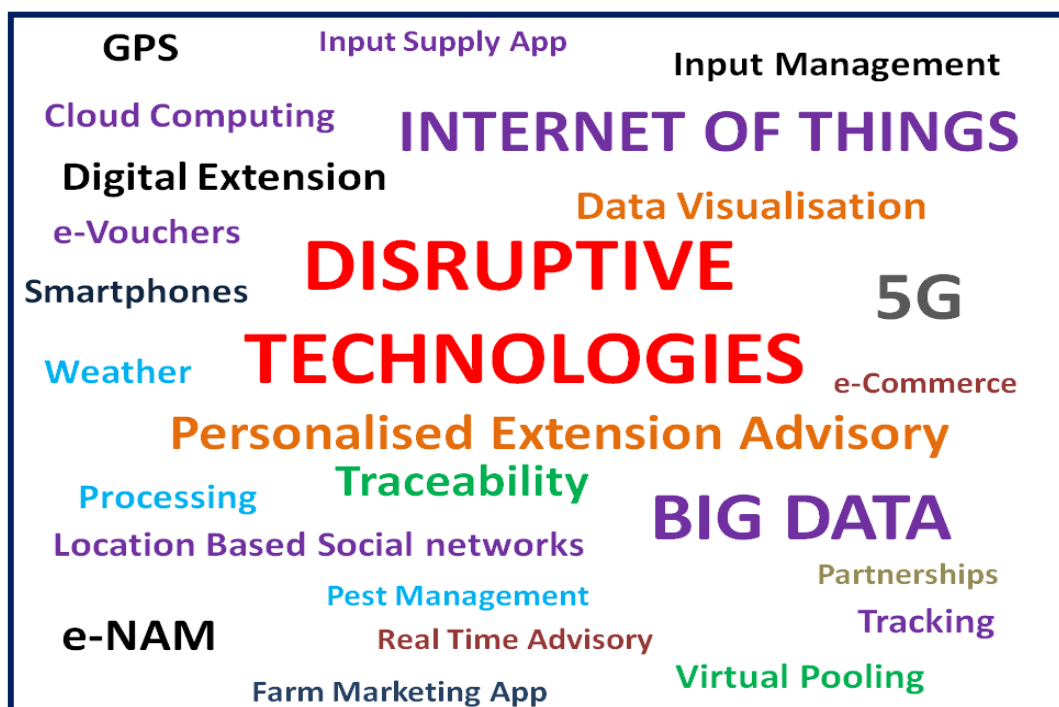## DISRUPTIVE TECHNOLOGIES - BIG DATA AND INTERNET OF THINGS IN STRENGTHENING EXTENSION & ADVISORY SERVICES

Future Extension and Advisory Services (EAS) needs to strategize convergence of big data with disruptive technologies such as mobile/cloud computing, Internet of Things, location-based social networks etc. Dr Shaik N Meera presents a framework to exploit these developments to strengthen EAS provision in this blog.

INTRODUCTION

We hear yet another buzz word viz., disruptive technologies, but what does this really mean? Is it a negative term as it denotes disruption? Not really. Instead, disruptive technologies are exciting because they challenge established patterns and the way we do things. I will spin this blog around a framework harnessing disruptive technologies and integrating them with the digital extension and advisory services (EAS) strategies. The conceptual framework describes the role of each stakeholder organization in harnessing the big data for better, faster and cheaper solutions to farmers. With the inexorable rise of smartphones in rural India, the real challenge is to develop agricultural applications and provide real time services to farmers.

Future EAS needs to strategize convergence of big data with disruptive technologies such as mobile/cloud computing, Internet of Things (IoT), location based social (LBS) networks etc. Highly personalized extension advisories are possible in India only when EAS embraces big data analytics and links them to unique *Aadhaar (12 Digit unique identification number of Indian citizens)*

1

numbers of farmers. Supplemented with the digitized land records and soil health status linked with GPS coordinates, the future of input supply can lead to a radical transformation. Big data in EAS will integrate information provided by farmers, players in the agri-food chain and markets (e-National Agricultural Market), which can be used to enhance productivity, reduce risk, increase resilience and improve profitability. This will bring new values to farming with small and marginal farmers getting maximum benefit out of such strategies.

Last two decades have witnessed several digital pilot projects in India. Now there is a need to bring rapid transition so as to remain relevant and cater to the emerging - information and service needs of farmers. With the proposed EAS framework, it is expected that farmers will be in a position to pull the knowledge and services on real time basis from a variety of sources. If this can be realized, from seed to harvest, post-harvest to storage and marketing, every farming decision can be supported with the digital extension strategies.

DISRUPTIVE TECHNOLOGIES

A disruptive technology is an innovation that creates a new market and value network, and eventually disrupts an existing market and value network, displacing established markets, leading firms, products and alliances. The term was defined and phenomenon analyzed by Clayton M. Christensen beginning in 1995.

I see this in relation to extension systems in two ways: a) Bringing disruption in an extensionists' functioning that includes transformed services, new innovations in the extension processes and b) Emergence of new players in EAS with disruptive innovations. Through farmers' perspective, it is a situation where extension systems cease to function in the usual manner, and start responding to rapid changes that may transform the very nature of the organization. A disruptive innovation in agriculture will allow small and marginal farmers' access to technologies and/or services that were historically inaccessible to them or accessible at higher costs only. For instance, rural communities are now able to access e-commerce goods and other services such as railway tickets due to the availability of digital platforms. Similarly, goods (agri-input, credit) and services (extension advisory, marketing) are yet to be accessed in agriculture, as there is no disruption.

There is a difference between bringing improvements to the existing extension system with digital technologies and bringing radical transformations into the very nature of extension services. To explain in easy terms, personal computer (PC) displaced the typewriter and forever changed the way we work and communicate. We are not talking about improving the efficiency of type writer here. Instead, we have witnessed a new form of communication and publishing. Social networking has had a major impact in the way we communicate. It has disrupted telephone, email, instant messaging and event planning. Smartphones with mobile apps disrupted pocket cameras, MP3 players, calculators and GPS devices among many others.

Cloud computing has been a hugely disruptive technology in the business world, displacing many resources that would conventionally have been located in-house or provided as a traditionally hosted service. The next and most radical generation of mobile communications – fifth generation (5G) – is three years away from now (http://www.gsma.com/network2020/technology/understanding-5g/). The 5G may radically change the technologies and business models of the mobile telecommunications industry. It will have positive consequence in primary sector like agriculture and extension systems will have to gear up to develop frameworks for best use.

THINKING BEYOND CONVENTIONAL DIGITAL EXTENSION PILOTS

Are we ready for digital disruption in extension? Or do we continue to initiate new digital extension pilots? The moot point is eventually how fast can we disrupt (in a positive way) the way extension organizations work? Are extension systems working towards capitalizing on the potential efficiencies, cost-savings or new opportunities created by low-margin disruptive technologies?

Online and mobile banking makes it possible to almost completely bypass the physical bank entities and human bank teller. Amazon, Flip Kart and Olx have revolutionized the classified advertisements and person-to-person sale of all matter of items, including farm equipment. Big basket has changed the way we buy fresh vegetables and fruits.

Initially big organizations dismiss the value of a disruptive technology because it does not reinforce current organizational mandates. I see a similar indifference in extension organizations as well. Improving the efficiency of extension systems had been attempted with a series of digital pilot projects in India (Meera, 2013).

One such digital pilots rolled out in 2016, at the national level in India, is eNAM (www.enam.gov.in/). We are aware of National Agriculture Market (NAM) - a pan-India electronic trading portal which networks the existing agriculture produce market committees (APMC) to create a unified national market for agricultural commodities. The NAM Portal provides a single window service for all APMC related information and services, including commodity arrivals and prices; buy and sell trade offers and provision to respond to trade offers, among other services. While material flow (agriculture produce) continues to happen through *mandis*, an online market reduces transaction costs and information asymmetry. This is an essential condition for disruption, though not a sufficient one.

Uber app is one of the best examples of disruptive force seen in the taxi industry that could be used to understand the disruption in EAS (Box 1).

Box 1: Uber app
The app allows a user to submit a request for a ride. Uber-approved drivers in the area are notified by the app and respond. Payment is not passed from rider to driver – it's done via the app which accesses the user's credit card. The app also makes use of smartphone GPS capability to show you exactly where and how far away the prospective Uber ride is. The app itself and the technology behind Uber are quite simple, but it provides a completely new approach that challenges how taxi services have been obtained for decades.

Now replace the word Uber App with Input supply App. Replace taxi industry with the supply chain management (specific to input supply). Keep in mind the farmer's need to access extension advisory with integrated supply chain management. You have the answer! Now please read further:

Input supply App can become a disruptive force in the supply chain management in agriculture. The app allows a user to submit a request for a specific input based on the personalized advisory. Approved input suppliers in the area are notified by the app and they respond. Payment is not passed from farmer to input dealer – it's done via the app which accesses the farmers *Adhaar* Card / Unique ID card linked to bank account number / credit card / subsidy vouchers (please see Zoona

vouchers program, Box 2). The app also makes use of smartphone GPS capability to show you exactly where and how far away the prospective input dealer / field officer of a private company is. The app and the technology are quite simple, but provide a completely new approach that challenges how input supply services have been obtained for decades. This is disruption!

> **Box 2: Zoona Vouchers in Zambia**
> Electronic Prepaid Vouchers for Input Purchases was piloted in Zambia that enables farmers to pre-pay for inputs. This system was developed by Zoona, a Zambian company that develops and offers electronic financial transactions systems. Each prepaid card contains a code that is electronically registered at the point of purchase, together with the farmer's unique national identification and mobile phone number. Upon registration, the network sends the farmer an SMS that validates the purchase and notifies them of the date and location where the inputs can be picked up. Prepaid vouchers can help input supply companies to increase sales during the period that farmers/ customers have resources available. The electronic registration of farmers' prepaid vouchers and their profile also enables companies to compile a database of customers for targeted SMS-based marketing, information and product promotion. Participating retailers can benefit by stimulating sales during traditionally slower periods. Farmers benefit by purchasing seeds at a discount and by gaining assurance that they will have the seeds they need during the planting season.
> (Source: http://pdf.usaid.gov/pdf_docs/PA00J7PB.pdf)

Now you replace the word Input supply App with Farm Marketing App. Farm Marketing App can become a disruptive force in the way farmers sell their produce. The app allows sellers to submit a request for selling a specific produce / commodity. Approved buyers in the area are notified by the app and respond. Payment is not passed from buyer to farmer– it's done via the app which accesses the buyers *Adhaar* Card / Unique ID card linked to bank account number / credit card. The app also makes use of smartphone GPS capability to show farmers exactly where and how far away the prospective buyer is. Similarly it will show buyers how many prospective sellers are available in nearby villages and how to virtually pool the marketable surplus (remember the Olx experience?). The app is quite simple, but it provides a completely new approach that challenges how agricultural marketing services have been addressed for decades. This is disruption!

Individuals are the backbone of any innovation and many entrepreneurs are innovative in their own ingenious ways with disruptive technologies. Often recognized as what is called "Jugaad Innovation", it is a very flexible, frugal and un-structured method of generating original ideas and solutions. We have enough of pilots, but what we need is a disruption in EAS.

BIG DATA IN AGRICULTURAL EXTENSION

Big data is extremely large data sets that may be analyzed computationally to reveal patterns, trends and associations, especially relating to human behavior and interactions. I guess if there would be one sector that has the potential to harness this functionality to the maximum, it would be agriculture. Within agriculture, EAS can do wonders with big data analytics. The EAS intentionally or unintentionally work on empirically driven data - but such data, information and knowledge continuum, could not be managed till now, because the data was not digitised.

Big data is being used to arrive at shocking and seemingly innocuous conclusions like "a car painted orange is highly likely to be in good shape for a used car deal" or when airline ticket prices are going to be favorable to the buyer. We can have several applications such as estimating rainfall or market prices by manipulating numerous data points.

Farmers have been managing their land with extension advisories coming from multiple sources. But neither the extension advisories nor the decision-making is based on the microscopic analysis of data from each farm. If such huge data is collected, collated and processed with big data analytics and real time advisories are pushed, then we can realize much talked about personalized advisories.

From pre-production (credits, input supplies) to production (varietal to management) and to post-production (processing and marketing), extension systems can harness big data platforms for better and informed decision-making. Agriculture may not immediately come to mind when considering opportunities for the application of big data particularly in Asia and Africa where small and marginal farmers dominate. But to begin with, it can offer solutions to EAS and private agri-business firms. Micro level data (such as soil health status, soil temperature, rainfall, moisture content) pooled at the village, block, district and regional level could serve as the big data for planning agricultural interventions. Extension informatics (personal, field history linked to advisory) can be achieved with predictive modeling. Remember that Google advertisements are customized based on our search history and access IP? Can we achieve this for providing personalized/ plot specific advisories?

Data visualization (visual representation of data in charts and graphs) has become popular in recent years. Organizations have invested in the production of data visualization, committing to the belief that visualization is an effective form of communication. Imagine the use of such visuals at the joint director agriculture office at district level or private sales executive at regional level, to plan the demand and supply, and product (varietal) targeting, based on empirical data.

Connecting extensionists' smartphones to a cloud-based analytics engine, can give farmers customized products and increase efficiency of advisory services. This technology will be more suitable for developing countries, characterized by the pre-eminence of small farms with very low investment capacity and reliance on intermediaries to a greater extent than farms in developed markets. Better market, crop and input information could boost yields and returns for farmers. For private firms, inventory tracking and product traceability with GPS vehicle tracking (telematics – like in case of ePDS) will result in better supply chain management.

The big data analytics in extension will bring significant changes in the personalized, field specific solutions along with pre-production to post-production service needs of farming community. It will lead to higher yields, lower input use per hectare and lower cost of cultivation. For example, the magnitude of yield improvement from commercial precision fertilizer application, according to various agribusiness market participants, ranges from 10 to 15 per cent. If effectively implemented (in combination with Internet of Things (discussed below), this will help small and marginal farmers in every step from credit access to marketing.

INTERNET OF THINGS (IOT)

According to *Industry Trend Analysis - IoT & Big Data In Agribusiness: Driving Future Sector Growth - NOV 2016*, the integration of Internet of Things (IoT) and big data technology in agriculture will pick up in the coming years, and be a major factor behind future improvement in global yields. (http://www.agribusiness-insight.com/industry-trend-analysis-iot-big-data-agribusiness-driving-future-sector-growth-nov-2016)

'Internet of Things' (IoT) is defined as connecting 'things' that can passively or actively monitor, collect and exchange data over a wired or wireless communication network. The IoT can have positive consequences on farm production, soil health, water, nutrient management, pest management, traceability and tracking, supply chain management, processing, transportation, storage, retailers, inventory management, food safety etc. The IoT can provide farmers with on-demand information based on the differential contexts that can be sensed through a network of IoT sensors. Large scale utilization of IoT systems in extension organizations will optimize efficiency of advisories and supply chain management.

Dairy and livestock farmers have been using radio frequency identification (RFID) to enable tracking of individual animals' health and levels of production for quite a number of years. There are many other potential areas for development, including sensor networks to monitor soil and crop conditions, equipment monitoring and automation (self driven planters/ harvesters etc.). These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices.

While in developed countries (particularly where landholdings run into '000 of hectares), these technologies are used by farmers directly, recommending the same for developing countries with smaller landholdings (with no need to remotely monitor fields), is like barking up the wrong tree. I see potential of the IoT more at the level of extension professionals (both public and private) rather than at field/ farmers' level. For example, customized advisories can be planned for a village/ cluster of villages based on sensor data received on irrigation (channels), pests surveillance/management, weather based agro-advisories, real time contingency plans, animal disease out breaks etc.

For instance, municipal dustbins with sensors send alerts to garbage collectors (truck drivers) to pick them up. Similarly sensors can send alerts to extension professionals about the possible outbreak of a pest / any other exigency under its jurisdiction. This is one way of reducing the higher costs of face-to-face contact methods employed by extensionists and will appropriate the human resources in extension systems.

To facilitate the purchase of farm inputs and selling of farm products, the smartphones of buyers' and sellers' can be equipped with IoT technologies such as Near-Field Communications (NFC), that facilitates the purchase of products without using cash. Mobile Internet and low-cost sensors could enable farmers to interact directly with the consumers, cutting off middleman. Kenya has developed M-Pesa kiosks in the rural communities for mobile money transfer.

With the use of IoT, decision makers can undertake appropriate agricultural interventions through large scale extension programs. These technologies can be integrated with a central system and help disseminate relevant personalized advisories to farmers. This can be used to identify pest outbreaks and map other trends. IoT systems can track farmers requiring transport to carry their

farm produce to distant markets. Similarly IoT will help consumers and traders with traceability of agricultural commodities.

LOCATION BASED SOCIAL MEDIA (LBS)

The inclusion of mobile positioning in social networking services that lets people know where they are at any given time may be termed in short as Location Based Social Media (LBS). LBS media monitoring could be used for segmentation of data from social networks (e.g., Facebook, LinkedIn and Twitter) by geographical location to identify patterns. For EAS, LBS networks present unprecedented large-scale check-in data to describe a farmer's (extensionist's) mobile behavior in spatial, temporal and social aspects. Based on the trends, contingency action plans and time critical advisories can be made available to farmers.

Several LBS could be provided - such as resource tracking along with dynamic distribution, finding nearest farmers willing to transport together to fetch higher market prices, weather fore-warning, proximity-based notification (push or pull) of extensionists/experts targeted advertising.

THE FRAMEWORK

There is never going to be a blueprint for how to proceed with disruptive technologies in extension. As stated by Hall (2016), what is clear is that business as usual is the anti-thesis of disruptive innovation, and as evident from e-commerce sector, in the early stages of disruption, the lower-performing technologies only meet the needs of a small segment of existing customer base. In most of the digital pilot projects initiated across the globe during 1990 - 2002, this was witnessed in agriculture sector.

As new technologies evolve, its efficiency improves and the innovation meets the needs of additional customers across the industry. Eventually, the original firms are driven out as the disruption meets the needs of the mainstream market. In the case of EAS, the disruption may not be to the magnitude of e-commerce (though in agri-commerce this may be seen).

The EAS Framework for harnessing disruptive technologies may be explored with three distinct areas viz., pre-production, production and post-harvest (Please see Fig 1).

Pre-production:
Weather details, aberrations, climatic factors, crop selection etc., in extension advisory provision depend largely on remote sensing, geographic information systems, management information systems, predictive modeling solutions and high impact knowledge management models. This also requires harnessing big data analytics and at times IoT (for e.g., advisories based on soil temperature, humidity). Mix of farming systems, various government schemes, access to credit and insurance could be handled with the emerging technologies to give personalized solutions to farmers and here, digital networking solutions will be of great help.

Production:
Sowing apps, cooperative land preparation, input management, water fertilizer management and pest management can be effectively handled by developing sensory devices, proximity devices, e-commerce/ m-commerce platforms/ applications, digital networking solutions, big data analytics, smart mobile apps and high impact knowledge management solutions.

Post-harvest:

Marketing, food processing, packing, storage and transportation will play an important role in future farming. Perhaps these factors will drive global agriculture in the coming years and this will have a bearing on the way small farmers operate. Digital cashless transactions, transactions linked to unique IDs and bank account numbers, linking credit and marketing with bio metrics will give EAS leverage over the past efforts. Digital networking solutions, risk sharing systems for agricultural lending, agricultural value chain networks, e-vouchers distributed through mobile interfaces, will transform EAS strategies in the developing world.
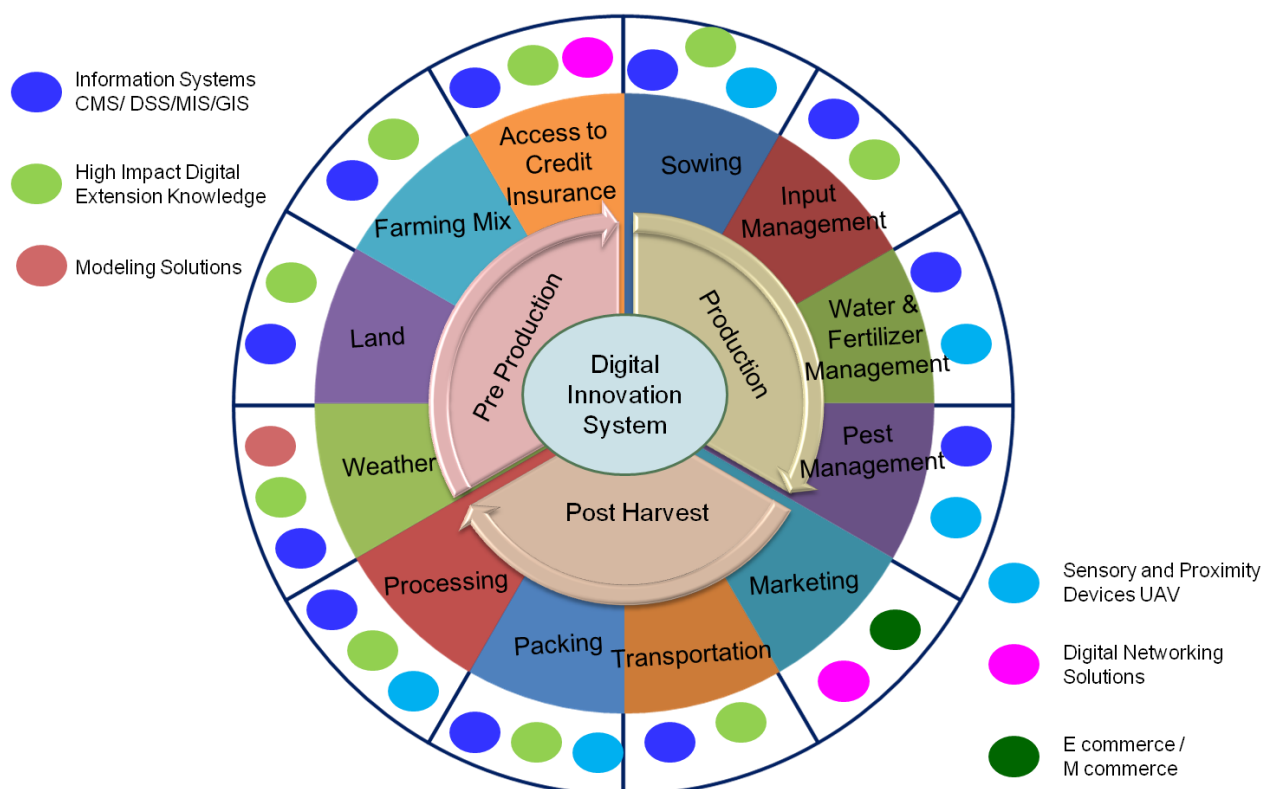

Fig 1: Digital Framework for Disruption in EAS

I will discuss the disruptions in each of the EAS services in a separate blog, but for the time being I would like to give an example of eNAM. Initiatives like electronic National Agriculture Market (eNAM) portal that provides a single window service for all market-related information and services is an essential, but not sufficient condition for bringing disruption. Anyone with basic understanding of agricultural marketing would know that price information (or price prediction as well) is only an essential condition but not sufficient condition for realizing the benefits to smallholder farmers. If a farmer gets to know about higher price in a distant market, it is not economical to lift his produce to such a market. In such cases there is a need for market disruption (with the technologies discussed) to realize the benefits to these farmers. This can be realized in many ways.

Virtual pooling (that was tried to some extent in ITC's e-choupal in India) will help pool the marketable surplus within farmers in proximity, who wish to collectively market in distant markets. Who knows there may be commission agents/farmers with digital skills - transforming

themselves to take advantage of this win-win situation (remember local retailers taking advantage of online marketing)? Together with virtual pooling, a series of e-Voucher platforms across the country could enable extension agencies to provide specific non-cash services. Such e-Vouchers are much easier to track than cash vouchers, and they also help avoid fraud, which is a common problem with paper vouchers. Think about joining this with the online soil health cards, Nutrient Manager App, optimum fertilizer recommendation and fertilizer supply, using e-Vouchers. This will dramatically improve fertilizer demand and supply dynamics.

Another interesting aspect to look is the effect of product imagery and experience with the upcoming technology in virtual reality environments. Apart from 3D, virtual reality is going to be a huge player in e-commerce in agriculture, both for farmers and private organizations. When all support systems are in place, I guess the market disruptions may happen that would ultimately help farmers and consumers alike.

Google is a good example of how innovative companies drive digital disruption across many industries. It was a simple website search engine few years back. Now Google has changed dynamics in many industries such as media, retailing and banking. With many new initiatives like fibre-to-home, home automation, Google Car and Google Glass, the company continues to drive creative disruption in telecoms infrastructure, utilities and the insurance industry. In a similar way, disruptive technologies may offer new expanded opportunities for extension system, to evolve into a completely unimaginable service providing organizations. The disruption may positively impact the very nature of EAS if only extension policies could be flexible to make structural and functional adjustments (Please see Fig 2).
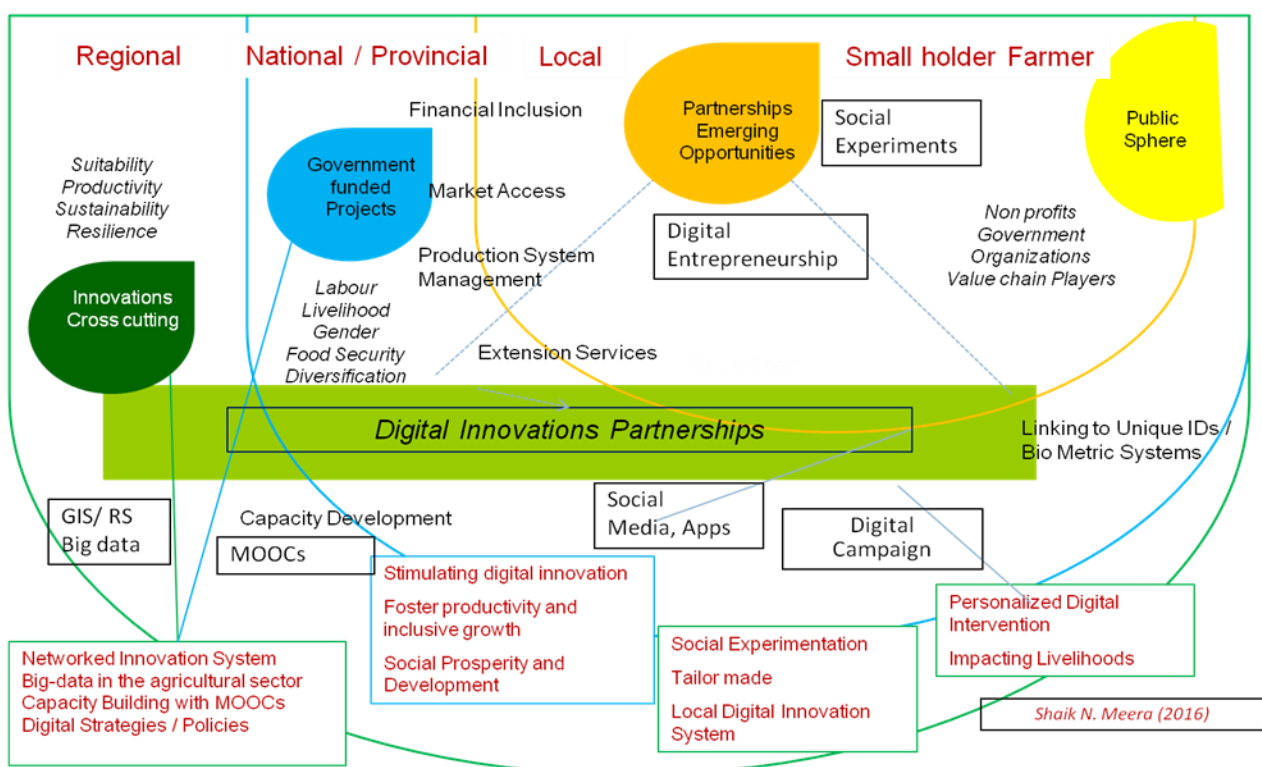

Fig 2: Digital Framework for Disruption in EAS

At provincial or nation level GIS / Remote sensing / big data can bring disruption for productivity, suitability and sustainability dimensions. Similarly the Massive Open Online Courses (MOOCs) strategies are capable of bringing disruption in capacity building within extension advisory systems. Provincial and local EAS organizations can focus on financial inclusion, market access, production system management and core extension services with a number of disruptive innovations. For this, a series of social experimentation within extension organizations (public and private) is required that can catalyse local digital innovations systems. Digital extension strategies would accelerate the impact of extension advisory, when they provide highly personalized, time critical services to the farmers.

IS DOING THE RIGHT THING WRONG?

Clayton Christensen, in his book, 'The Innovator's Dilemma', argued that successful executives tend to follow the path of past successes in their decision-making. This helps sow the seeds of their own demise by allowing other firms that innovate to move beyond the status quo. He therefore defined the innovator's dilemma as, "doing the right thing is the wrong thing". If we really feel there is a need for radical change in EAS, disruptive technologies provide better opportunities.

To begin with, a few private firms started exploiting prescriptive planting strategies that have the potential to disrupt the agricultural industry. For example, there are big data applications to precisely understand where is one of the 25 million mapped agricultural fields in the USA, to plant what type and volume of seed, to achieve the desired crop yield. Monsanto's FieldScripts product combines an extremely detailed database of 150 billion soil observations, 10 trillion weather-simulation points and hundreds of thousands of seed-yield data points. Monsanto's planting machines, which can steer themselves using GPS, can plant a field with different varieties at different depths and spacing according to the climate data. Farmers who have trialed Monsanto's system claim it has increased yields by around five per cent over two years. All these do not mean that the same could be replicated at farmers' level in South Asia or in many other developing countries. But within EAS, these strategies could well be deployed, or other forms of disruptions suiting South Asian conditions could be explored.

ITC Infotech's Digitaligence services and solutions are designed to meet the growing needs of the Banking and Financial Services industry, providing cutting edge insights, superior customer experience and engagement, and delivering an 'anywhere, anytime' service to consumers. In a similar way if we were to think about disruptive technologies in extension advisory, then what would the opportunities be? If disruptive technologies are a combination and integration of telescopic, microscopic, processor and remote functionalities, we need to think how these four functionalities will help extension in creating disruption. http://www.itcinfotech.com/digitaligence/

Investing in disruptive innovations in agriculture can boost garnering and harnessing new ideas. Governments should support entrepreneurs with business models which have the potential to strengthen and promote digital agriculture. Many start ups are emerging that can initiate digital disruption in EAS. The vision of digital disruption is exciting. However, pathways to prosperity need to be more clearer. The success of disruptive technologies such as IoT and big data analytics for rural development depends on the participation and support of both, public and private bodies. Support could be in terms of finance, standards development, data sharing and access, analytical tools and technology.

FINAL REMARKS

Whether one likes it or not, disruptions are likely to happen (or already happening) in the extension processes, activities and methods. Perhaps, disruption may not happen within EAS immediately. My main intention behind writing this blog is to provoke thoughts to bring about disruption in extension processes rather than bring disruption in the organizational structures. A series of such disruptive extension processes will surely transform the very nature of EAS. Until then keep thinking and exploring what best could be done by us.

REFERENCES

Hall A. J (2016.) Thoughts about what disruptive innovation means for agriculture research organisations, Food Systems Innovation Blog, (Available at: https://foodsystemsinnovation.org.au/blog/thoughts-about-what-disruptive-innovation-means-agriculture-research-organisations.

Meera, S N (2013.) Extension, ICTs and Knowledge Management: The 10 difficult questions, AESA Blog 15, Agricultural Extension in South Asia (Availabe at: http://www.aesa-gfras.net/admin/kcfinder/upload/files/Blog%2015%20Extension%20ICTs%20and%20Knowledge%20Management%20The%2010%20difficult%20questions.pdf).

Dr Shaik N Meera is a Principal Scientist at the ICAR-Indian Institute of Rice Research and is a pioneer in digital extension movement in India. He is a Digital Optimist and is involved in creating an ecosystem for shaping ICTs; knowledge & innovation management, capacity building and large scale demonstration strategies for Indian rice sector. Contact him at shaiknmeera@gmail.com, meera.shaik@icar.gov.in

AESA Secretariat: Centre for Research on Innovation and Science Policy (CRISP), Road No 10, Banjara Hills, Hyderabad 500034, India
www.aesa-gfras.net   Email: aesanetwork@gmail.com