as Esoko in Ghana, which makes aWhere's weather data and agronomic models available to its clients (Storum 2015).

Access to this combination of weather intelligence and agronomic recommendations is expected to help farmers make more informed decisions—for example, to delay planting because of a projected delay in the start of the seasonal rains. Policy makers, researchers, and development practitioners can also use aWhere's online platform for their own analysis and decision making (image 15.4). By importing their own data sets into the platform, they can identify correlations that might be helpful, such as correlations between rainfall levels and market prices or disease outbreaks.

An added capability is that researchers and commercial practitioners can combine weather data with historical information on crop yields to generate field-specific agronomic models, as well as management recommendations for weather-smart agriculture. These models and recommendations generate new agricultural intelligence that can enhance traditional agricultural practices and provide guidance to farmers for mitigating the risks of adverse weather events and climate variability. This new, real-time information

³² The majority of the text provided in this summary was adapted from content that came directly from Tarah Speck at aWhere. Some of the text is from the module's primary author, and was drawn from publicly available information about aWhere. To learn more about aWhere, visit <http://www.awhere.com/>.

IMAGE 15.4. Screenshot of aWhere's Online Dashboard

Source: aWhere.

Note: Used with permission. New request for permission is required if image is reused.

allows farmers and stakeholders across the world to make evidence-based agricultural decisions and optimize farming practices as the dynamics of agriculture change.

All of aWhere's weather and agronomic data can be delivered through RESTful APIs, allowing for their integration into customized apps or widgets. More details, including samples and JavaScript visualizations, can be found on their developer's portal (<http://developer.awhere.com/>).

REFERENCES

- Alba, R., A. Phillips, S. Mackie, N. Gillikin, C. Maxwell, P. Brune, W. Ridley, J. Fitzpatrick, M. Levine, and S. Harris. 2010. "Improvements to the International Life Sciences Institute Crop Composition Database." *Journal of Food Composition and Analysis* 23: 741–48.
- Banham, Russ. 2014. "Who Owns Farmers' Big Data?" *Forbes Brand Voice*. <http://www.forbes.com/sites/emc/2014/07/08/who-owns-farmers-big-data/>.
- Bilbao-Orsorio, Beñat. 2014. *The Global Information Technology Report 2014: Rewards and Risks of Big Data*. World Economic Forum, Cologne. http://www3.weforum.org/docs/WEF_GlobalInformationTechnology_Report_2014.pdf.
- BIS Research. 2014. *Global Precision Agriculture Market Analysis & Forecast (2015–2022) Technology (VRA, Soil Mapping, Yield Monitoring, Precision Irrigation, Others), Components and Systems*. http://www.researchandmarkets.com/research/fk898n/global_precision.
- Bujoreanu, Luda. 2013. "The Power of Mobile: Saving Uganda's Banana Crop." *Information and Communications for Development* (blog). <http://blogs.worldbank.org/ic4d/the-power-of-mobile-saving-ugandas-banana-crop>.
- Burns, Matt. 2015. "3D Robotics Taps Qualcomm for \$50M Series C and Mobile Tech." *TechCrunch*. <http://techcrunch.com/2015/02/26/3d-robotics-taps-qualcomm-for-50m-series-c-and-mobile-tech/>.
- CAC (Codex Alimentarius Commission). 2003. "Guideline for the Conduct of Food Safety Assessment of Foods Derived from Recombinant-DNA Plants." CAC/GL 45-2003, Rome.

- Clark, Helen. 2014. "How Big Data Is Helping Farmers Save Millions." *GizMag*. <http://www.gizmag.com/big-data-crops-climate-change/34400/>.
- Conor, Anthony. 2014. "Benefits and Limitations of Crowdsourcing Agricultural Data." *AGROAM* (blog). <http://www.agroam.org/blog/benefits-and-limitations-of-crowdsourcing-agricultural-data/>.
- Crawford, John, John Hutchins, Richard Tiffin, and Alistair Stott. 2015. "AIMS: Putting the UK at Heart of the Big Data Revolution in Agriculture." *AgriTech Strategy* (blog). <https://agritech.blog.gov.uk/2015/03/27/aims-putting-the-uk-at-heart-of-the-big-data-revolution-in-agriculture/>.
- Crimson Hexagon. 2011. "Twitter and Perceptions of Crisis Related Stress." *UN Global Pulse*. <http://www.unglobalpulse.org/projects/twitter-and-perceptions-crisis-related-stress>.
- CTA. 2015. "Satellites and Mobile Phones Improve Crop Productivity in Sudan." <http://www.cta.int/en/article/2015-06-17/satellites-and-mobile-phones-improve-crop-productivity-in-sudan.html>.
- Dawson, Ross, and Steve Bynghall. 2012. *Getting Results from Crowds: The Definitive Guide to Using Crowdsourcing to Grow Your Business*. 2nd ed. Essen: Advanced Human Technologies.
- Essiet, Daniel. 2015. "Combating Challenges of Poor Data-driven Agriculture." *The Nation* (Nigeria). <http://thenationonlineeng.net/combating-challenges-of-poor-data-driven-agriculture/>.
- European Space Agency. 2014. "Mobile App Provides Weather Forecasts for Rwandan Coffee Farmers." *Phys.org*. <http://phys.org/news/2014-03-mobile-app-weather-rwandan-coffee.html#jCp>.
- Fahlgren, Noah, Malia A. Gehan, and Ivan Baxter. 2015. "Lights, Camera, Action: High-Throughput Plant Phenotyping Is Ready for a Close-Up." *Current Opinion in Plant Biology* 24: 93–99. <http://www.sciencedirect.com/science/article/pii/S1369526615000266>.
- Ferster, Warren. 2014. "U.S. Government Eases Restrictions on DigitalGlobe." *Space News*. <http://spacenews.com/40874us-government-eases-restrictions-on-digitalglobe/>.
- Freischlad, Nadine. 2015. "Drones over the Rice Paddy: Ci-Agriculture Brings Smart Tech to the Field." *Tech in Asia*. <https://www.techinasia.com/ci-agriculture-precision-farming-indonesia/>.
- Fung, Kaiser. 2014. "Google Flu Trends' Failure Shows Good Data > Big Data." *Harvard Business Review*. <https://hbr.org/2014/03/google-flu-trends-failure-shows-good-data-big-data/>.
- Gartner. 2012. "Gartner Says Big Data Creates Big Jobs: 4.4 Million IT Jobs Globally to Support Big Data by 2015." <http://www.gartner.com/newsroom/id/2207915>.
- . 2013. "Gartner Survey Reveals that 64 Percent of Organizations Have Invested or Plan to Invest in Big Data in 2013." <http://www.gartner.com/newsroom/id/2593815>.
- Gilpin, Lyndsey. 2014. "How Big Data Is going to Help Feed Nine Billion People by 2050." *TechRepublic*. <http://www.techrepublic.com/article/how-big-data-is-going-to-help-feed-9-billion-people-by-2050/>.
- Graziano da Silva, José. 2016. "Big Data, Small Farms." *Foreign Affairs*. <https://www.foreignaffairs.com/sponsored/big-data-small-farms>.
- Greatrex, Helen, James Hansen, Samantha Garvin, Rahel Diro, Sari Blakeley, Margot Le Guen, Kolli Rao, and Daniel Osgood. 2015. "Scaling Up Index Insurance for Smallholder Farmers: Recent Evidence and Insights." CCAFS Report 14, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhagen. https://cgspace.cgiar.org/bitstream/handle/10568/53101/CCAFS_Report14.pdf.
- Gustafson, Thomas Andrew. 2013. "I'm Not Just Gaming, Ma! I'm Helping the World's Farmers." *NPR*. <http://www.npr.org/sections/thesalt/2013/11/25/247210031/i-m-not-just-gaming-ma-i-m-helping-the-world-s-farmers>.
- Halais, Flavie. 2015. "7 Challenges the Agriculture Sector Must Address to Unleash its Data Revolution." *Devex*. <https://www.devex.com/news/7-challenges-the-agriculture-sector-must-address-to-unleash-its-data-revolution-86310>.
- Hamm, Steve. 2011. "Watson on Jeopardy! Day One: Man vs. Machine for Global Bragging Rights." *A Smarter Planet* (blog). <http://asmarterplanet.com/blog/2011/02/watson-on-jeopardy-day-one-man-vs-machine-for-global-bragging-rights.html>.
- HarvestChoice. 1995. *Dynamic Research Evaluation for Management (DREAM) 3.1*. Washington, DC: International Food Policy Research Institute (IFPRI) and University of Minnesota. <http://hdl.handle.net/1902.1/18230>.
- . 2012. "Visualize HarvestChoice Indicators: MAPPR." International Food Policy Research Institute, Washington, DC, and University of Minnesota, St. Paul. <http://harvestchoice.org/node/2258>.
- . 2014a. "AgriTech Toolbox." International Food Policy Research Institute, Washington, DC, and University of Minnesota, St. Paul. <http://harvestchoice.org/node/9034>.
- . 2014b. "HarvestChoice Data Services." International Food Policy Research Institute, Washington, DC, and University of Minnesota, St. Paul. <http://harvestchoice.org/node/9025>.
- Hosenally, Nawsheen. 2012. "Mapping Trees for Food Security." *ICT Update* 69. <http://ictupdate.cta.int/Feature-Articles/Mapping-trees-for-food-security/>.
- IDC. 2014. "The Digital Universe of Opportunities: Rich Data and the Increasing Value of the Internet of Things." EMC². <http://www.emc.com/infographics/digital-universe-2014.htm>.
- Jones, J. W., G. Hoogenboom, C. H. Porter, K. J. Boote, W. D. Batchelor, L. A. Hunt, and J. T. Ritchie. 2003. "The DSSAT Cropping System Model." *European Journal of Agronomy* 18 (3): 235–65.
- Kahneman, Daniel. 2011. *Thinking, Fast and Slow*. New York: Farrar, Straus & Giroux.
- Kay, Alexx. 2001. "Artificial Neural Networks." *Computerworld*. <http://www.computerworld.com/article/2591759/app-development/artificial-neural-networks.html>.
- Kelly, Jeff. 2015. "Executive Summary: Big Data Vendor Revenue and Market Forecast, 2011–2026." *Wikibon*. <http://premium.wikibon.com/executive-summary-big-data-vendor-revenue-and-market-forecast-2011-2026/>.
- Laney, Doug. 2001. "3D Data Management: Controlling Data Volume, Velocity, and Variety." *META Group* (blog). <http://blogs.gartner.com/doug-laney/files/2012/01/ad949-3D-Data-Management-Controlling-Data-Volume-Velocity-and-Variety.pdf>.

- Lavars, Nick. 2015. "MIT's Crop-Saving Drones at the Ready." *Gizmag*. <http://www.gizmag.com/mit-crop-drones/37526/>
- Lawler, Ryan. 2015. "Planet Labs Nabs \$95 Million and a New COO to Cover the Earth with Flocks of Tiny Satellites." *TechCrunch*. <http://techcrunch.com/2015/01/20/planet-labs-95m/>.
- Leclerc, Rob, and Melissa Tilney. 2015. "AgTech Is the New Queen of Green." *TechCrunch*. <http://techcrunch.com/2015/04/01/the-new-queen-of-green/>.
- Letouzé, Emmanuel, and Patrick Vinck. 2014. "The Politics and Ethics of CDR Analytics." Data-Pop Alliance White Paper Series. <http://static1.squarespace.com/static/531a2b4be4b009ca7e474c05/t/54b97f82e4b0ff9569874fe9/1421442946517/WhitePaperCDRsEt hicFrameworkDec10-2014Draft-2.pdf>.
- Marr, Bernard. 2015. "From Farming to Big Data: The Amazing Story of John Deere." *Data Science Central* (blog). <http://www.datasciencecentral.com/profiles/blogs/from-farming-to-big-data-the-amazing-story-of-john-deere>.
- Martin, Steven W., James Hanks, Aubrey Harris, Gene Willis, and Swagata Banerjee. 2005. "Estimating Total Costs and Possible Returns from Precision Farming Practices." *Crop Management*. <http://naldc.nal.usda.gov/download/11889/PDF>.
- McKinsey Global Institute. 2011. "Big Data: The Next Frontier for Innovation, Competition, and Productivity." http://www.mckinsey.com/insights/business_technology/big_data_the_next_frontier_for_innovation.
- McLaren, Robin. 2015. *Managing Unintended Consequences of Democratizing Land Rights*. http://www.fig.net/resources/proceedings/fig_proceedings/fig2015/papers/ts02b/TS02B_mclaren_7687.pdf.
- Nelson, G. C., H. Valinb, R. D. Sands, P. Havlík, H. Ahammad, D. Deryng, J. Elliott, S. Fujimori, T. Hasegawa, E. Heyhoe, P. Kyle, M. Von Lampe, H. Lotze-Campen, D. M. d'Croz, H. van Meijl, D. van der Mensbrugghe, C. Müller, A. Popp, R. Robertson, S. Robinson, E. Schmid, C. Schmitz, A. Tabeau, and D. Willenbockel. 2014. "Climate Change Effects on Agriculture: Economic Responses to Biophysical Shocks." *Proceedings of the National Academy of Sciences of the United States of America* 111 (9). <http://dx.doi.org/10.1073/pnas.1222465110>.
- Paynter, Ben. 2008. "Feeding the Masses: Data In, Crop Predictions Out." *Wired Magazine*. http://archive.wired.com/science/discoveries/magazine/16-07/pb_feeding.
- Practical Action. 2012. *Poor People's Energy Outlook 2012: Energy for Earning a Living*. Bourton, UK: Practical Action Publishing. <http://practicalaction.org/ppeo2012>.
- Quinn, Sara. 2014. "Creating a Community of Practice in Sub-Saharan Africa to Utilize Unmanned Aerial Vehicle-based Tools for Agricultural Development." International Potato Center. <http://cipotato.org/press-room/blogs/creating-practice-sub-saharan-africa-unmanned-aerial-vehicle-based-tools-agricultural-development/>.
- Reader, Ruth. 2015. "Google Ventures Leads \$15M Investment in Big Data for Farmers." *VentureBeat*. <http://venturebeat.com/2015/05/19/google-ventures-leads-15m-investment-in-big-data-for-farmers/>.
- Ridley, W. P., Shillito, R. D., Coats, I., Steiner, H-Y, Shawgo, M., Phillips, A., Dussold, P., Kurtyka, L., 2004. "Development of the International Life Sciences Institute Crop Composition Database." *Journal of Food Composition and Analysis* 17: 423–38.
- Ronanki, Rajeev, and David Steier. 2014. "Cognitive Analytics." *Tech Trends* 2014. <http://dupress.com/articles/2014-tech-trends-cognitive-analytics/>.
- Rosegrant, M. W., Msangi, S., Ringler, C., Sulser, T. B., Zhu, T., and Cline, S. A. 2008. "International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT): Model Description." 42, International Food Policy Research Institute, Washington, DC.
- Rosegrant, M. W., J. Koo, N. Cenacchi, C. Ringler, R. D. Robertson, M. Fisher, C. M. Cox, K. Garret, N. D. Perez, and P. Sabbagh. 2014. *Food Security in a World of Growing Natural Resource Scarcity: The Role of Agricultural Technologies*. Washington, DC: International Food Policy Research Institute. <http://dx.doi.org/10.2499/9780896298477>.
- Saporito, Patricia. 2014. "2 More Big Data V's—Value and Veracity." *SAP Business Innovations* (blog). <http://blogs.sap.com/innovation/big-data/2-more-big-data-vs-value-and-veracity-01242817>.
- See, Linda. 2013. "Citizen Scientists Rival Experts in Analyzing Land-Cover Data." http://www.iiasa.ac.at/web/home/about/news/PLOS_ONE_Citizen_scientists_rival_experts_in_analyz.en.html.
- See, Linda, I. McCallum, S. Fritz, C. Perger, F. Kraxner, M. Obersteiner, U. D. Baruah, N. Mili, and N. R. Kalitas. 2013. "Mapping Cropland in Ethiopia Using Crowdsourcing." *International Journal of Geosciences* 4: 6–13. <http://dx.doi.org/10.4236/ijg.2013.46A1002>.
- Sicular, Svetlana. 2014. "Big Botched Data." *Gartner Blog Network*. <http://blogs.gartner.com/svetlana-sicular/big-botched-data/>.
- Silversmith, Alex, and Drew Tulchin. 2013. "Crowdsourcing Applications for Agricultural Development in Africa." USAID, Washington, DC. http://pdf.usaid.gov/pdf_docs/pa00j7p7.pdf.
- Storum, Doug. 2015. "Farmers Stay Aware with aWhere's Weather Data." *Boulderopolis*. <http://boulderopolis.com/farmers-stay-aware-with-awheres-weather-data/>.
- Thomasson, Alex. 2015. "The Future of Farming: Drones, Robots, and GPS." *The Conversation*. <http://mashable.com/2015/03/22/farmers-drones-robots/>.
- Tsotsis, Alexia. 2013. "Monsanto Buys Weather Big Data Company Climate Corporation for Around \$1.1B." *TechCrunch*. <http://techcrunch.com/2013/10/02/monsanto-acquires-weather-big-data-company-climate-corporation-for-930m/>.
- United Nations, Department of Economic and Social Affairs, Population Division. (2015). *World Population Prospects: The 2015 Revision, Key Findings and Advance Tables*. ESA/WP.241. New York: United Nations.
- USDA (U.S. Department of Agriculture). 2005. "Agricultural Aircraft Offer a Different View of Remote Sensing." *AgResearch Magazine*. <http://agresearchmag.ars.usda.gov/2005/mar/remote>.
- Winston, Clifford. 2013. "Government Implementation of Large-Scale Projects: Government Failure, Its Sources, and Implications for the ACA Website Launch." Brookings Institution. <http://www.brookings.edu/research/testimony/2013/12/04-government-implementation-large-scale-projects-winston>

- World Bank. 2014. "Big Data in Action for Development." http://live.worldbank.org/sites/default/files/Big%20Data%20for%20Development%20Report_final%20version.pdf.
- . 2015. *Big Data Solutions: Innovative Approaches to Overcoming Agricultural Challenges in Developing Nations by Harnessing the Power of Analytics*. Washington, DC: World Bank. <https://openknowledge.worldbank.org/handle/10986/26436>.
- World Economic Forum. 2011. "Personal Data: The Emergence of a New Asset Class." http://www3.weforum.org/docs/WEF_ITTC_PersonalDataNewAsset_Report_2011.pdf.
- . 2015. "Data-Driven Development Pathways for Progress." http://www3.weforum.org/docs/WEFUSA_DataDrivenDevelopment_Report2015.pdf.
- World Wide Web Foundation. 2015. *Open Data Barometer Global Report*. 2nd ed. <http://barometer.opendataresearch.org/assets/downloads/Open%20Data%20Barometer%20-%20Global%20Report%20-%202nd%20Edition%20-%20PRINT.pdf>.
- You, L., S. Wood, U. Wood-Sichra, and W. Wu. 2014. "Generating Global Crop Distribution Maps: From Census to Grid." *Agricultural Systems* 127: 53–60.
- Zoltner, John. 2015. "The Future Is Here with Sensors and Geospatial Analytics in International Development." *ICTworks*. <http://www.ictworks.org/2015/06/15/the-future-is-earlier-here-with-sensors-and-geospatial-analytics-in-international-development>.

GLOSSARY

2G, 3G, 4G. Second-, third-, and fourth-generation [developments in mobile wireless technology]. 2G mobile wireless has basic functionality: voice and short messaging service (SMS); 3G has advanced functionality: general packet radio service; and 4G has broadband functionality: long-term evolution (LTE).

Active infrastructure sharing. The shared use of electronic infrastructure such as network components (for example, access node switches), radio transmission equipment, and core network software systems. See *passive infrastructure sharing*.

Aerial photography and orthophoto mosaic. An image (once a photograph, now a digital image) of the ground taken from an airplane, helicopter, or radio-controlled aircraft at a given altitude. Aerial images are presented as an orthophoto mosaic that is an alternative to a map. These images are higher in resolution (decimeter) than satellite images, proving useful for those who want more details of the terrain such as crop conditions or land use.

Agricultural innovation system (AIS). A network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance.

Application. A software program or groups of programs enabling users to perform particular operations. They consist of systems software (operating systems for managing computer resources, for example) and programs such as those for data processing, word processing, and a multitude of functions that run on systems software. An IT application for managing dairy cooperatives, for example, relies on numerous kinds of applications running on the operating systems of any number of devices and the Internet. See <http://www.webopedia.com/TERM/A/application.html>.

Basis risk. In index-based insurance, the imperfect relationship between the policy holder's potential loss and the behavior of the index. One farmer's loss from drought may not perfectly match that of all others; some farmers will lose more and some less.

Biometric cards. Identification cards with a microchip or barcode that contains information on the physical characteristics of the holder. These cards can help prevent fraud and identity theft by providing a more accurate means of identification.

Broadband. Specifically, a signaling method that handles a relatively wide band (spectrum) of electromagnetic frequencies. More generally, the term refers to a telecommunications signal or device of greater bandwidth than another standard or usual signal or device (and the broader the band, the greater the capacity for traffic). The wider (or broader) the bandwidth of a channel, the greater its information-carrying capacity, given the same channel quality. (Based on http://en.wikipedia.org/wiki/Broadband#Internet_access, accessed July 2011.)

Chain traceability. Recording and transferring product or process data through a supply chain between various organizations and locations involved in the provenance of food. See *internal traceability*.

Cloud computing. A model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. Cloud computing permits organizations without the resources to invest in extensive computing power to rent this service from a provider and access it remotely. (Based on http://en.wikipedia.org/wiki/Cloud_computing?oldid=0, accessed August 2011.)

Commercial supply chain. In agriculture, a supply chain in which a private agribusiness is sourcing agricultural produce from farmers or selling products to farmers in accordance with a profit-seeking business model. Often used interchangeably with supply chain and value chain.

Commodity futures exchange. A market in which multiple buyers and sellers trade commodity-linked contracts on the basis of rules and procedures set out by the exchange. Such exchanges typically act as a platform for trade in futures contracts (standardized contracts for future delivery of a commodity). (Based on a definition by the United Nations Conference on Trade and Development.)

Crowdsourcing. Shorthand for leveraging mass collaboration through ICTs by distributing tasks to or requesting information from a large group of people or community ("crowd") through an open call or message.

Data mediation. The process of using many data sets to produce a single, coherent set of information. Data mediation software organizes different types of data (such as hourly versus daily) and synthesizes different approaches to classification (for example, the use of a different classification vocabulary), helping to mediate differences between data sources—particularly those on the Internet.

Data mining. The extraction of stories or patterns from large amounts of data. Data mining can follow four major patterns: clustering (discovering groups), classification (forming a structure), regression (finding a function), and associations (finding relationships).

Digital divide. Differences in the capacity to access and use ICTs among individuals, men and women, households, geographic areas, socioeconomic groups, ethnic groups, and so forth. The capacity to access ICTs encompasses physical access as well as access to the resources and skills to participate effectively as a "digital citizen." (Based on the definition in http://en.wikipedia.org/wiki/Digital_divide, accessed July 2011.)

Digital orthophoto quads. Digital maps that combine the geometric information of a regular map with the detail of an aerial photograph.

Digital soil mapping. The creation and the population of a geographically referenced soil database generated at a given resolution through field and laboratory observation methods, coupled with environmental data through quantitative relationships. A variety of technologies—including satellite, remote sensors, and cameras—can be used to survey soil and collect data to create digital soil maps.

Digital terrain model. A digital representation of an area's terrain on a GIS that provides accurate position and elevation coordinates. Such models can be used to meticulously engineer projects such as roads, drainage, gravity-fed irrigation works, and detention reservoirs. At the field level, digital terrain models can monitor and improve areas affected by waterlogging or flooding.

e-government. A government's use of ICT to enhance public services.

e-Learning. is the use of electronic technologies to deliver, facilitate, and enhance both formal and informal learning and knowledge sharing at any time, in any place, and at any pace.

Elite capture. When better-off or politically connected farmers capture public programs.

Enterprise resource planning (ERP). Software integrates the many functions of an enterprise into a single system. It centrally stores many kinds of organizational data and manages data transmission and use between departments within the organization and external partners, such as suppliers. ERP is more of a methodology than a piece of software, although it does incorporate several software applications under a single, integrated interface.

e-readiness. The ability to use ICT to develop or improve one's economy or situation through proper preparation.

Farmer-led documentation (FLD). A process in which local communities take the lead role in the documentation process. The results are used by community members for learning within the community (internal learning); exchange between communities (horizontal sharing); and cooperation between communities, development agents, and policymakers (vertical sharing). See www.prolinnova.net/flid.php.

Feature phones. A modern low-end phone that is not a *smartphone*. Feature phones do not run a mobile operating system like smartphones but run on specialized software enabling them to access various media formats in addition to offering basic voice and SMS functionality. They substitute for multiple ICT devices that are also available as stand-alone appliances (digital camera, voice recorder, flashlight, radio, and MP3 player). Rural consumers prefer the combined devices because of their affordability. (Based on http://en.wikipedia.org/wiki/Feature_phone, accessed July 2011.)

Financial inclusion. The delivery of affordable financial services to disadvantaged and low-income segments of society. Research on financial exclusion and its direct correlation with poverty has made the availability of banking and payment services to the entire population without discrimination a prime objective of public policy. (Based on http://en.wikipedia.org/wiki/Financial_inclusion, accessed July 2011.)

Fixed-mobile convergence. The increasingly seamless connectivity between fixed and wireless telecommunications networks, devices, and applications. Also refers to any physical network

that allows mobile phones to function smoothly with the fixed network infrastructure. FMC seeks to optimize transmission of all data to and among end users, no matter their locations or devices. (Based on the definition in <http://searchmobilecomputing.techtarget.com/definition/fixed-mobile-convergence>, accessed July 2011.)

Genetically modified (GM). A genetically modified organism (GMO) in which the genetic material has been transformed using the techniques of genetic engineering. Examples include cotton that has been genetically transformed to resist a particular herbicide. Many countries strictly control the production, use, export, and import of GM plants and animals.

Geographical information system (GIS). Geographic data collected through computer hardware and software to capture, store, update, and display all forms of geographically referenced information by matching coordinates and time to other variables. Data sets formed by a GIS constitute "layers" of information (for example, on topography, population size, or agricultural household income) that can be merged and analyzed to establish relationships and produce maps or charts that visualize geographical traits.

Georeference. To establish the position of something through its geographical coordinates.

Global positioning system (GPS). A satellite-based navigation system with three basic components: satellites that orbit the Earth, control and monitoring stations on the Earth, and the GPS receivers owned by users. GPS receivers pick up signals from the satellites, including precise orbital information (latitude, longitude, and ellipsoidal GPS altitude) of a given object or location, as well as the time.

ICT. Information and communication technology.

Index-based insurance. Insurance that substitutes individual loss assessments with an indicator that is easy to measure (such as weather) as a proxy for the loss. Weather indices have been used in insurance products protecting against drought and loss of inputs. Vegetation has been used in livestock insurance products as an indicator of livestock losses. See also weather-based index insurance and basis risk.

Infomediary. An infomediary works as a personal agent on behalf of consumers to help them take control over information gathered about them for use by marketers and advertisers. (Based on <http://en.wikipedia.org/wiki/Infomediary>, accessed September 2011.)

Internal traceability. Data recorded within an organization or geographic location to track a product or process. See *chain traceability*.

Laser scanning, or light detection and ranging (LiDAR). An active airborne sensor using a set of laser beams to measure distance from an aircraft to features on the ground. Airplanes and helicopters can be used for laser scanning. The data from laser scanning are three-dimensional at very high accuracy, and they also allow ground elevation under the tree canopy to be measured.

Market intelligence. Information relevant to the markets that a producer (or company) wishes to reach, which is gathered and analyzed specifically for making strategic decisions that will help to maximize profits in relation to market opportunities, market penetration, and market development. Market intelligence is necessary when entering a new market (foreign or domestic).

Mobile application. Software on a portable device (such as a mobile phone handset, personal digital assistant, or tablet computer) that enables a user to carry out one or more specific tasks that are not directly related to the operation of the device itself. Examples include the ability to access specific information (for instance, via a website), make payments and other transactions, play games, and send messages.

Nanotechnology. The ability to engineer new attributes by controlling features at or around the scale of a nanometer (one-billionth of a meter, or about 1/80,000 the width of a human hair).

Passive infrastructure sharing. The sharing of nonelectronic infrastructure, equipment, and services at mobile network base stations, including the site space, buildings, towers, masts, and antennas; power supply, back-up batteries, and generators; security; and maintenance.

Precision farming (precision agriculture). Farming based on observing and responding to variations within a field detected through ICTs, such as satellite imagery. Precision farming also makes use of GPS, GIS, and variable rate technology to match practices more closely to the needs of crops, soils, animals, or fisheries.

Primary wholesale market. A market large enough to dominate trade in some goods over a large area. (Based on <http://www.merriam-webster.com/dictionary/primary%20market>, accessed July 2011.)

Radio-frequency identification (RFID). Uses radio waves to transfer data between a reader and an electronic tag attached to a product, animal, or person for identification and tracking. The technology uses hardware (readers) and tags (also known as labels) as well as software. Most tags contain at least two parts: one is an integrated circuit for storing and processing information, and the other is an antenna for receiving and transmitting the signal. (Based on http://en.wikipedia.org/wiki/Radio-frequency_identification, accessed July 2011.)

Risk. Imperfect knowledge where the probabilities are known. Traditional risks to agriculture in developing countries include inclement weather, pests, disease, outbreaks, fire, theft, and conflict. Newer risks include commodity and input price volatility. Risks can be idiosyncratic—affecting only individual farms or firms—or covariate, affecting many farms and firms simultaneously.

Risk coping. Actions that help the victims of a risky event (such as a drought, flood, or pest epidemic) cope with the losses it causes. They include government assistance to farmers, debt restructuring, and remittances.

Risk mitigation. Actions that prevent events from occurring, limit their occurrence, or reduce the severity of the resulting losses (for example, pest and disease management strategies).

Risk transfer. Actions that transfer risk to a willing third party, at a cost. Financial transfer mechanisms trigger compensation or reduce losses generated by a given risk, and they can include insurance, reinsurance, and financial hedging tools.

Sanitary and phytosanitary (SPS) protection. Measures, including regulations and agreements, to protect: (1) human or animal health from risk arising from additives, contaminants, toxins, or disease organisms in food, drink, and feedstuffs; (2) human life from risks associated with diseases carried by plants or animals;

(3) animal or plant life from pests, diseases, and disease-causing organisms; and (4) a country from other damage caused by the entry, establishment, or spread of pests. Such measures include national control of contaminants, pests, and diseases (vaccination programs, limits on pesticide residues in food) as well as international controls to prevent their inadvertent spread (for example, the rejection of insect-infested food shipments that pose a risk to domestic food production).

Satellite imagery. An image of Earth taken from satellites in orbit. Satellite imagery can be spatial (size of surface area); spectral (wavelength interval); temporal (amount of time); and radiometric (levels of brightness). Each type of images captures a variety of variables about a given area of varying size. The resolution (in meters) of these images depends on the satellite system used and its distance from Earth; weather can interfere mainly with satellite systems utilizing visible wavelengths of light.

Side-selling. A farmer sells produce to a buyer other than the agreed-on buyer. Farmers may fail to honor contracts with buyers for a number of reasons (buyers pay late, or prices in the local market are higher than the original price agreed on with the buyer, for example).

Smartcard. A pocket-sized (usually plastic) card with embedded integrated circuits containing volatile memory and microprocessor components. They include credit cards, identification cards, and the SIM cards used with mobile phones. As discussed in this sourcebook, one of their most influential roles has been to extend the use of mobile phones in financial transactions such as purchases of subsidized inputs, conditional cash transfers, agricultural credit, and agricultural information services. (Based on http://en.wikipedia.org/wiki/SmartCard#Cryptographic_smart_cards, accessed July 2011.)

Smartphone. A high-end mobile phone that offers more advanced computing ability and connectivity than a contemporary feature phone. A smartphone runs a complete mobile operating system and combines the functions of a personal digital assistant (PDA) and a mobile phone. Today's models typically serve as portable media players and camera phones with high-resolution touch-screen, global positioning system (GPS) navigation, Wi-Fi and mobile broadband access. (Based on <http://en.wikipedia.org/wiki/Smartphone>, accessed July 2011.)

SMS (short messaging service). A service to send text messages via mobile or fixed-line phones, usually limited to about 160 characters.

Soil carbon sequestration. Transferring carbon dioxide from the atmosphere into the soil through crop residues and other organic solids (like mulch), is one technique to restore carbon levels in soils.

Soil organic carbon. Carbon held within the soil as a result of the decay of once-living plants and animals. The amount of carbon within the soil is used as a measure of soil organic matter; soils with high levels of organic matter are better at holding water and contain more nutrients.

Spatial modeling (among other models). Closely related to spatial analysis or statistics, models are an attempt to simulate real-world conditions and explore systems using their geographic, geometric, or topological properties.

Spectrum rights. Rights to specific parts of the radio spectrum used for radio transmission technologies and applications. The radio spectrum is typically regulated by governments, and in some cases is sold or licensed to operators of private radio transmission systems (for example, cellular telephone operators or broadcast television stations). (Based on http://en.wikipedia.org/wiki/Radio_spectrum#Broadcasting, accessed July 2011.)

Subscriber identity module (SIM). An integrated circuit that securely stores the service-subscriber key used to identify a subscriber on mobile devices (such as mobile phones and computers). A SIM is held on a removable SIM card, which can be transferred between different mobile devices. (Based on http://en.wikipedia.org/wiki/Subscriber_Identity_Module, accessed October 2011.)

Supply chain. The set of buy-sell interactions as goods flow from raw materials through production to the final retailer where consumers can buy them. Often used interchangeably with commercial supply chain and value chain.

Supply-chain management (SCM systems). Software running on networked computers and handheld devices to perform some or all of the following functions: store information about suppliers; transmit an order to the supplier (in an agricultural supply chain, often the farmer); monitor production and quality; transfer payments; and track goods from the farm gate to the warehouse or retailer.

Technological neutrality. A leading regulatory policy principle for ensuring the affordability of ICTs, technology neutrality is the principle of refraining from specifying technology requirements within telecommunications licenses.

Telecenter. A public place where people can use digital technologies (computers, the Internet, even mobile phones) to gather information, create, learn, and communicate with others. Some centers are established specifically for people to learn these essential digital skills; others simply operate for profit. But telecenters often help to support community, economic, educational, and social development—reducing isolation, bridging the digital divide, and creating economic opportunities. (Based on <http://en.wikipedia.org/wiki/Telecenter>, accessed July 2011.)

Traceability (product tracing system). The information system necessary to provide the history of a product or a process from origin to point of final sale. Traceability is used in the food sector primarily for food safety, but agrifood and nonfood sectors such as forestry and textiles have instituted traceability requirements for product identification, differentiation, and historical monitoring. For food products, traceability systems involve the unique identification of products and the documentation of their transformation through the chain of custody to facilitate supply chain tracking, management, and detection of possible sources of failure in food safety or quality.

Uncertainty. Imperfect knowledge, where the probabilities are not known. Many losses expected from risks inherent in modern agrifood systems are related to uncertain events for which there are no known probabilities.

Universal access (UA). (also termed “public,” “community,” or “shared” access) occurs when everyone can access

communications networks somewhere, at a public place. (Generally, the goal is to have at least one point of access per settlement over a certain population size.) As a policy objective, UA is used primarily in developing countries, which seek to expand geographic access to ICTs by the population at large, often for the very first time. UA obligations provide for a minimum level of coverage, especially of remote communities.

Universal service (US). A concept underpinning the definition of access to ICTs, US occurs when every individual or household can have service from communications networks, accessing services privately at home or increasingly through portable wireless devices. US focuses on upgrading and extending communication networks so that a minimum level of service is delivered, even in the least accessible areas. As a policy objective, US is used primarily in developed countries and generally pursued by imposing universal service obligations on network operators. For some services, a goal of US is too ambitious at present in a developing country, because the services must be affordable as well as available. Goals may be cast in terms of the proportion of the population that can afford private service.

Userability. The degree to which an ICT application is user friendly—a critical aspect of successful ICT implementation.

Value chain. The whole ecosystem of players involved in producing and marketing an article, from the retailer back to the producer. Often used interchangeably with commercial supply chain and supply chain.

Variable rate technology. Technology enabling farmers to vary the rate of an input applied to a crop. This technology uses a variable rate control system in combination with application equipment to supply inputs at the precise time and/or place where they are required. Components of the technology include a computer, software, differential GPS receiver, and controller. See *precision farming*.

Weather-based index insurance. Insurance that substitutes an indicator that is easy to measure for individual loss assessments (in this case, weather) as a proxy for the loss. Weather events or visible vegetation have served as typical indicators. This practice reduces the cost of assessing damage and problems of adverse selection, because the insured cannot influence the index or the loss assessment.

Web 2.0. Web 2.0 sites (unlike websites where users passively view content) incorporate applications that facilitate participatory information sharing, interoperability, user-centered design, and collaboration through the Internet. Examples include social networking sites, blogs, wikis, video sharing sites, and hosted services. (Based on http://en.wikipedia.org/wiki/Web_2.0, accessed September 2011.)

WiFi. Wireless local area network that allows various devices to connect to the Internet remotely.

Wireless sensor network. A group of small sensing devices, or nodes, that capture data in a given location and send it to a base station in the network, which transmits the data to a central computer that performs analyses and extracts meaningful information.

Information and communication technology (ICT) has always mattered in agriculture. Ever since people have grown crops, raised livestock, and caught fish, they have sought information from one another. Today, ICT represents a tremendous opportunity for rural populations to improve productivity, to enhance food and nutrition security, to access markets, and to find employment opportunities in a revitalized sector. ICT has unleashed incredible potential to improve agriculture, and it has found a foothold even in poor smallholder farms.

ICT in Agriculture, Updated Edition is the revised version of the popular ICT in Agriculture e-Sourcebook, first launched in 2011 and designed to support practitioners, decision makers, and development partners who work at the intersection of ICT and agriculture. Our hope is that this updated Sourcebook will be a practical guide to understanding current trends, implementing appropriate interventions, and evaluating the impact of ICT interventions in agricultural programs.



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