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Digital Agriculture:
Challenges and Possibilities in India

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Abhishek Beriya

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Abstract

Farmers' incomes in India are very low and efforts have to be made to enhance their incomes. For this, increasing the efficiencies of agricultural production processes and the entire value chain is important. Digital Agriculture is emerging as one of the ways to increase efficiencies and enhance incomes in agriculture globally. We define Digital Agriculture in the Indian context and list the challenges as well as the possibilities for Digital Agriculture in India. We find that lower cost of technology, easy to use portable hardware, pay per use renting models, policy support and harnessing the power of farmer collectives are essential for the success of Digital Agriculture in India.

1.0 Introduction:

The focus area in Indian Agriculture, in the recent times has been on enhancing farmer incomes. This took the shape of official government policy after the clarion call of the Prime Minister of India to double farmers' incomes and the subsequent budget announcement[1] to this effect.

As far as agricultural production is concerned, India ranks[2] first in the production of milk, jute and pulses, and is placed second in producing wheat, rice, groundnut, vegetables, fruits, cotton and sugarcane. It is also among the leading producers of fish, livestock, poultry, spices and plantation crops. Thus, to an extent, production is not the biggest problem of Indian Agriculture, whereas due to tiny landholdings, farmers' incomes are definitely not sufficient. One of ways of enhancing farmer incomes is through the use of Digital Technologies in Agriculture to increase the overall efficiency of the agricultural production processes as well as the entire value chain. "The future of food is unequivocally digital, and the future of digital is inevitably AI (Artificial Intelligence). From gene sequencing in seed production to Internet of Things (IoT) networks of implements and sensors that generate data and image recognition technologies that assay and grade crops and commodities, AI applications are being deployed across different aspects of agriculture." (Gurumurthy and Bharthur, 2019)

India's National Strategy on AI also aims to realise the potential economic and social benefits the technology offers. Further, the National Strategy on AI recognizes agriculture as one of the priority sector areas for implementation of AI driven solutions. (Niti Aayog, 2019)

Ours is a Columbia University project in partnership with The Energy and Resources Institute (TERI) titled, "A New Indian Model of ICT-led Growth and Development". The project examines the potential for a new Information and Communication Technologies-led model of growth and development in the Agriculture sector in India and seeks to make recommendations for India to continue to leapfrog the development process using ICTs in key sectors including agriculture, among others. This paper examining the challenges and possibilities of Digital Agriculture in India is part of our continued efforts in the project. In this paper, we first look at various definitions of Digital Agriculture and what constitutes Digital Agriculture. Then we explain certain applications of Digital Agriculture and finally we contextualize Digital Agriculture in the Indian context by enumerating the challenges and possibilities of Digital Agriculture.

1 https://www.indiabudget.gov.in/doc/bspeech/bs201617.pdf

2 http://www.fao.org/india/fao-in-india/india-at-a-glance/en/

2.0 The definition of Digital Agriculture

2.1 There are differences in how different entities define digital agriculture or digital farming, precision agriculture/farming and smart agriculture/farming and AI in Agriculture.

2.2 The International Society for Precision Agriculture which claims to be the sole international scientific society completely devoted to Precision Agriculture defines[3] Precision Agriculture as “Precision Agriculture is a management strategy that gathers, processes and analyzes temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production.”

2.3 The EU funded BIOPRO Baden-Württemberg GmbH project dossier (2018[4]) defines Precision farming and smart farming thus: “Precision farming is an agricultural concept involving new production and management methods that make intensive use of data about a specific location and crop. Sensor technologies and application methods are used to optimize production processes and growth conditions. In contrast to conventional agricultural methods, using digital data can increase resource and cost efficiency as well as reduce environmental impact. Further, Smart farming (also known as Farming 4.0 and digital farming) is the application of information and data technologies for optimizing complex farming systems. The integration of smart agricultural technologies and modern data technologies enables seed planting to be adapted to a specific field to ensure an efficient production process. The application of information and data technologies support farmers in making informed decisions based on concrete data. “

2.4 The media organisation specializing in IoT, IoT For All describes[5] “Smart farming as an emerging concept that refers to managing farms using modern Information and Communication Technologies like IoT, robotics, drones and AI to increase the quantity and quality of products while optimizing the human labor required by production. They specifically identify sensors, software, connectivity, location (gps, satellites etc.), robotics and data analytics as the technologies that can be used for smart agriculture. Further they specify Precision Farming or agriculture, as “an umbrella concept for IoT-based approaches that make farming more controlled and accurate. In simple words, plants and cattle get precisely the treatment they need, determined by machines with superhuman accuracy. The biggest difference from the classical approach is that precision farming allows decisions to be made per square meter or even per plant/animal rather than for a field.” In fact, they go on to claim that smart farming is paving the way for what they call the ‘third green revolution’ in agriculture due to its potential

3 https://ispag.org/site/newsletter/?id=90

4 https://www.biooekonomie- bw.de/en/articles/dossiers/digitisation-in-agriculture-from-precision-farming-to-farming-40

5 https://www.iotforall.com/smart-farming-future-of-agriculture/

to deliver a more productive and sustainable form of agricultural production which is also beneficial for the environment, though, for example, more efficient use of water, or optimization of treatments and inputs.

2.5 Smart Farming[6] is a farming management concept using modern technology to increase the quantity and quality of agricultural products. Farmers in the 21st century have access to GPS, soil scanning, data management, and Internet of Things technologies. By precisely measuring variations within a field and adapting the strategy accordingly, farmers can greatly increase the effectiveness of pesticides and fertilizers, and use them more selectively. Similarly, using Smart Farming techniques, farmers can better monitor the needs of individual animals and adjust their nutrition correspondingly, thereby preventing disease and enhancing herd health.

2.6 According to Emerj AI Research, Artificial Intelligence (AI) is steadily emerging as part of the technological evolution in agriculture and can be categorized into 3 main groups[7]:

- Agricultural Robots – to replace human labor intensive tasks by robots
- Crop and Soil Monitoring – leverage computer vision and deep-learning algorithms to monitor crop and soil health.
- Predictive Analytics – develop and use machine learning models to track and predict various environmental impacts on crop yield such as weather changes.

2.7 European Agricultural Machinery Association (CEMA) defines[8] Agriculture 4.0, as "integrated internal and external networking of farming operations. This means that information in digital form exists for all farm sectors and processes; communication with external partners such as suppliers and end customers is likewise carried out electronically; and data transmission, processing and analysis are (largely) automated. The use of Internet-based portals can facilitate the handling of large volumes of data, as well as networking within the farm and with external partners." The same report goes on to mention that Agriculture 5.0 will be based around robotics and (some form of) artificial intelligence.

2.8 Digital farming is integrating both concepts - precision farming and smart farming. According to a paper[9] on Digital Agriculture by DLG (German Agricultural Society), digital

6 https://www.schuttelaar-partners.com/news/2017/smart-farming-is-key-for-the-future-of-agriculture

7 https://emerj.com/ai-sector-overviews/ai-agriculture-present-applications-impact/

8 https://www.cema-agri.org/images/publications/position-papers/CEMA_Digital_Farming_-_Agriculture_4.0__13_02_2017_0.pdf

9 https://www.agrocares.com/en/news/precision-digital-smart-farming

farming is understood to mean "consistent application of the methods of precision farming and smart farming, internal and external networking of the farm and use of web-based data platforms together with Big Data analyses".

2.9 Thus, if we carefully look at the above definitions of Agriculture 4.0, Digital Agriculture, Precision Agriculture and Smart Agriculture, we find that these are overlapping concepts and a clear compartmentalized definition is difficult to establish. Taken together, Precision Agriculture and Smart Agriculture constitute Digital Agriculture. The concepts of Agriculture 4.0 and 5.0, AI in Agriculture area also constitute Digital Agriculture. In this paper, we stick to this comprehensive definition of digital agriculture as covering all the aspects and concepts of precision agriculture, smart agriculture, use of ICT in Agriculture extension and use of AI and robotics in Agriculture.

3.0 Applications of Digital Agriculture:

3.1 There are a wide variety of applications and use of digital technology in Agriculture. Some examples and possibilities are listed below.

3.2 AgroPad: AI-powered technology helping farmers check soil and water health. AgroPad[10], developed by IBM, is a paper device about the size of a business card. The microfluidics chip inside the card performs on the spot a chemical analysis of the sample, providing results in less than 10 seconds. A drop of water or soil sample is placed on the AgroPad and the set of circles on the back of the card provide colorimetric test results; the color of each circle represents the amount of a particular chemical in the sample. Using a smartphone, the farmer can then take a single snapshot of the AgroPad by using a dedicated mobile application and immediately receive a chemical test result for a water or soil sample.

3.3 Plantix and crop disease identification over WhatsApp: Developed by PEAT, a German startup, Plantix[11] is a mobile application, which is a massive database of pictures of plant disease that can be used for comparison. This helps in identification and subsequent diagnosis and treatment. PEAT aims to support farmers across the world to enhance their agricultural output through timely and informed disease treatment. The facility is now also available[12] over WhatsApp where just an image of the infected leaf is required to be sent to the Plantix WhatsApp number and the diagnosis is messaged back to the sender via WhatsApp in real time and many farmers in India are using this service.

10 https://www.ibm.com/blogs/research/2018/09/agropad/

11 https://www.networkedindia.com/2016/10/11/german-startup-peats-plant-disease-app-empowering-indian-farmers/

12 https://plantix.net/en/blog/plant-disease-detection-whatsapp

3.4 Pay per use based farm tech and mechanization: Trringo[13] and EM3 Agriservices are the 2 pioneers of farm equipment rental service. They can be called the ubers of the Agriculture sector and have successfully replicated the uberisation of renting farm machinery and tractors in India. Using their services, through a mobile application or a phone call, farmers can rent their required farm machinery on a pay per use basis thus saving them time and ensuring reasonable costs while reducing uncertainty around availability. EM3 calls its app Samadhan[14] (Hindi for Solution) and categorises it as Farming as a Service (FaaS) that 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. These centres are managed through IT enabled systems and manned by agri-professionals and equipped to handle a comprehensive suite of basic and precision farm operations throughout the entire crop production cycle.

3.5 Use of drones to fight locusts in India: Locusts have been attacking[15] and destroying large swathes of India's crops on a regular basis since the winter months of 2019 and the attack is continuing. The Agriculture Ministries both at the federal level and the state levels have been using drones for anti-locust spraying. They are proving to be effective[16] solution in an otherwise challenging scenario where India stares at large amounts of crop loss[17] in the states of Rajasthan, Gujarat, Madhya Pradesh and Uttar Pradesh.

3.6 Use of drones for rural property mapping in India: The Government of India recently launched the 'Swamitva[18] scheme' under which Drones will draw a digital map of every property falling within the geographical limits of a village and demarcate the boundaries of every revenue area. Property card for every property in the village will be prepared by states using accurate measurements delivered by such drone-mapping. These cards will be given to property owners and will be recognised by the land revenue records department which will enable the property holders to access formal finance from bank by using their property as collateral. It can have positive implications for agriculture because asset light rural citizens as

13 http://www.trringo.com/farmers.php

14 http://www.em3agri.com/

15 https://indianexpress.com/article/explained/the-difference-between-a-locust-plague-upsurge-and-outbreak-6492132/

16 https://economictimes.indiatimes.com/news/economy/agriculture/agriculture-ministry-eyes-drones-for-night-duty-in-locust-fight/articleshow/76681161.cms

17 https://www.financialexpress.com/lifestyle/science/locust-swarms-attack-centre-lists-out-various-measures-taken-curb-the-menace/2020812/

18 https://www.hindustantimes.com/india-news/what-is-swamitva-yojana-launched-by-pm-narendra-modi-all-you-need-to-know/story-UpshkST02eW59ZGsF9jxLK.html

well as non-land owning farmers would stand a chance to access formal and cheaper financing by using their property as collateral.

3.7 Grain Bank Model of 'Ergos': Ergos has one of the most unique models in the Agri-tech landscape. They have a "Grain Bank model" that is providing doorstep access to end-to-end post-harvest supply chain solutions to small and marginal farmers, i.e. enabling farmers to convert their grains into tradable digital assets, avail credit against those assets through partner NBFCs and Banks, and get better prices for their produce. The Ergos model offers farmers the flexibility to store/ withdraw a single bag of grains. Farmers get immediate liquidity and better income, as they don't have to sell all their produce at once at the prevailing market rates during harvest season. Through an efficient use of technology and direct farmer engagement, they provide the following services to farmers at the farmgate presently in the state of Bihar.
Storage – Ergos has a network of scientifically managed micro-warehouses at the farm gate, where farmers can store even a single bag of grains.
Credit availability – Post harvest, farmers need liquidity. With Ergos they have an option to take credit against the value of stored grains from partner lending institutions.
Market linkage – Farmers can sell even a single bag of grains stored with Ergos, for immediate liquidity. Ergos aggregates the demand from buyers and supply from farmers and offers farmers market linkage to sell their stored grains at a fair price.

3.8 Quality Assessment using technology: AgNext[19] produced a technology platform Qualix, to assess trade quality and safety parameters for multiple commodities (grains, pulses, tea, spices, herbs, milk and honey etc.) in a minute. It is a platform for introducing rapid quality estimations in agriculture and food value chain through technologies like AI based spectral and AI based image analytics using a mix of hardware, software and data analytics. Thus their solution, they claim, helps in identifying chemical and physical composition of grains such as wheat, rice, pulses, maize and oilseeds in less than a minute with the help of a small pocket sized device. Using the same Bluetooth enabled, battery operated hand held device, which works in coherence with a mobile application, the chemical composition of milk and honey can be identified to detect the presence of adulterants. The same device also checks fat%, protein, lactose and SNF content in a milk sample.

3.9 Digital tools for agriculture farm monitoring and risk management: Yuktix Technologies is an Agritech startup based out of Bangalore that focuses on creating digital tools for agriculture farm monitoring and risk management. The solution helps growers make decisions and implement best practices that increase yield and cut losses. The tools are powered by their hardware and software solution that they call GreenSense IoT devices and GreenSense dashboard. Yuktix GreenSense is an off grid remote monitoring and analytics solution for

[19] https://agnext.com/product.html#qualixsection

agriculture. GreenSense nodes with dashboard provide an effective tool for monitoring and DPI (Disease, pest, and irrigation) management. Their solar powered weather stations provide real time weather conditions anytime from anywhere. For instance, in Odisha they deployed a network of Yuktix micro-weather station to collect data from different locations, use existing indigenous knowledge, combine it with research to provide a digital tool that helped them distribute crop specific advisory to a group of tribal farmers to use climate smart agriculture practices.

4.0 Contextualising Digital Agriculture in India:

4.1 To understand the challenges associated with digital agriculture in India, let us consider a typical Indian farm and how it compares with the average farm in the US, Australia and Europe. The average farm in US in Hectares is 179[20] , in Australia, it is 4331[21] and in Europe, it is 16.1[22] while that in India, it is 1.08[23] Hectares. This disparity implies huge implications for how Digital Agriculture can be implemented in India. It means that Digital Agriculture has to be customized to be applicable to a typical Indian small farm if we want Digital Agriculture to be scalable and be available to a majority of Indian farms.

4.2 Business Insider[24] Intelligence projects there to be nearly 12 million agricultural sensors installed globally by 2023. Additionally, tech giant IBM estimates that the average farm can generate half a million data points per day – helping farmers to improve yields and increase profits. Even though the typical Indian farm is very small and it may generate substantially lesser data points yet millions of data points, to suitably aggregate and analyse, would require computing, storage and processing power which would come at a cost; thus still there is some distance to be travelled here for Indian farms.

4.3 Precise financial estimates of the cost of technology per unit of land/ per individual farmer and corresponding savings/ return on investments are not available yet in Indian context which make it doubly difficult for anyone to evaluate the technology from the perspective of economic aspects.

20 https://www.nass.usda.gov/Publications/Todays_Reports/reports/fnlo0419.pdf

21 https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/7121.0Main+Features12015-16#:~:text=Average%20farm%20size%3A%204%2C331ha,of%20107%20megalitres%20of%20water.

22 https://ec.europa.eu/eurostat/statistics-explained/pdfscache/1191.pdf

23 https://pib.gov.in/newsite/PrintRelease.aspx?relid=199780

24 https://www.businessinsider.com/smart-farming-iot-agriculture?IR=T

4.4 Thus for Digital Agriculture to succeed in India the innovations must focus on:

4.5 Low cost technology: Lowering the cost of technology so that it is available and affordable for the smaller farmers: The average income of a farmer in India is estimated at Rupees 77,976[25] (approx. 1000 US dollars) per year, according to the Dalwai committee report. This figure is itself explanatory of the precarious financial circumstances in which a typical farmer operates in India. Thus it is natural that for the farmer, his or her ability to invest financially in technology is very limited. Keeping this aspect in mind, it is imperative that the technology that is affordable as well as can provide financial returns in quick turnaround time (say a crop season), will be attractive to farmers.

4.6 Easily portable hardware: Plug and play hardware (ensuring mobility) has better chances of succeeding in India: As we have already mentioned, typical Indian farms are very small in size and 1-2 acres farm plots are the most common. Also, agricultural land leasing under various arrangements is widely prevalent in India. Thus, its commonplace to find that 1 season a farmer is farming on a particular plot of land but the next season the same farmer may shift to another farm plot. In such a scenario, equipment which is plug and play (that which can be easily installed and reinstalled and used for multiple locations during its lifetime) would definitely be more attractive for the farmer to pay and invest in.

4.7 Renting and sharing platforms for agriculture equipment and machinery: Due to both limited financial resources and small farm plots, renting and sharing platforms rather than outright purchase for equipment and machinery like tractors, harvesters etc. make eminent sense. As we have already mentioned, agriculture technology (‘agtech’) startups like EM3 Agriservices as well as Trringo are already extending their services and the market is very big and still wide open for scaling up in this respect of Digital Agriculture.

4.8 Policy reorientation towards facilitating Digital Agriculture: In recent times, there has been a focus on technology from the government side in India for the welfare of farmers. The direct income support schemes of the several state governments as well as the federal government spurred the focus on data about the numbers and identification of farmers to be supported through cash transfers directly in their bank accounts. These schemes required a digital database of farmers with certain details so that they could be implemented in short period of time. This implementation exigency was not possible by using the legacy paper based systems of data collection. To be sure, the unique biometric identifier, Aadhaar has also played a key role in facilitating the data collection and quick implementation and a digital farmer database was generated. Now, making use of such a database, one of the states, Telangana, which

25 https://www.financialexpress.com/budget/economic-survey-2017-18-agriculture-climate-change-likely-to-lower-farmers-income-by-25/1035560/

pioneered the direct income support scheme Rythu Bandhu[26] is moving towards regulated farming. As per the scheme[27] announced, the government would guide farmers on the choice and extent of crops to be cultivated in a particular area based on analysis of different parameters, supply, demand and price forecasts at the time of harvest. The Rythu Bandhu income support payout and purchase of output by the government at Minimum Support Prices has been linked to the farmers following this advisory. This is a first attempt at regulated farming in India. This has been made possible only because of a robust digital agricultural database and goes on to show the potential of harnessing data for betterment of Agriculture.

4.8.1 Further, recent developments in the Agriculture policy space have the potential to give a fillip to Digital Agriculture in India. The changes in Agriculture policy aiming to open the agriculture marketing to private players, corporates and end the monopolies of mandi (state regulated market yards) as the only avenue for the farmer to sell his produce, promote contract farming, end controls by amending the essential commodities act and the formation and promotion of Farmer Producer Organisations (FPOs) have far reaching potential as far as Digital Agriculture goes.

4.8.2 The first change seeks to provide for the creation of an ecosystem where the farmers and traders enjoy the freedom of choice relating to sale and purchase of farmers' produce which will promote efficient, transparent and barrier-free inter–State and intra-State trade and commerce of farmers' produce also outside the physical premises of markets or deemed markets notified under various State agricultural produce market legislations. Besides, the Ordinance will provide a facilitative framework for electronic trading also[28]. This opens the market for various players that want to use Digital channels to rationalize the value chain from the farm gate to the end consumer.

4.8.3 The second policy change seeks to provide for a national framework on contract farming agreements that allows agri- business firms, processors, wholesalers, exporters or large retailers to directly engage with farmers towards production and purchase agreements. This opens the field for these entities to support the farmers in production using the latest technologies and advisory including Digital tools and advisory.

4.8.4 The third step to amend[29] the essential commodities act and deregulate holding, movement, distribution and supply of food items will lead to harnessing of economies of scale

26 https://government.economictimes.indiatimes.com/news/policy/telangana-government-to-decide-which-crop-to-be-grown-in-each-district-under-regulated-farming-policy/75889636

27 https://telanganatoday.com/telangana-to-regulate-farming

28 https://pib.gov.in/PressReleasePage.aspx?PRID=1629750

29 https://pib.gov.in/PressReleseDetail.aspx?PRID=1629869

and attract private sector/foreign direct investment into agriculture sector. It will help drive up investment in cold storages and modernization of food supply chain and this will ultimately help the farmers to grow more and hence help them increase the income. Cold storages, warehousing and transportation are the sectors where Digital Technology can play a major role in driving overall efficiency and reducing costs thus benefiting all stakeholders from farmers to end consumers.

4.8.5 Finally, the biggest opportunity for Digital Agriculture across the entire agriculture vale chain from the upstream (inputs and production processes) to the downstream (post-harvest and value addition including food processing) is with the emergence of FPOs[30] in India. These FPOs are the vehicle for consolidating farmers, their production as well as the marketing of the produce. Both precision agriculture technologies as well as smart agriculture, that is, the full spectrum of technologies under Digital Agriculture have the potential to be deployed for FPOs because consolidated and consequently bigger land parcels are available for technology rollout. At the same time, technology becomes affordable and widely available through the medium of the FPO for even the smallest of the farmer creating a win-win for all stakeholders.

4.9 Further, our extension services and agriculture related academic institutions should also reorient themselves towards digital agriculture because they are the people who are interacting with farmers for introducing anything new.

4.10 Overall, the scenario for Digital Agriculture is promising in India. The key factors that will determine the success of Digital Agriculture in India are affordability of technology, ease of access and operations, easy maintenance of systems, timely grievance redressal and appropriate policy support. There is also need for robust research and development that also factors in last mile delivery and ground challenges so that Digital Agriculture can empower Indian farmers in a meaningful way.

References:

- Gurumurthy A. and Bharthur D., Taking Stock of AI in Indian Agriculture, August 2019. IT For Change

- Mahindru T., Role of Digital and AI Technologies in Indian Agriculture: Potential and way forward, September 2019. Niti Aayog, Government of India

30 https://economictimes.indiatimes.com/news/economy/agriculture/narendra-singh-tomar-releases-new-guidelines-for-setting-up-10000-fpos/articleshow/76899255.cms