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**DIGITALIZATION OF AGRICULTURE IN INDIA:
CHALLENGES AND PROSPECTS**

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Abstract: *If we want pro-poor growth and real development, high agricultural growth and rising incomes for farmers are essential and digitization is an important variable for fast growth in this sector. In the rural sector, e-Agriculture focuses on agriculture by using information and communication technology for better conceptualization, design, development, evaluation, and innovation. Critical data about agriculture can be generated, processed, transmitted, disseminated, sorted, archived, and retrieved through mobile phones. Some apps are available and more can be developed to address farmers' specific needs. Mobile devices and the internet facility keep the farmers updated with relevant information related to farming. All this requires a great revolution in research technology development, agricultural extension services and a major network of marketing, storage, and distribution. The research is descriptive. The study is conceptual and based on secondary data collected from company websites, newspapers, and journals. The scope of the study is restricted to the agricultural sector only.*

Keywords: *M-agriculture, Mobile devices, Internet of things*

Introduction

In India high agriculture growth is needed for the overall growth of the economy and to provide employment and food security to the majority population. Growth may be higher during the previous two decades, but inclusive growth in terms of focus on agriculture has been missing. If we want pro-poor growth and real development, high agricultural growth and rising incomes for farmers are essential and digitization is an important variable for fast growth in this sector. According to APJ Abdul Kalam

to provide good nutrition and plenty of food to all Indians, food grains production needs to be enhanced to 360 million tons by 2020 so that along with sufficient domestic consumption have sufficient margin for food exports and aid other countries. All this requires a great revolution in research technology development, agricultural extension services and a major network of marketing, storage, and distribution. The research is descriptive. The study is conceptual and based on secondary data collected from company websites, newspapers, and journals. The scope of the study is restricted to the agricultural sector only.

Scope for Digitization in India

To meet the challenges of climate change use of ICT in agriculture is more necessary than optional and can prove permissible to improve the conditions of smallholder farmers. E-agriculture opens opportunities for non-traditional players in the agriculture value chain. It provides reliable data for research and policy-making and fills the current information gap. Better data will allow government as well as non-government organizations to design farmer-friendly policies and planned interventions. It also brings transparency in agricultural supply chains, removing the huge inequality that exists and guaranteeing adequate income to the farmers.

Digitization of agriculture or e-agriculture is seen as an emerging field focused on enhancing agricultural and rural development through improved information and communication processes. "E-agriculture is a multi-stakeholder process that involves bringing together many different ministries and departments as well as private sector players such as insurance, banking, and mobile network operators. Countries have been experimenting with the use of technology for agriculture for a long time, however, due to a lack of a multi-stakeholder-based approach in sustaining these initiatives, we see that many of these initiatives/solutions have not moved from the pilot or experimenting phase," says Gerard Sylvester, regional knowledge and information management officer, FAO. ICT Development Index (IDI) 2015, published by UN International Telecommunications Union, measures the level of information and communication technology access. It ranked India a low 131 out of 167 nations. This is reflective of the poor access of the population to ICT services. Although India has made tremendous progress in raising its telecom density, the country remains far behind when it comes to providing internet access. The report noted that 43.4% of the global population has internet access. In contrast, only 18% of Indians have access to the Internet. With higher levels of ICT, workers become more efficient and their productivity increases as a result income increases at a high rate. The digitization of the agricultural sector can play a significant role in increasing employment opportunities, improving the standard of living in the agricultural sector and reducing the risk and uncertainties that our farmers must deal with presently. Both the private and government sectors should complement each other in providing the latest information and communication technologies to empower the rural population (Anand and Sharma).

Technology is key to increasing growth through providing better services and innovative delivery models. Crop health can be measured from pest infestation levels to moisture readings of the crop to satellite imagery of the warehouses. Mobile telephony is connected to satellites and data is delivered to centralized servers which is instrumental in converting grain into monetized assets. This type of high-tech intervention will allow financial institutions to use agri-crop as the primary collateral helpful in promoting financial inclusion. Technology can increase crop protection curtailment of food wastage and increase credit availability to the stakeholders of the agri-value chain. Likewise, software and technology have revolutionized other sectors, agriculture, warehousing, and agri-finance are all set to evolve. (<https://economic.times.indiatimes.com>) Digital farming provides a real-time flow of data from the fields to the company office about day-to-day farming operations. This enables us to take care of the entire value chain, right from sowing to harvesting through agribusiness. With the help of digital systems advice can be given to farmers and field staff attached to them can ensure best practices in their fields. Through digital monitoring, fields are digitally managed by giving the right course correction advice and taking regular updates on the health of the farm through pictures. Digitization is going to change agricultural practices in various means such as remote sensing of plots through satellite systems with precision as close to 5X5 meter resolution can help identify the pest or disease-affected areas of the plot. This can be done through Big Data Analytics, with indicators like Normalized Difference Vegetation Index (NDVI), Red Edge Index etc. It will be immensely helpful in weed and pest management. The digitization of agricultural practice provides traceability across the entire supply chain. It also helps farmers to connect with buyers and initiate sales by availing online marketplace, it gives farmers more independence and the option to choose a buyer. Digitization boosts income and lowers costs by optimally using chemicals and fertilizers and managing bottlenecks. The production process can be traced through pictures and farmers can give end-to-end traceability. It is more useful for organic farmers to validate their claims.

Globally Internet of Things (IoT) is being adopted by countries in spaces such as retail, consumer wearables, commerce, and smart infrastructure. Currently, India has a comparatively small market for IoT but it aims to grab at least 20% market share in the next five years. Efforts of the Indian government in the face of Digital India highlight the role of IoT and cloud technologies to step forward in the digital revolution for growth in India. In the 2016-17 Union Budget, the government promised an outlay of Rs 7296 crores as part of its AMRUT mission to build 100 smart cities, and its success is dependent on the adaptive use of sensors, smart devices, and connectivity, cloud, and Big Data technologies. In urban infrastructure development, IoT implementation is useful but on the other hand, it is interesting to evaluate the impact of IoT and rural technologies on the penetration of welfare services in rural areas where almost 70% of the country's population reside, as per the census of India 2011 Provisional Population Totals of Rural Urban Distribution. The Telemedicine network for e-healthcare services

delivery is transforming accessibility in remote parts of the country. In telemedicine centers interaction of doctor patient in which patient's health records are automatically wired to doctors for reference. In the coming decade, India has growing opportunities in the agriculture sector for improving lives making India a true leader in agriculture IoT by revolutionizing the way farmers plant, fertilize and harvest in the next decade. Advancement from chipmakers is making computer and connectivity hardware and software technologies more affordable. Almost 50% of the population is employed in the agricultural sector and it will increase the overall growth of the country this sector should avail the benefits of the huge potential of IoT-driven solutions for improving supply chains and farm practices which will enhance yield and higher monetization of the sector. Precision Farming techniques using field sensors to monitor farming operations should be used by many farmers. Farmers in Brazil use unmanned tools such as drones, to collect, analyze and transmit real-time crop intelligence to regulate the use of chemicals and irrigate dry fields to generate sustainable and high-yielding results. The information can be transmitted to their mobile handsets. Farmers can use these informed real-time data-based decisions for the utilization of their resources and the overall performance of their yield. In the dairy industry technology has been reported to be used in some parts of Europe namely Voluntary Milking Systems (VMS) in which cows voluntarily approach robots for milking up to four times a day, per their biological needs. Agri-Robotics is being used in developing countries for activities ranging from surveillance to basic farming activities like tilling, ploughing etc. Private and public investments in smart agriculture are being aggressively used but in India, their full-scale adoption is low as its cost is high, therefore, not viable to small and medium farmers. According to NSSO for 2012-13, these costs amount to 30% of the total output that an average farm household obtains from a crop, thus reducing their profitability margins. Thus, IoT device and solution providers should innovate and promote low-cost sustainable solutions to reduce costs and low-cost sensors should be widely available with ubiquitous connectivity through cellular NB-IoT, having optimized power consumption built on power efficient sensors and processors so that maintenance problems can be dealt with. According to NASSCOM, there are about 28 IoT startups in India, out of them 40 focus on smart agriculture. Innovations can increase smart irrigation, agri-drones, robotics harvesting, produce monitoring and agri-sensors. In arid and semi-arid regions smart irrigation technology can ensure efficient use of water resources based on the humidity of the soil, the needs of the crop and weather patterns, the right type of sensors and connectivity will optimally use scarce resources. Drones can be used to dispense fertilizer and pesticides over acres of farmland in a very efficient manner through wireless connectivity and precise positioning smart sensor technology is helpful in monitoring produce quality, wind and light conditions, soil temperature, acidity, and mineral content. Startups are being set up which combine such sensors to provide real-time feedback to farmers for appropriate action. Governments should create an environment for startups vital for the country. In the IoT draft policy of the Indian government, its scope for the agriculture sector has been

outlined and is providing incentives to capture investor interest although much needs to be done about cost reduction and awareness about the use of IoT. (www.indiatimes.com).

Farmers' income can be increased and positive effects on agriculture are seen through the emergence of farm technologies with well-connected robust information communication technology (ICT). Technology in Indian agriculture helps overcome productivity stagnation, strengthen market linkages, and improve farm management. Farmers can also be modernized by adopting technology-driven production practices ensuring uniform annual returns to farmers, reduced risk of crop failure and increased yields. Digital technology can be applied in remote sensing via satellites, geographic information systems, crop and soil health monitoring and livestock and farm management. At the pre-harvest stage digital technology can assist in crop and input selection and helpful in providing and getting credit and insurance. During the on-farm stage weather advice and disease and pest-related help can be provided. During the post-harvest stage, real-time data in both domestic and export markets can be estimated. For improving food quality to meet competition technology can provide farmer-friendly solutions by promoting data generation as well as advanced analytics which favours them to make smart decisions about farming and to economize the use of inputs and labour. The eco-system for technology and digital solutions in the agriculture sector is expanding at an impressive rate as this sector is attracting large conglomerates, leading IT companies, investors, and young innovations in India. In India, an estimated 34 ventures received US\$295 million in investments in 2016 in the country.

ITCs e-Chaupal has proved to be a comprehensive digital knowledge hub for farmers which has 6,100 installations covering 35,000 villages serving 4 million farmers (<http://www.itcportal.com/business/agri-business/agri-commodities-and-rural-services>) It was launched in 2000 benefiting farmers doing business through their network and producing a ripple effect on the public sector managed food grain management system leading to upgradation.

Tata Consultancy Services (TCS) offers personalized advisory services in voice and visual formats through communication devices such as mobile phones through its m-Krishi platform. The prevalence of mobile phones in the rural sector has increased, therefore several mobile-based applications by government departments, entrepreneurs and the private sector are being developed. With mobiles, farmers can connect with other farmers and traders and utilize their mobile phones for information on input availability or market prices and allowing them in getting competing prices and choose the best one and avail information about, selecting seed varieties appropriate to a particular farm, adopt best activation practices, bear weather risks and coping with plant diseases.

Many young entrepreneurs have used digital technology for reducing the time duration of crop cycles, economize water and energy, reduce the use of agrochemicals, automation to improve farm management, strengthen farmer market linkages, and improve cold chain logistics for high-value addition.

The ekgaon One Village One World Network is leveraging mobile communication technology to encourage the sustainable development of Self-Help Groups (SHG) and small farmers across India. The platform has over 9,00,000 women and 3,00,000 farmers spread across villages in India (<https://ekgaon.co.in/ekg/index.php.agnext>, an Indian startup has developed drones apart from other digital technologies for creating integrated hyper-local farm data collection crop analytics platforms. (www.wipo.int/edocs/pubdocs) Seth Ankur and Ganguly Kaveri Digital Technologies Transforming Indian Agriculture.

Digital India was launched on 1st July 2015 to create a digital infrastructure for empowering rural communities, enabling the digital delivery of services and promoting digital literacy. Digital agriculture can be defined as ICT and data ecosystems to support the development and delivery of timely, targeted localized information and services for profitable and sustainable agriculture through providing safe, nutritious, and affordable food for all. Rural connectivity can be enhanced by providing low-cost data and access to information. As a result, rural youth will realize their full potential, profits of farmers can be increased by better access to markets and rural businesses through value addition. The project has three core components, viz. digital infrastructure, digital services, and digital literacy. Mobile phone is the preferred delivery medium with a focus on m-Governance and m-Services. The m-Agriculture and m-GramBazar, out of the seven components covered under m-Services, directly impact agricultural extension and marketing services. The project will benefit small farmers. It seeks to

1. Transform rural India into a digitally-empowered knowledge economy
2. provide universal phone connectivity and access to broadband in 250,000 villages
3. Extend timely services to farmers through information technology and its tools
4. to enhance efficiency in agricultural governance through digital literacy and electronic delivery of services. This article briefly highlights the government's initiatives and suggests the need for harnessing the potential of digital India for agricultural development.

Agriculture is getting more and more digital and its future lies in leveraging real-time analytics and automated systems. In the global economy in the past few decades, digital technologies have transformed virtually every sector including agriculture. New digital technologies accelerate agricultural growth. Both the Central and State Governments should adopt different steps to increase investment in agriculture research and to create an environment for promoting agriculture business through policy initiatives such as:

1. The Government wants to promote a virtual agricultural market by providing common electronic platforms to farmers for selling their produce to buyers all over the country. The National Agriculture Market online trade portal has been created.

2. Rashtriya Krishi Vikas Yojna encourages states to allocate more funds to agriculture and allied sector by undertaking appropriate growth-oriented projects.
3. Direct Benefit Transfer system and unique identification number, Aadhar, to support the transfer of government subsidies to citizens; these platforms can also be used for government interventions about soil health, Prime Minister Krishi SinchaiYojna, national markets and weather-indexed insurance.
4. Different Institutions related to the agriculture sector such, as the State Government's Department of Agriculture, State agricultural universities, Krishi Vigyan Kendras, regional research institutions, farmer producer organizations, corporate/industrial/business houses and multinational companies engaged in manufacturing/production and distribution of farm inputs, farm equipment and machinery, rural financial institutions, insurance companies can contribute their professional knowledge to develop a digital ecosystem for agriculture and make it available for farmers.
5. Modern equipment and improvised machines can enhance production and storage.
6. Kisan call centres provide services to farmers where they can directly interact with the executives for their queries. They are provided information through mobile phones about suitable techniques needed to maintain the fertility of the soil to increase production showing positive results. Information communication technology can change the face of the agriculture sector by raising crop productivity and profitability per unit area and resources. Mobile connectivity in terms of service users is increasing at a fast rate. IMAI study showed 80% of people in rural areas use tele density for communication, 67% for online services, 65% for e-commerce and 60% for social networking

In the rural sector, e-Agriculture focuses on agriculture by using information and communication technology for better conceptualization, design, development, evaluation, and innovation. Critical data about agriculture can be generated, processed, transmitted, disseminated, sorted, archived, and retrieved through mobile phones. Some apps are available and more can be developed to address farmers' specific needs. Mobile devices and the internet facility keep the farmers updated with relevant information related to farming. The Government has set up three portals as farmer portal, the Kisan call centre and the m-Kisan portal to help farmers make informed decisions in various agro-climate conditions for better farming. E-Governance program provides soil health card software that has been standardized and web-based software developed to provide integrated nutrient management through soil test crops. The national E-Governance plan in Agriculture provides information to farmers through multiple channels such as the common service Centre. Internet Kiosks and SMSs. 12 identified clusters of services provide information on weather, soil health, seeds,

nutrients, pests, irrigation, crops, good agricultural practices, farm machinery, marketing infrastructure, farm commodity prices, arrivals, procurement points, electronic certification for export and import, drought relief and management, livestock, fisheries management, training monitoring implementation and evaluation of schemes. NABARD has also designed agricultural portals for farmers. Entrepreneurs with start-ups are exploring opportunities in the field of automation, cloud integration and communication. This trend is a positive indication for the government sector and private sector jointly working through digitization to revolutionize agriculture by transforming its structure and reshaping it with modern equipment and techniques

Limitations of digitization of Indian agriculture relate to the development and upgradation of agricultural content timely, ownership issues of public and government-generated data, inadequate public-private partnership, awareness, and training of farmers in remote areas, monitoring of instructions to farmers, expenses related to automated systems, robotics, and other equipment and expertise for modernized machines. (Ganguly and Patra).

GEOSYS's satellite-based remote sensing combines historical records with real-time observations and helps in predicting problems even before the real symptoms appear. Precision agriculture through drones equipped with sensors that take images of crops and apply fertilizers or pesticides according to requirements. Geo-tagging helps to trace the farm produce detecting places from where the raw materials are bought and customers want to know the details of the raw materials used in the final product. Likewise, various techniques can merge field data with crop/weather/soil data useful both to the farmers and agribusinesses as well. Agribusinesses associated with agricultural equipment manufacturers are capital-intensive but prove to be highly beneficial if updated regularly. Sensors-fitted irrigation delivery equipment delivers water after analyzing the soil moisture, crop, and weather conditions, AGRIVI app helps in planning, monitoring, and tracking the input status, expenses, weather, and extent of pest attacking risk. For simple and efficient management of all types of Agri digital maps Module Map can be used. Mobile Platforms such as digital mobile apps and connected farmer system is very successful, through connecting farmers in a single mobile by virtual aggregation and agribusinesses can identify patterns, efficiencies, and best practices by registering farmers, managing contracts, providing extension services, making payments, extend farmer loans, and provide SMS receipts. Agribusiness should take up on a priority basis: (Reddy).

- a. To make up with competition alliances and joint ventures should be consolidated.
- b. Without compromising quality reduce cost.
- c. Through upstream and downstream upgradation optimize vertical integration.

- d. Upstream upgradation includes measures to strengthen R&D and develop new products to consumer tastes. The design and shelf life of the product are equally important and should fit well into their lifestyle.
- e. Downstream upgradation requires measures to digitalize agriculture and improve infrastructure by providing raw materials uninterrupted and qualitative.
- f. Sales should be extended internationally and efficiently provided in present markets

Digitalization can help track produce from the farm to the table and in this chain reduce wastage and improve food safety. Technology can help detect pathogens and allergens before reaching consumers. Helpful in marketing by addressing price discovery issues and solving the present problem of lack of transparency in the wholesale market. It can help bring farmers in touch with profitable customers and help in building sustainable partnerships to improve farming productivity. The holistic digital platform will increase availability, affordability, consumer awareness, quality, safety, and access to food. (Mukerjee).

Digitization will improve rural connectivity and will be key in providing low-cost data and access to information and will empower rural youth to realize their full potential, farmers to increase their profitability by accessing equitable markets and rural businesses to offer value-added services. Spatial Data Infrastructure and low-cost smartphones and tablets to support the bi-directional flow of data and information to rural consumers. Advanced agriculture industries help farmers manage their production and market risks through the application of spatial/temporal databases that are cloud-enabled and integrated through Application Programming Interfaces (APLs). This enables a rich and dynamic data ecosystem providing advanced analytics to inform farmers regarding the best economic options to maximize profitability and minimize risk. Remote sensing provides large data resources to support the development of derived weather products (radar), improved hydrology and watershed management, soil health, crop coverage and crop health estimates among other applications. Africa, Brazil, and China have successful business models using mobile phones to increase value chain efficiency for appropriate inputs and credits. The same can be applied in India to double farmers' income. Digital Agriculture can use social media platforms for improving human capital and capacity. Digital Green uses participatory videos in which farmers explain best management practices to other farmers. Farmers are better related if someone relating to them explains build livelihood under similar circumstances. Digital agriculture will facilitate the achievement of Sustainable Development Goals before 2030 and help the objectives of the National Food Security Act efficiently, effectively, and equitably so that everybody can access safe, nutritious, and affordable food. (Bergvinson).

Startup India launched in 2016 aims to boost startups across sectors by providing handholding services, access to funding and incubation and is of great significance for the agriculture sector.

Conclusion

Digital transformation will provide access to finance through exposure and awareness due to digitization, forecasts on climate change to enable the right decisions, accessibility of farm equipment and new technology, inputs for better soil fertility and soil structure, access to markets, access to information, small holdings utilization and enables predictive analysis. It requires planning, capacity building, identification of the right stakeholders, mechanisms for governance and monitoring and providing buyers and sellers with one platform. This technology platform will reduce costs, improve productivity and quality, improve prices, reduce risks, and create a sustainable ecosystem. 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 enterprises and innovation to thrive. High and inclusive growth can be well promoted with digitization. For India, at a time when national, regional, and international research institutes have already developed technologies, farmers need motivation and encouragement to adopt this proven yield-enhancing, cost-efficient and environment-friendly technology. Finally, digitization will change the scene of Indian agriculture in future and guarantee higher income to farmers and reduce distress.

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