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Digital Farming: The Beacon of New Age Agriculture for Feeding Billons in India

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Sustaining in remote areas of the world, struggling to nurture crops on tiny plots of poor land, farmer of India overuse macro fertilizers and miss the benefits they could gain from micro-fertilizers appropriate for their crops and soil. They also have no scientific understanding of pest life cycles, and thus often experience crop failure when a preventable infection or infestation arises. Now, new Agro-input companies have come up with the products—including fertilizer, seeds and pesticides—to help these farmers grow healthier, more abundant crops. However, these companies are failing to reach smallholder farmers with the products and product advice they need. With no access to meaningful market information, these companies struggle to develop aggregate demand forecasts required to drive costs out of the supply chain and maximize sales. Smart Farming is the new industry which is combining large data sources with advanced crop and environment models to provide actionable on-farm decisions. Digital/ Smart Farming is structurally similar to the concept of 'Industry 4.0'.
Smart Farming in India, already is a reality in some areas: for example, GPS guidance systems is used for controlled traffic farming, site-specific fertilization or plant protection measures as part of a full production/input cycle using proprietary cloud-based connectivity. So, automated data processing and completely integrated, harmonized networks still present a not-so-distant future for agriculture and agricultural machinery. Dedicated efforts by all concerned stake holders are needed to realize this future vision. Besides the exchange of agricultural specific data concerning field and crop operations, there also is a requirement of standardizing more transaction related data exchange with other actors in the supply chain.

Key Words: *Dedicated efforts, Smart Farming, GPS guidance, Traffic farming, Automated Data*

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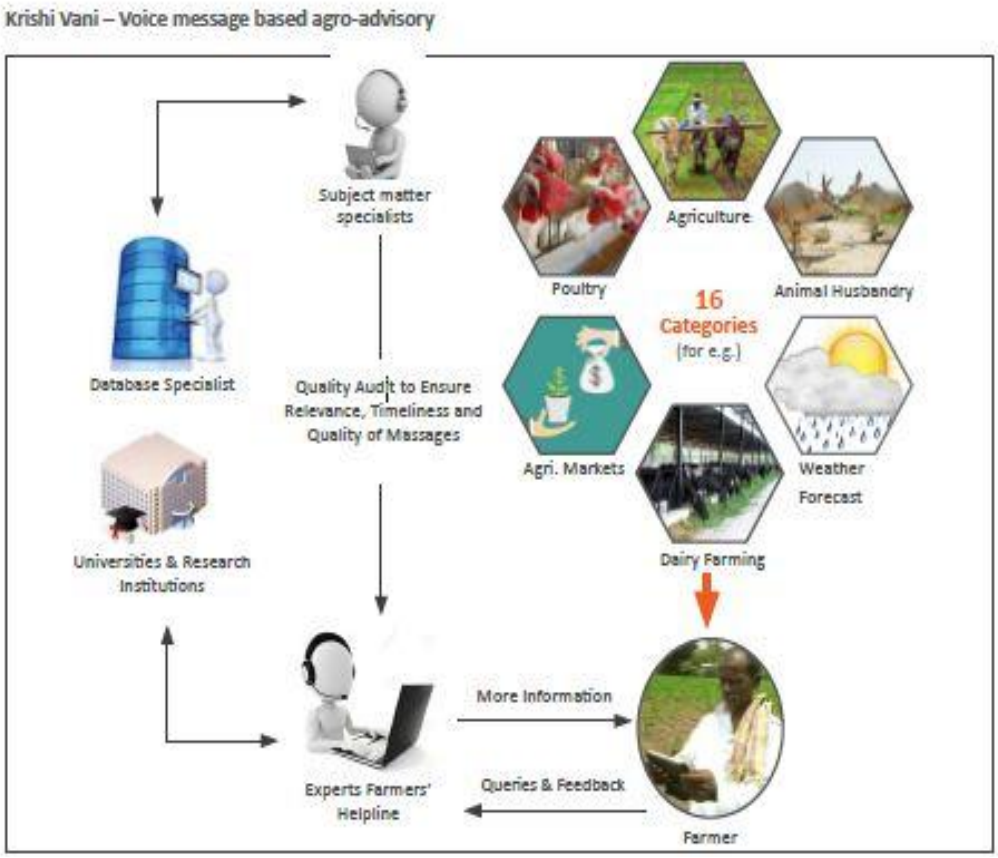
I. Introduction

Addressing food requirement in India is of vital importance since a large portion of the population is living below the poverty line, and income inequalities are raising by the day. It is estimated that more than 790 million Indians live on less than 20 Rupees per day. This country has achieved higher economic growth, improved the balance of payments position and achieved price stability. However this development has not been accompanied by a growth in value added in agriculture. The states, which are economically better off, performed well in farming development while the states, which were at the bottom of farming progress, had a low level of human development. Again, India is the world's largest sourcing destination for the information technology (IT) solutions, accounting for approximately 67% of the US$124– 130 billion markets. However, the emergence of farm technologies integrated with a robust information and communication technology (ICT) framework is still evolving in India, is in nascent stage, and it holds tremendous potential to both positively impact agricultural performance and enhance farmers' income. Technology cans empower Indian agriculture time and again by helping overcome productivity stagnation, strengthening market linkages, and enhancing farm management. The illustration of Krishi Vani is given below.

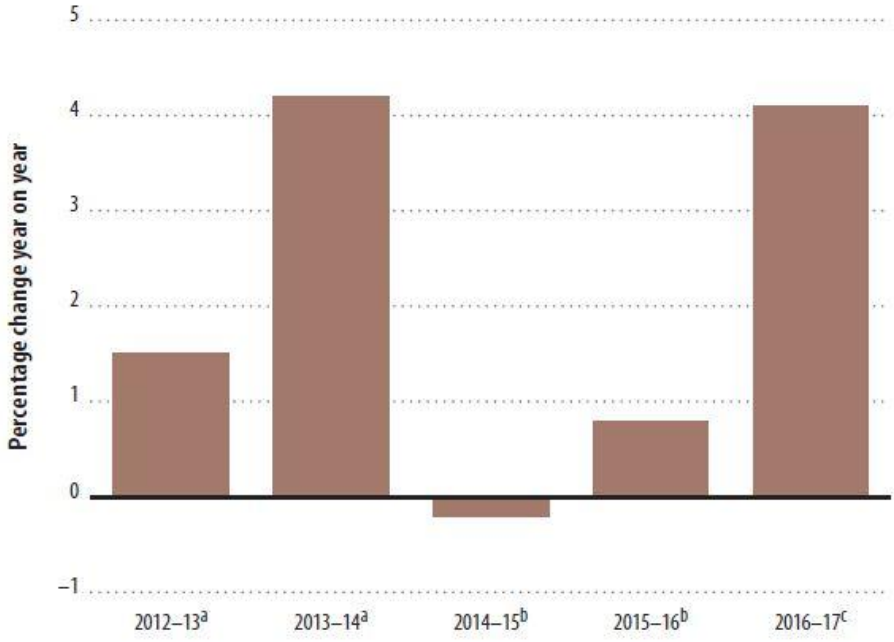


Objective of The study: The research undertaken in this article consisted essentially of desktop and industry research. Most of the published information available related to crop and horticulture production. The research also involved an analysis of range of different technologies, software products and associated digital platforms.

Indian Trajectories on Farm Output

Yields of major crops are low in India compared with those in other developed countries. For instance, the rice yield in India is 2.6 tonnes per hectare—far lower than the 4.7 in China, 3.7 in Brazil, 5.9 in the United States of America (USA), or 9.5 in Australia; production of wheat is 3.0 tonnes per hectare in India, 5.3 in China, and 3.1 in the USA; and the maize and soybean yields are 2.5 and 0.75 tonnes per hectare in India compared with 5.9 and 1.8 tonnes, respectively, in China. Cutting edge technology to achieve higher and sustainable agricultural growth is not novel for farmers and other relevant stakeholders in India. Notable are the green revolution (1966–67), the white revolution (1970–96), and the gene revolution (in cotton) in early 2000. The green revolution, which revolved around extensive cultivation of high-yielding varieties of wheat, led to a fivefold increase in production and, as a result, led to rising farmers' incomes. The three decades from 1973 to 1999 can be considered as the highlight in the timeline of agriculture productivity in India, when the food grain production nearly doubled. It is interesting to note that the increase in production was more a result of an enhancement in the yield rather than an expansion of cultivated area. Similarly, the white revolution yielded record milk production in India and enabled higher returns for dairy farmers. It constituted a national milk grid and introduced the process of crossbreeding of indigenous cows with high-milk-yielding European breeds, pasteurization of milk for long-duration storage, and refrigerated transport systems to distribute milk across the country. During the same period, agriculture machines were put to test on Indian farms lands; these primarily consisted of tractors and seed drills to improve productivity per unit of land and water. Following the successful introduction of Bacillus thuringiensis (BT) cotton, India's cotton production increased from 14.0 million bales in 2000–01 to 38.6 million bales in 2014–15, resulting India became the largest cotton producer in the world, accounting for 26% of the global production. Likewise to respond successfully to the growing food demands both domestically and globally, India will have to produce more.

Figure 1: Growth rate of gross value added in agriculture and allied sectors, 2011–12 base prices



Source: Government of India, 2017b; 2017c.
Note: Data are government estimates: [a] second revised estimate; [b] first advance estimate; [c] first revised estimate.

In view of concerns that intensive farming adversely impacts environmental balance, India will have to adopt sustainable farming practices that include employing efficient irrigation methods with a simultaneous focus on groundwater regeneration, monitoring soil degradation, and adopting energy-efficient production methods. Adopting advanced technology has helped small countries, including the Netherlands and Israel. Notably, these countries, have added the production of high-value crops through huge productivity breakthroughs and, even more importantly, by ensuring the maximum utilization of resources and maintaining the environmental balance.

The Digital Farming

One of the applications of digital farming is an android app, which is designed as a mobile data collection tool as well as an information dissemination tool. There are Farmer facilitators (FFs) who register farmers and collect farm-level data using the application on a tablet. These people also provide targeted information to farmers such as: soil test based crop specific fertilizer recommendations and crop wise improved package of practices in the local language. This information generally is tailored for a particular farm based on the specific farm details available in the database. Looking at the food production chain as focus, data is a key tool to demonstrate compliance with legal obligations and risen societal expectations with regards to food safety and production methods. With enhanced transparency and traceability, it is possible for India to produce more and better food for a growing population while reducing the environmental footprint. The new technologies that cater to the optimal utilization of resources (particularly those that are linked to natural resource availability and environmental impact), effective market linkages for improved service delivery, and the discovery of the highest price possible as observed in the case of India through the country's electronic National Agricultural Market (e-NAM)—a technology-driven unified market platform—have a brighter future in India. The success of this technology adoption lies in customizing to address particular challenges at the local level, supporting institutions and policies to create an enabling ecosystem, and harnessing the potential of these technologies to scale and commercialize within a defined time period.

The rise of entrepreneurial firms for Digital Farming

The agriculture sector has attracted large corporate houses, leading IT companies, investors, and young innovators in India; the ecosystem for technology and digital solutions is expanding at an impressive good pace. The global market for precision agriculture is also expected to grow at an annual growth rate of 13.09% to reach a market size of over US$6.34 billion by 2022, Although Northern America will maintain its dominance in this area, the fastest growth is projected for India and China, which are expected to achieve an annual growth rate of 18.29% until 2022. The agro-tech start-up ecosystem in India has also been receiving renewed attention from investors, and where almost 34 ventures received US$295 million in investments in 2016 in the country—the highest investment amount recorded in India in the past three years. In Asia, China had 10 deals totaling US$427 million, while 53 Indian start-ups raised US$313 million and four Japanese companies raised US$8.9 million. The most active geographies—those countries with the highest number of agriculture start-ups—remained consistent year-over-year, with the USA, India, Canada, the United Kingdom, Israel, and France remaining the top six by number of deals.

e- Choupal

The e-Choupal, a comprehensive digital knowledge hub for farmers, which 100 has 6, installations covering over 35,000 villages and serving over 4 million farmers. **e-Choupal** is an initiative of ITC Limited, a conglomerate in India, to link directly with rural farmers via the Internet for procurement of agricultural and aquaculture products like soybeans, wheat, coffee, and prawns. e-Choupal solves the challenges posed by Indian agriculture, characterized by fragmented farms, weak infrastructure and the involvement of intermediaries. The programme installs computers with Internet access in rural areas of India to offer farmers up-to-date marketing and agricultural information. Online access enables farmers to obtain information on mandi prices, and good farming practices, and to place orders for agricultural inputs like seeds and fertilizers. This helps farmers improve the quality of their products, and helps in obtaining a better price. This kiosk with Internet access is run by a sanchalak — a trained farmer. The computer is housed in the sanchalak house and is connection to the Internet via phone lines or by a VSAT connection. Each installation gives services to an average of 600 farmers in the surrounding ten villages within about a 5 km radius. The sanchalak bears some operating cost but he earns a service fee for the e-transactions done through his e-Choupal. The warehouse hub is managed by the same traditional middle-men, now called samyojaks, but who has no exploitative power due to the reorganization. These middlemen make up for the lack of infrastructure and fulfill critical jobs like cash disbursement, quantity aggregation and transportation. Since the starting of e-Choupal services, farmers have seen a growth in their income levels because of a rise in yields, improvement in quality of output, and a fall in transaction costs. Even small farmers have gained from the initiative. Farmers can get real-time information in spite of their physical distance from the *mandis.* The system saves procurement costs for ITC Limited. The farmers do not pay for the information and knowledge they get from e-Choupal; the principle is to inform, empower and compete in the market.

Trringo

This model led to a ripple effect on the public sector– managed food grain management systems that resulted in an upgrade. Mahindra & Mahindra (M&M), one of India's leading producers of tractors and farm equipment, is involved in innovating alongside expanding its core business. This mobile based app enabling farmers to rent tractors is an example of leveraging technology to help farmers use machinery without having to make the large investment (US$7,500) of buying tractors. Through Trringo, the farmers benefit from available latest machines, freeing labour as well as raising productivity and product quality. In addition, the farmers are required to pay for the services they use without locking any money in the venture as capital. This is particularly revolutionary in a country like ours, where farming is characterized by smallholders (who operate on less than 2 hectares of land) and who are often resource poor and lack access to formal credit channel. India's foremost organized rental services, Trringo, for tractors and agricultural equipment and part of the USD 19 billion Mahindra Group, by now has successful completion of 1 lac hours of farm mechanization rental, post operationalization of the service in October 2016. Through rapid expansion work covering more than 1,000 villages by the beginning of 2018. Moreover, it has touched the lives of farmers in the states of Karnataka, Maharashtra, Gujarat, Rajasthan and Madhya Pradesh by over 100 TRRINGO hubs. TRRINGO has incorporated a new platform in September 2017, with several enhancements. Its digital disruption so far is recognized across various platforms – namely, IDC Digital Transformation Award, Assocham India Africa Biz Award and the SABRE Awards South Asia 2017.

mKRISHI

Through mKRISHI, Tata Consultancy Services (TCS), provides personalized advisory services in voice and visual formats using communication devices such as mobile phones. The growing penetration of mobile phones in rural regions of India is driving the development of several mobile based applications by government departments, entrepreneurs, and the private sector. The rural subscriber base in India for mobile services has been growing at good pace, reaching approximately 342 million subscribers in 2012–13, 378 million in 2013–14, and 414 million at the end of 2014–15.With easier access to mobile phones, cultivators can now connect with traders and other cultivators. A Small farmer can also utilize their mobile phones to get information on input availability or market prices, thereby reducing costs—both because they do not have spend the time needed to get into town to find this information, and it allows them to get competing prices and choose the best one. Other benefits that have been recorded are improved access to information about selecting seed varieties appropriate to a particular farm; and how to identify best cultivation practices, protect from weather-related damage, and get a better handle on plant diseases.

Start Up Projects

Digital technology in Indian agriculture is a big box solution. A large number of young entrepreneurs have also ventured into this field to tackle specific challenges. The technology focus of these ventures has been on reducing the time duration of crop cycles, saving on water and energy, reducing the usage of agro chemicals, automating for efficient farm management, strengthening farmer market linkages, and improving cold chain logistics for higher value addition

STELLAPPS

This is one of the leading startups include **Stellapps** Technologies, which is providing dairy farm optimization and monitoring services with a special focus on small- and medium-herd farms. Their applications and tools leverage the Internet of Things, big data, the cloud, mobility, and data analytics to improve milk production, milk procurement, and the cold chain, and to boost animal insurance and farmer payments there by helping small and marginal farmers.

EKGAON

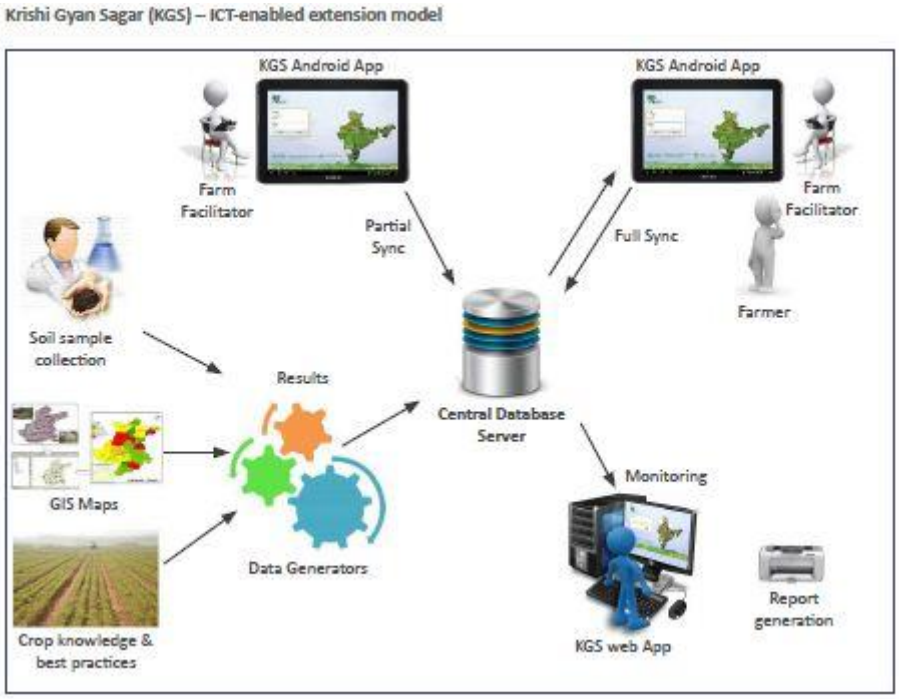
Ekgaon Technologies, an IT-based network integrator, provides a range of services to farmers, rural businesses, and women. The ekgaon, One Village One World Network is leveraging mobile communication technology to encourage the sustainable development of women-self-help-groups (SHGs) and small farmers across India. The platform has over 900,000 women and 300,000 farmers spread across villages in India. Drones and robotics are mainly used in Indian agriculture, although the ventures in this area are still budding and there is a long way to go before these technologies are scaled up in any major way through Ekgaon.

AGNEXT

AgNext, an Indian start-up, has developed drones in addition to other digital technologies with the objective of creating an integrated hyper local farm data collection and crop analytics platform. AgNext is now innovating digital intervention to solve agricultural issues introducing a unique platform of hardware, software and analytics as a service. They are into making precision agriculture accessible and affordable to world's agriculture community through various ICT based technological Innovations. It is also creating integrated hyper local farm data collection and crop analytics platform using latest technological innovations.

Skymet

Skymet Weather Services is involved in monitoring and predicting weather and offering agri-risk solutions. Skymet measure and predict yield at the village level for any crop with a high level of accuracy and can also accurately forecast the weather in the short, medium, and long term. Skymet was the first private sector entity to provide weather forecasts and weather graphics to the Indian media in 2003. It was founded by Jatin Singh in 2003 and is headquartered in Noida, India. Skymet also offers weather service information to most of the major insurance companies in India, power sector and agriculture sector. Skymet provides wind and solar forecast for different renewable energy companies by running its own meso and micro scale NWP. Skymet along with few NGOs are closely working to improve the sustenance of farmer in different remote blocks of many states in India. Skymet also provides to different companies for marine weather forecast. Very recently it launched a weather website that allows a common user to get accurate weather information for free.



ECOZEN

This company has developed state of- the-art solar-powered products for irrigation and cold storage, with the aim of catering to smallholder farms and regions with limited or no electricity. Barrix Agro Sciences provides eco-friendly crop protection methods that have the potential to minimize a significant proportion of the damage caused by pests and diseases without overdosing crops and plants with chemicals, thus preventing soil and water contamination. These are also ventures that started out as agri-tech start-ups in. The company delivers state-of-art solar powered products for irrigation. Ecozen Solutions is committed to each customer, to quality installations, and to making "going green" an effortless experience. We strive for win-win scenarios with our customers. From small scale systems to community level solar solutions, this company has been delivering to the rural customer segment with its astute engineering approach. The company also delivers state-of-art turnkey solar pumping solutions. We are committed to each customer, to quality installations, and to make "going green" an effortless experience. We strive for win-win scenarios with our customers.

EM3

EM3 AgriServices, founded in 2014, has become a pioneer in the farming-as-a-service (FaaS) model. EM3's *Samadhan techno kheti* centers provide machines needed to perform all critical farm operations on a pay-for-use basis. At their centers, the organization employs agri-professionals who are well versed in the agronomy of the target area. Samadhan - FaaS (Farming as a Service) creates a platform that enables technology to reach the farmer and the farm in an efficient and affordable manner through a network of farm centers (Samadhan Kendras). Each center, managed through IT enabled systems and manned by agri-professionals, is equipped to handle a comprehensive suite of basic and precision farm operations throughout the entire crop production cycle.

eKutir Global

Another such exemplary venture, eKutir Global, provides an online and mobile based platform to connect marginal farmers with stakeholders across the value chain such as soil-testing labs, suppliers of seeds and fertilizers, banks, exporters, food-processing units, and branded retailers. Agri Suite by eKutir provides a one-stop solution for all the needs of a farmer; their field partners also train local farmers to use their application. Over time, services that it go beyond merely selling a product but that also provide training about how to use, maintain, and repair that product, as well as supplementary components such as advisory and marketing services, have become an increasingly important and integral part of any product offering.

Few Global Trend Setters

NETAFIM

Netafim is an Israeli manufacturer of irrigation equipment. This company produces drippers, dripper lines, sprinklers and micro-emitters. Netafim also manufactures and distributes crop management technologies,

including monitoring and control systems, dosing systems, and crop management software for farmers. Netafim holds an over-30% share of the global drip irrigation market. The company recorded revenues of over $822 million in 2015. Netafim also produces drip irrigation systems and other water technologies intended to increase yields and improve crop production while preserving quality and quantity of water and soil fertility. The company products are designed to offer solutions in the areas of efficient irrigation, control and agronomy for a range of field crops, orchards and vineyards grown under varied topographic and climatic conditions throughout the world. At present Netafim is developing ecological solutions for producing fuel from alternative sources. Concurrently, this firm is launching a low pressure irrigation system that offers a solution for areas where water pressure and/or electrical infrastructure do not permit using high pressure systems. This development will facilitate introduction of the drip irrigation systems into additional agricultural areas.

Ghana Model

In the northern region of Ghana, an initiative offers tailored climate information services to farmers which assist their decision making vis-à-vis climate variability. Up to about 1000 farmers (33% of which are women) are now accessing and applying seasonal forecast information in their farm management operations and other livelihood activities. A recent survey showed 97% of farmers willing to pay for access to climate information. Primary users consist of individual farmers and traders, farmers' associations, agribusinesses, and public sector organizations such as national agricultural ministries. An online platform handles buy and sell offers, agricultural input and crop prices, extension messages, locations where seeds and fertilizers are available, among others. Users usually access content on the internet and on their mobile phones, choosing from a range of applications to create a personalized interface.

ISABELA

In West Africa, the Imagery for Smallholders – Activating Business Enterprises and Leveraging Agriculture (ISABELA) initiation promotes the use of imagery by smallholder farmers and intermediaries to make agriculture a profitable undertaking. The project aims to tackle two problems: 1) Lack of transparent land tenure information services, which deters investment by smallholders and puts them at a disadvantage vis-à-vis urban and international investors and 2) Inability to cost-effectively predict and value seasonal agricultural production. These problems have been solved using a combination of four technologies: satellite imagery, UAV (unmanned aerial vehicle) imagery, ground-based digital sensors, web-2-mobile platforms, A sustainable, subscription-based rural land tenure information service supported by very high-resolution satellite imagery led to the delineation of over 300,000 smallholder parcels in two sub-divisions in Mali (Koutiala district) and Nigeria (Kano State). Increased land tenure security leads to higher investment in improved land management practices, eventually leading to higher and more sustainable agricultural productivity.

Problems with Smart Farming in India

Despite the fair gains achieved, the long-term impact of the earlier technology revolutions was limited to selected agricultural pockets in the country, and further efforts to advance these revolutions lost momentum over time. In the context of start-ups, the common barriers to commercialization and the scaling up of technology are related to procurement to finance, which is in turn related to operational finance, funding/ capital deficiencies, and cash flow management; gaps in technology infrastructure; and issues concerned with cyber security. Furthermore, limited access to farmer networks for effective piloting of the products is seen to create problem of the commercialization plans of start-ups. For innovation and entrepreneurship to be effective in transforming agriculture in India, it is important to address these issues and create an enabling environment in which they can grow and flourish. To a large extent, the effort towards this transformation has been catalyzed by the government's special programme on start-ups, Startup India. Moreover, large companies with knowledge about the diversity of Indian agriculture should also support these start-ups by mentoring, which would help them pilot and scale up their activities for potential commercialization.

Barriers to Digital Agriculture

IT adoption is a process with a certain level of heterogeneity in terms of the factors that affect it. It is useful to understand these factors in the process of technology adoption in order to increase the rate of adoption. These factors are,

1. Difficulty with data manipulation from equipment, machines, and software

In Experts perception, the producers' lack of ability to organize and manipulate data obtained by the equipment's sensors is an obstacle. The expert reported, for example, that some experimental weather stations installed on rural properties generate a relevant amount of data; however, in most cases, the producers do not know how to use the information and lack the programs to convert these data into a more accessible form.

Complex systems present a challenge in terms of acceptability and usability, causing the farmers to revert to using ad hoc calculations via, for example, standard spreadsheet software. With the largest volume of data available, analytical systems and graphical interfaces need to increase the capacity for farmer data analysis with useful and easy-to-read information. There is a trend toward integrating sensors and computers to analyze livestock digital farming. Farmer advisors and those involved in the production process need to adapt to the new availability of data and information in productive systems and learn how to handle these systems.

2. Lack of integration among systems

With regards to the technology adoption barriers on farms, Experts reported a number of challenges, including the integration of computer systems. Generally Farmers in India are not loyal to one brand and tend to acquire equipment from several companies. Hence lack of integration among the available tools on the market limits digital adoption as by European producers. Several companies are working on systems integration and methods for crosschecking data from different sources in order to integrate information about climate and soil; however, these initiatives are not prudent. Integration across systems is one of the major areas where digital technologies need to advance by incorporating decision making, production, and property management tools. Due to enhanced agricultural machinery and equipment sales, companies are trying to create new products and services by providing after-sales machinery and agricultural implementation services, such as configuration services, the optimization of remote machine regulations, and recommendations based on the data obtained from machines.

3. Education and knowledge of farmers and the low technological level of farms

Many Experts cited lack of knowledge as the main difficulty for farmers when they purchase agricultural machinery that involves a higher level of technology. The level of education among rural workers is one of the main challenges to adopting technologies in India, compared to other developed countries. This knowledge comprises both the educational foundation and the technological sophistication needed to manage the tools. In India, 27% of rural landowners are still illiterate, 9% did not complete elementary school (non-illiterate), and 53% have only an elementary education. This may indicate a possible barrier to the diffusion of innovations in technologies such as digitalization in agriculture in India. One study has reported a positive relationship between education and adoption of management technologies .Therefore, education should increase farmers' ability to process information, make decisions, and use digital technology.

4. Poor telecommunications infrastructure in rural areas

Another hurdle raised by many experts is the precarious telecommunications infrastructure in rural India, which makes data transmission via devices such as mobile phones and tablets unreliable digital technology requires real-time connection with the internet to enable the use of information. Many of the office operation control systems, such as seed volume, fertilizers, and pesticides, require high-quality internet connection to produce better results. Furthermore, access to IT by Indian farmers tends to occur predominantly on large farms which is again not good always. In recent years, with the expansion of mobile telephones, a greater number of rural producers have gained access to mobile internet; however, input speed and signal quality are still at poor condition, so the internet has been one of the main challenges to digital technology adoption in India.

Government Policy and Institutions:

NAARM

The National Academy of Agricultural Research Management (NAARM) of India is the only institution of its kind in the world focusing on capacity building in agricultural research and education management. It was started by the Indian Council of Agricultural Research (ICAR) in 1976 at Hyderabad. The main objective of NAARM is to enhance individual and institutional capacities in National Agricultural Research Systems (NARS) for innovation and sustainable agricultural development.

a-IDEA

a-IDEA (Association for Innovation Development of Entrepreneurship in Agriculture), is a Technology Business Incubator(TBI) established by ICAR-National Academy of Agricultural Research Management, Hyderabad (ICAR-NAARM) & Department of Science & Technology, Govt. of India (DST, GOI). a-IDEA has been housed in the Centre for Agri-Innovation at ICAR-NAARM for fostering innovation and entrepreneurship in agriculture in India. a-IDEA aims to help entrepreneurs to ideate, incubate and accelerate their innovative early stage startups that are scalable to become competitive food and agri-business ventures through capacity building, mentoring , networking and advisory support.

Government of India Remedial Steps

India's contemporary public policy with regard to agriculture is focused on encouraging innovation and entrepreneurship, and out-of-box thinking towards achieving sustainable higher growth and income security in the agriculture sector. Because more than 50% of the working population is in agriculture and farm land size is shrinking resulting the per capita output is small. Thus it is true and desirable that people move out of agriculture and bring the current percentage of the workforce employed in agriculture from 54.6 % to come down. New forms of engagement have emerged in this sector that could make agriculture more profitable and exciting for the new generation. The government—through its flagship programme Startup India, launched in 2016—aims to boost start-ups across sectors by providing handholding services, access to funding, and incubation. This programme is of immense significance for the agriculture sector. The other flagship programme—Digital India, which seeks to empower people through digital technology riding an increasingly robust infrastructure and service platform—has equally immense potential to positively impact cultivation. The government has also launched the Custom Hiring Centre, a rental model for utilizing tractors and other farm equipment with the twin objective of encouraging rural entrepreneurship and fast-tracking the mechanization of Indian agriculture. The budget for 2016-17, 17-18 announced by the central government confirms its commitment to modernize agriculture systems in India through a slew of measures such as setting up a dedicated micro-irrigation fund, establishing new mini labs in the Krishi Vigyan Kendras (KVKs) agricultural extension centre, ensuring 100% coverage of all 648 KVKs in the country for soil sample testing, and expanding the coverage of the e-NAM from 250 markets to 585 markets.

II. Conclusions

Digital Technologies Transforming Indian Agriculture as a business enterprise involving constant innovation and catering to requirement of market demand. Although agricultural technologies are fast evolving in India and a mix of business models are driving the ecosystem, there is a need to design the pathway to successful commercialization and to scale it up by utilizing the right incentives for Indian Farmer and policy support. In Karnataka, providing localized knowledge through a farmer-centric peer-to-peer approach is helping enhance uptake of improved farm management technologies. Short videos created by farmers in the local language on topics relevant to neighboring farmers are proving to be an effective dissemination strategy.

With the private sector playing an increasingly important role in investments, operations, and expertise, agriculture is likely to gain immensely as the public sector catalyses these efforts. The IT revolution in India was brought forward by the private sector, with the public sector creating an enabling ecosystem. Uptake of technologies at market prices in a sector that has traditionally been heavily subsidized remains challenging, but farmers need to be prompt to identify what works in their interest and are ready to pay for it. Digital technologies offer the potential to achieve the necessary conditions for scale, with distributed low cost and customized delivery, creating a unique opportunity for private enterprise and innovation to thrive. So the challenge before India lies in balancing high growth with inclusive growth; leveraging technology to achieve these twin goals will be a fascinating journey to track.

A developed agriculture system is based on three key parameters: knowledge, infrastructure, and a robust delivery mechanism. Supporting the research and development ecosystem in agriculture directly contributes to creating knowledge and preparing for the future. To strengthen the supporting framework for growth, it is important to focus on creating new physical markets, improving storage and transport facilities, making better roads, and ensuring a continued electricity and water supply. These system components are also to facilitate efficient mechanisms for delivery and the monitoring of relevant government schemes and extension services that will accelerate the pace of development. The public policy regime in India has been supporting technology-led agricultural growth and has been increasingly developing new institutions to ease access and affordability of technology adoption among farmers.

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