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Digitalization of Agriculture in India: Advocating for Doubling Farmers' Income

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Abstract
The COVID-19 pandemic has underscored the necessity for a more resilient, efficient, productive, lucrative, and sustainable agricultural sector. Consequently, the Government of India has prioritized the optimal utilization of advanced technologies to ensure uninterrupted food security and empower farmers by doubling their income. This paper delves into the digitization of Indian agriculture to add value to the farming community and expand opportunities for doubling farmers' income. It examines the application of various digital technologies aimed at increasing farm yield, enhancing farm-level decision-making, optimizing resource utilization, and ultimately boosting the incomes of smallholder farmers. Utilizing an analytical approach, this paper draws insights from a survey of literature, relying on secondary sources such as books, research articles, policy documents, reports from government and non-government organizations, online databases, and discussion papers. The paper advocates for policymakers to concentrate on doubling farmers' income across different stages of food production and the supply chain.

Keywords: COVID-19, agriculture, digitalisation, digital technologies, doubling farmers' income, public policy.

1. Introduction

Agriculture has been the oldest and the most labour -intensive profession. It has become more vulnerable to disruptions like the COVID-19 pandemic. An estimate projects that there will be a 50 per cent increase in food requirements due to the addition of new 2 billion people on earth by 2050. It is challenging to provide food security to all from the same quantity of agricultural land (12 per cent of global land) (FAO, 2011). The adverse impact of such vulnerabilities will be severe in India, where the majority (86 per cent) of farmers are small and marginal. The Indian food supply chain faces unprecedented shocks at every stage, beginning from pre-production and production to postproduction (Department of Agriculture & Farmers Welfare, 2021). Besides, the natural uncertainties due to climate change and risks associated with unsustainable agriculture practices have also increased distress in agriculture. The unfavourable changes in crops or sudden pest attacks due to climate change force farmers to increase the use of pesticides. These chemical fertilisers ultimately lead to environmental degradation and a high cost of production (Khandelwal, 2021) (Table 1). Agriculture has therefore become the policy issue for policymakers to ponder and frame policies to make it more sustainable. There are three critical challenges before the policymakers. One is to make farming a remunerative profession; the second is to ensure food security to citizens, and the third is to increase the resilience of food production and supply chain to withstand the disruptive situation.

Table 1: Impact of COVID-19 on the agriculture sector

Agriculture Value Chain Phase	Key disruptions	Key impacts on actors
Inputs	-Increased prices -Shifts in market demand for products led to demand for different inputs -Closure of shops including agri-businesses	-Inability to purchase inputs, inability to pay for logistics -Loss of income and liquidity for input dealers
On-farm production	-Inaccessible equipment rentals	-Inability to hire adequate labour or machinery for harvest, planting, processing leads to crop wastage and seed consumption
Post-harvest: storage	-Closing of warehousing	-Loss of income by warehouse actors
Access to markets	-Decreased local and overseas markets -Shifts in product demand	-Strained customer/buyer relationships

Source: Adapted from *(Payne & Willis, 2021, p. 13)*

Indian agriculture has minimal use of digital technologies in food production systems despite having a strong IT industry base and advancement in satellite technology. It is argued that comprehensive digital interventions are required for resilience and innovation to increase land productivity and ensure the overall sustainability of agriculture, i.e. economic, environmental and social (Khandelwal, 2021).

2. Materials and methods

2.1 Sources

The researchers consulted secondary sources such as books, research articles, policy documents, reports published by government and non-government organisations, online databases, and discussion papers for this paper. Literature includes the reports of World Bank, Food and Agriculture Organisation (FAO), United States Agency for International Development (USAID), Organization for Economic Cooperation and Development (OECD) and policy documents of various committees appointed by the Government of India (GoI), Annual Report of Ministry of Agriculture and Farmers' Welfare, Confederation of Indian Industry (CII), Government of Maharashtra. This paper surveyed the literature on the digitalisation of the agrifood system and increasing farmers' income in India.

2.2 Methodologies

The researchers adopted the qualitative research method to conduct the study. The paper analyses the scope of application of advanced digital technologies in agriculture. The primary contribution of the present paper involves a review of policy initiatives by the GOI and finding policy gaps in the process of digitalisation of agriculture. This paper suggests the principles to integrate digital technologies in the agrifood system for maximising the impact of digitalisation to enhance farmers' income.

3. Discussion

The present disruption due to the COVID-19 is accelerating and forcing the government to use digital tools, services and new technologies such as Artificial Intelligence (AI), machine learning, remote sensing, Internet of Things (IoT), and digital platforms. The different stakeholders of food production and supply chain, starting from farmers, input providers, retailers, exporters to consumers, are adopting digital solutions in their day to day working as there is no other better alternative. In other words, they are left with no option other than the digital transformation to maintain continuity in the unprecedented disruptive situation (Payne & Willis, 2021). The next section explains various digital approaches which can be used in agriculture to double farmers' income in India.

4. Digital Approaches in Agriculture

There are broadly four categories of digital approaches used in the agriculture sector: 4.1 Data-Driven Agriculture, 4.2 Precision Agriculture, 4.3 ICTEnabled Extension, and 4.4 Digital Financial Services (USAID, 2018, p. 10).

4.1 Data-Driven Agriculture

Digitalisation in agriculture begins with data collection from agriculture inputs and environmental factors. The availability of accurate data is crucial for realising goals of digital agriculture in the country. The data comprises of satellite images, soil health information, land record, season-wise cropping pattern, market-related data, and the farmers' data. Central and state government can collect such data from different sources for data-driven policy intervention in agriculture.

There are many advantages of data. Data collected from satellites is applied in land use, land cover classification, and crop characterisation. Similarly, data gathered from instruments implanted on drones/Unmanned Arial Vehicles (UAV) is a cost-effective alternative for high-resolution satellite imagery. It is used for Geographic Information System (GIS), topographic mapping, terrain modelling, and dedicated surveying purpose (Confederation of Indian Industry, 2021, p. 9). Data related to weather is collected through satellite, and after analysis, weather information is disseminated on digital platforms and smartphones. Farmers can access real-time weather-related data on smartphones, which help them plan agricultural activities (Government of Maharashtra, 2021). According to International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), farmers who followed Sowing App advisories experienced an average yield increase of 30 per cent compared to farmers who delayed their planting due to a lack of information (Manfre & Laytham, 2018).

4.2 Precision Agriculture (PA)

The objective of Precision Agriculture (PA) is to enhance agricultural production through the optimisation of input resources for achieving economic and environmental dimensions of sustainability. Small farmers' income can be improved by enhancing crop yield, water, and efficient use of resources. More accurate farm-level decision making and harnessing the potential of a data platform linked with drones, satellites, and IoT sensors fixed at the ground would contribute significantly to the doubling of farmers' income.

The Internet of Things (IoT) has various applications in the agricultural sector, as this technology uses a network of sensors and other devices to transform actions or processes into data. IoT-enabled devices can track the stock and flow of water and measure water flow for irrigation (Yadav et al., 2020, p. 11). The studies show that the application of IoT in the USA increased the per hectare crop yield by 2 per cent and reduced water requirement for irrigation by 8 per cent along with the conservation of energy (Government of Maharashtra, 2021) (Sarni et al., 2016).

4.3 Digital Agriculture Extension

Many farmers do not have any authentic source for updated information regarding extreme climate occurrence such as droughts, storms, floods, and other natural calamities (Rajkhowa, 2021). Digital agriculture extension employs digital tools and services that are used used to deliver information effectively. Short Message Service (SMS), Interactive Voice

Response (IVR), interactive radio, low-cost video are generally used by the extension workers to reach a large number of farmers in a short period for providing extension services like timely reminders and alerts, weather forecasting best practices for enabling farmers to enhance productivity. The traditional way of extension, which includes person-to-person information sharing, is costly and time-consuming, and it may not create value for the farming community. However, with the help of digital technology, the scope of extension can be enhanced (USAID, 2018).

It is necessary to provide the correct information to make an informed decision and realise their full potential. At every stage of the cropping cycle, the information provider must be well connected with the farmers. Thus, digital technologies enable the creation of farmers' networks and keep connected with the service/ advisory providers (Yadav et al, 2020, p. 3)

Figure 1: Empowerment of Farmers

Digital extension services are helpful for the following reasons, (i) they can be adapted to the local context, (ii) Demand-driven and farmer-led, (iii) Market-oriented, (iv) Pluralistic (involve multiple actors), (v) Accountable, (vi). Sustainable, g. Scalable (USAID, 2018). In India, using technologies in agriculture has resulted in a 34.63 per cent increase in yield (Mittal & Mehar, 2012). A study shows that there are advantages of issuing advisory to the farmers through digital platforms. For instance, it reduces the input use by 15 to 20 per cent; increases crop productivity by 18 per cent and commercialisation by 5 to 7 per cent. In nutshell, it results in an increase in farmers' income by 25 to 29 per cent (Rajkhowa, 2021).

4.4 Digital Financial Services (DFS)

Digital Financial Services (DFS) became a reality after implementing the JAM trinity in India, i.e. Jan Dhan bank accounts, Aadhar card and availability of mobile phones in both urban and rural areas (Economic Survey, 2016). Direct Benefit Transfer (DBT) scheme leverages digital technologies to link the Aadhaar card (the 12 digits unique identity number based on biometrics) with the farmers' bank account and land record. This enables the provision of input credit directly to the small farmers, digital headcount of livestock, monitoring and analysing their health through RFID (Radio Frequency Identification) and micro-chips based ear tags. Similarly, digital barcodes are used to trace fruits and vegetables for their source of origin. In the electronic National Agricultural Market (e-NAM), digital technologies such as digital platforms are used to link farmers with a national level market without any hurdle (Ministry of Agriculture and Farmers' Welfare, 2018).

Pradhan Mantri Kisan Saman Nidhi (PM-KISAN) has eased the process of providing input credit to farmers in their Aadhar linked bank accounts directly without any bureaucratic interference and documentation process (Varshney et al, 2020). Many state governments also used the DFS approach to provide input subsidies, post-disaster help and loan waiver to the farmers, which reduced fraud claims and corruption. Through Pradhan Mantri Fasal Bima Yojana (PMFBY), the Government of India has been incorporating the DFS for maximising the impact of insurance service in the agriculture sector. The use of drones has accelerated the agri-insurance claim process. The crop damage is assessed by using drones, increasing accuracy and speed in settling insurance claims (Government of Maharashtra, 2021, p. 6). Drones are used to assess the crop damage, which in turn would increase accuracy in document verification.

In Bihar, 98 per cent of the goat rearing is done by women. These women are the poorest of the poor, and they cannot afford half an acre of land. Instead, they graze their goats. They are using mobile phones to upload photos of their goats on eBay-like sites to increase their potential market, reach buyers who are 800 kilometres away. They fetched 20 to 47 per cent more per head for their goats due to use of mobile phones (Boettiger & Sanghvi, 2019).

5. Food Traceability and Resource Optimization

Food traceability is crucial for consumer satisfaction for "safe and nutritious food". Digital platforms enable it by providing real-time information about where, when, and who cultivate the crop, i.e. journey of food produce from pre-harvest to marketplace. Digital technologies such as IoT and Blockchain transform food supply chains by enabling traceability and consumer satisfaction. Transparency of the food production system can be maintained through digital technologies. This would help gain consumers' trust and reduce wastage in the food supply chain by decreasing the supply-demand mismatch. It is estimated that integration of the food production and supply chains from farmers to end consumers will require production of food which is 25 per cent less than the current food production (Khandelwal, 2021).

It is noteworthy that the case study of the banana value chain in India highlighted the positive impact created by integrated value chains. A decade ago, India did not have a substantial share in the global market despite being the world's largest producer of bananas. Lack of integrated value chain, infrastructure, and standard practices increased wastage and low shelf life. After creating infrastructure, end-to-end traceability and packaging innovations enhanced the shelf life by over 50 per cent. The application of technology reduced wastages to below 2 per cent, which is better than any world benchmark. Finally, this resulted in the doubling of farmers' income (Khandelwal, 2021). The next section discusses the efforts of Government of India in digitalising agriculture to double farmers' income.

6. Digitalisation of Indian Agriculture

The report on doubling farmers' income by 2022 advocates for the adoption of digital technologies in agricultural practices it will help in boosting farmers' income. To achieve the vision of the Self-Reliant India Movement and Sustainable

Development Goals (SDGs), the transformation of traditional agriculture into digital agriculture is imperative. Government of India's Digital Agriculture Mission (2021-2025) and consultation paper on Digital Agriculture Ecosystem are the essential steps towards the digitalisation of Indian agriculture.

Farmers are the main stakeholders in the food production and supply chain as producers. Thus, it will be challenging to achieve and sustain food security without ensuring farmers' well-being and satisfaction. Policymakers have to focus on the empowerment of the farming community by making farming a more remunerative, easy, secure, respectable, attractive, and less risky profession, ultimately generating food security as a by-product.

Digitalisation has the potential to make agriculture policy more effective in minimising the undesired impacts and maximising the benefits of farming. The digital agricultural policy replaces the technologies used in traditional farm policy. It offers newer alternatives for an agricultural policy: real-time databased or more evidence-based policy interventions for effectively addressing the challenges in the agriculture sector. Thus digitalisation is shifting the agriculture policy from direct intervention to information-based governance, which will increase the policy outcomes and ultimately secure the trust of farming communities and will maximise their satisfaction (Ehlers et al, 2021).

7. Digitalization of Indian Food Production and Supply Chain: Policy and Practices

According to the Indian Agricultural Census 2015-16, 86 per cent farmers in India are small and marginal farmers (Department of Agriculture & Farmers Welfare, 2021).

Table 2: Types of Farmers

Sr. No.	Type of farmers	Percentage	Landholding
1	Marginal Scale Farmers	68.45	Up to 1 Hectare
2	Small Scale Farmers	17.62	1<=2 Hectare
3	Semi-Medium Scale Farmers	9.55	2<=4 Hectare
4	Medium Scale Farmers	3.80	4<=10 Hectare
5	Large Scale Farmers	0.57	10<=20 Hectare

India has a diverse geographic area that includes 15 Agro-Climatic Regions and 127 Agro-Climatic Zones. The generalised agri-advisories are insufficient to advise farmers in agricultural practices. The requirement of each crop and farmer is different from others. Therefore, the personalised or targeted, timely, Agro- Climatic Zone specific extension service is required to enhance production and mitigate various types of risks in the agricultural sector (Madaswamy, 2020). The Doubling Farmers' Income by 2022 Report (2018), discusses the science and technology-based interventions and advocate for the shifting focus from the "Science of discovery to science of delivery" (Ministry of Agriculture and Farmers' Welfare, 2018). The Government of India has laid the first stepping stone towards the digitalisation of the agriculture sector in 1987 by launching "District Information System on Agricultural System (Agriculture, Animal husbandry and Fisheries)Agricultural information System (AGRIS) project with "Village as its basic Unit." This initiative was launched with the help of the National Informatics Centre (NIC) in more than 520 districts of the country. Thus leveraging a mix of available advanced technologies to reduce costs and increase ICT use in the agriculture sector for its development is essential (Rao et al, 2016).

8. Farmers' Database

The centralised and land record linked database of farmers across the country will benefit from better planning, monitoring, policy-making, strategy formulation and smooth implementation of different central and state-level agriculture-related schemes for the empowerment of farmers (Ministry of Agriculture & Farmers Welfare, 2021).

The Committee for Doubling Farmers Income Report by 2022 (2018) has suggested policy measures for increasing the farmers' income. The volumes (3, 4, 11 and 12) of this report highlighted the application of digital technologies in different stages of food production and supply chain in India. The volumes that are relevant to the integration of digital technologies in agriculture are as follows:

i. Volume 3: "Post-production Agri-logistics: maximising gains for farmer" **ii.** Volume 4: "Post-production interventions: Agricultural Marketing"

iii. Volume 11: "Empowering the Farmers through Extension & Knowledge Dissemination"

iv. Volume 12: "Science for Doubling Farmers' Income- Digital Technology in Agriculture" (Ministry of Agriculture and Farmers' Welfare, 2018).

The Ministry of Agriculture and Farmers' Welfare signed 5 Memorandum of Understanding (MOU) with private companies (CISCO, Ninjacart, JioPlatforms Limited, ITC Limited and NCDEX e-markets Limited (NeML)) in 2021 for promoting digital agriculture in India. The Ministry also launched Digital Agriculture Mission (DAM 2021-25) for initiating projects which involve digital technologies such as Artificial Intelligence (AI), Block Chain, Remote Sensing (RS) and GIS, Drones/UAV and Robotics. The purpose of these new initiatives is to provide inputs to farmers and stakeholders of food production and supply chain for making informed decisions on the selection of crops for cultivation, improved variety of seeds, available best practices for maximising output, procurement, transportation and storage (Ministry of Agriculture & Farmers Welfare, 2021).

In 2017, The Department of Agriculture & Farmers Welfare had merged different space technology initiatives related to agriculture (such as Crop Assessment & Monitoring, Agricultural Resources Management, Disaster Monitoring and Mitigation and Satellite Communication and Navigation Applications) under one programme, named as "National Programme on use of Space Technology for Agriculture (NPSTA)" (Ministry of Agriculture & Farmers Welfare, 2017).

9. Concluding remarks

India has digitally intervened in the agriculture sector through its policies and project. However, India lags in adopting digital technologies at the farm level as most of the initiatives are limited to governance purposes and provide information to farmers (Confederation of Indian Industry, 2021). The Report on Doubling Farmers Income by 2021 emphasised the introduction of emerging advanced digital technologies in agriculture. However, any government-led initiative will be successful when it receives maximum public participation. An ecosystem has to be created to digitalise agriculture in India. It is essential to promote digital literacy among youth in rural areas for unleashing the full potential of digital technologies. Institutions play a significant role in assimilating new technologies into society. It is required to upgrade the existing agriculture extension system. Agricultural institutions like State Agricultural Universities or Krishi Vigyan Kendras (KVKs) are essential to disseminate unformation related to Digital Agriculture technologies.

Data acts as a fuel for digital agriculture practices as it is the life source of digital technologies (such as AI, Satellite Image processing). Accurate and updated data on weather conditions, soil type, market, crop variety, crop yield is required to develop and implement innovations and interventions. There is a need to create a trusted and centralised digital data repository to enable efficient data access to different stakeholders, which will help reduce time and cost for digital intervention. Further there is a need for data sharing, data validation and interoperability and data privacy mechanisms. It is essential to create data-driven solid policies and regulatory agencies for facilitating standardisation and interoperability. Finally, digital infrastructure such as internet connectivity, mobile phone network, and the cost of internet and digital devices are crucial for the farming community's extensive adoption and continuous use of digital technologies. People in rural areas still do not have access to basic facilities like all-season roads, regular electricity and clean drinking water. Thus, creating digital infrastructure in a rural area may take time, which may delay the digitalisation of the agriculture sector. Policymakers must prioritise the rapid creation of digital infrastructure in rural areas and promote the development of AgriTech startups in each Gram Panchayat (GP) to get benefits of new technologies to farmers and increase their income. The existing COVID-19 pandemic offers an opportunity to accelerate digital technologies' adoption in agriculture. The time is apt to transform traditional agriculture into digital agriculture and create "e-Farmers" or "Smart Farmers" in India.

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