Administrative Development: A Journal of HIPA, Shimla. Vol. VIII (SI-1), 2021

HARNESSING DIGITAL AGRICULTURE TECHNOLOGIES FOR SUSTAINABLE AGRICULTURE IN INDIA: OPPORTUNITIES AND CHALLENGES

Dr. Jeevan Kumar Cheruku[*] & Vishal Katekar[†]

Abstract

Agriculture in India faces an unprecedented challenge. As a signatory to Sustainable Development Goals (SDG), India must end hunger by 2030. Achievement of this goal hinges on finding viable solutions to make farming a sustainable source of income generation by adopting sustainable agricultural practices. A survey of the literature reveals that digital technologies offer promising results to farmers globally. However, India lags in the adoption of digital technologies in agriculture. The paper identifies opportunities in promoting the development and adoption of digital agriculture technologies. It analyses policy interventions of the Government of India, such as Digital Agriculture and Precision Agriculture, to make the agriculture sector more sustainable in terms of economic, environmental, and societal perspectives. This research paper discusses barriers to their adoption and provides policy suggestions. It is an analytical paper based on a survey of literature that is secondary sources such as books, research articles, and policy documents, reports published by various government and non-government organizations, online databases, and discussion papers. Thematic analysis was used to identify sustainable agriculture dimensions and discover opportunities and challenges in using digital agriculture technologies.

[*]*Assistant Professor, Department of Public Policy, Law and Governance, Central University of Rajasthan, Bandarsindri, Ajmer, Rajasthan, India, (Corresponding Author) Email: jeevan_pplg@curaj.ac.in*

[†]*Research Scholar, Department of Public Policy, Law and Governance, Central University of Rajasthan, Bandarsindri, Ajmer, Rajasthan ,India, Email: 2019phdpplg05@curaj.ac.in*

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

Keywords: *Sustainable Development Goals (SDG), digital technologies, digital agriculture, precision agriculture, public policy, sustainability.*

I. Introduction

Agriculture is essential for the survival of human beings on the planet. Farming contributes to the agrifood system as it is the source of food for all and livelihood for most of the population. Needless to say, that lack of food results in under-nutrition and malnutrition, contaminated food leads to food-related health issues. However, nowadays, the agriculture sector has been facing unprecedented challenges regarding the profession's sustainability. Youth in the current generation are not interested in pursuing farming as a profession. Declining land productivity, environmental degradation, increase in the cost of production, low-income generation, high risk due to natural uncertainty makes farming an unattractive occupation. There is a flip side of the agrifood system, i.e. it contributes to environmental stress due to the overexploitation of natural resources (Schroeder, Lampietti, & Elabed, 2021).

In India, the agriculture sector faces significant challenges, including degrading soil, water stress, inadequate market infrastructure/linkages, unpredictable, volatile prices, post-harvest losses, wastages, lack of crop planning due to information asymmetry. Intensive farming adversely impacted the environment (Department of Agriculture and Farmer Welfare, 2021). Agriculture has not become a much attractive profession among the youth due to various types of risks associated with it, including production or yield risk, price or market risk, institutional risk, human or personal risk, financial risk (Bhaumik, 2008).

It requires a fundamental shift in the agriculture and food system to make it a more attractive and sustainable profession for youth, environment-friendly, safe and nutritious food for an ever-growing population. Environmental balance is critical for the sustainability of agriculture. The

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

government needs to adopt sustainable agriculture practices by shifting agricultural technology (Beheraa et al., 2015) by efficiently using the available resources.

India lags in the adoption of digital technologies in agriculture. This research paper discusses opportunities in adopting digital technologies and barriers to their adoption. This paper analyses two digital interventions in agriculture by the Government of India (such as Digital Agriculture, Precision Agriculture) from economic, environmental and societal perspectives. The paper provides suggestions for adopting digital technologies in agriculture to become a more resilient and sustainable source of livelihood.

2. Materials and methods

2.1 Materials

The researchers consulted secondary sources such as books, research articles, policy documents, reports published by government and non-government organizations, online databases, and discussion papers for this paper. Literature includes the World Bank, FAO, Organization for Economic Cooperation and Development (OECD) and policy documents of various committees appointed by the Government of India (GoI). This paper surveys the research literature about digital agriculture, precision agriculture, Sustainable Development Goals (SDG) and public policy to provide the overall digitalization of the agrifood system in India.

2.2 Methods

The researchers adopted the qualitative research method to conduct the study. Thematic analysis was applied to identify the dimensions of sustainability of agriculture, types of agriculture technologies and find out the opportunities and barriers in using these technologies. The digital transformation of the agrifood system has been started and making

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

progress, but there is a lack of systematic analysis on its scale and scope. The primary contribution of the present paper involves an overview of policy initiatives and an understanding of policy gaps to accelerate the adoption of digital technologies in agriculture for the achievement of SDGs.

2.1 Dimensions of sustainability in agriculture

Sustainable agriculture is “the successful management of resources for agriculture to satisfy the changing human needs, while maintaining or enhancing the quality of the environment, improving the social and economic conditions of the farmers, and local communities, and safeguards the health and welfare of farmers and conserving renewable natural resources" (Committee on doubling farmers' income, 2017). In other words, it includes achieving higher food production without compromising biodiversity conservation (Bali, Kajal, & Chaudhari, 2016).

Sustainable agriculture includes environmental, economic and social dimensions, which are discussed below:

Environmental dimension: This dimension includes that agriculture should have a low negative impact on the surrounding environment and human health, efficient utilization of natural input resources, better integration with the ecosystem, maintenance and preservation of the biodiversity (Committee on doubling farmers' income, 2017).

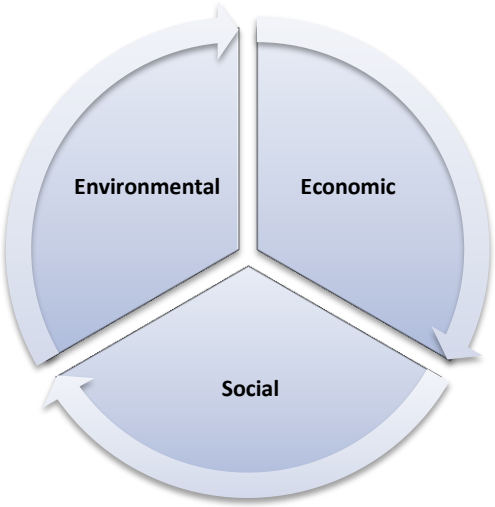
Economic dimension: This dimension assesses the viability of agriculture in economic terms, such as cost of production and matching profit, the role of subsidies in promoting environmentally friendly farming practices.

Social dimension: This dimension focuses on the equitable access of farm-related improved technologies to all types of farmers. It is also associated with the participation of farmers in decision making related to the farming

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

aspects, the wellbeing of farmers and farmworkers with decent employment in farming (Overseas Development Institute, 2003).

Figure 1: Dimensions of Sustainable Agriculture



2.2 Opportunities for Digital agriculture technologies

The United Nations (UN) adopted 17 Sustainable Development Goals (SDG) globally in 2015. The second goal of SDG is about the elimination of hunger from the world, which includes the target of promoting sustainable agriculture. By 2030, the governments have to ensure sustainable food production systems and implement resilient agricultural practices to increase productivity and production, to help maintain ecosystems, to strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality" (Project Breakthrough, 2020). For the study, two approaches: precision agriculture and digital agriculture, have been discussed.

Precision Agriculture

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

Precision Agriculture (PA) is a digital technology based farm management system to identify, analyze, and manage location and time variability within the agricultural fields for optimum productivity and profitability, sustainability and conservation of critical natural resources, and the reduction of production costs. It is also known as satellite farming, site-specific crop management, which include decision making with the help of Decision Support System (DSS) for optimization of input use with their application at the precise time, amount, and place (Hakkim & Joseph, 2016).

PA is a system approach to reorganizing the total agriculture system towards low input, high efficiency, and sustainable agriculture. India can leverage advantages in using PA technologies such as advancement in space technology (from Indian Space Research Organization, ISRO), Information Technology (IT) revolution, and economic development (Mondal & Basu, 2009). Though precision-based agriculture is capital intensive, it will have many benefits. It will reduce the use of harmful chemicals by their precision application, which will conserve nature and save human health from the adverse effect of these chemicals.

Digital Agriculture (DA)

DA is another emerging approach towards managing farms by using technology, including sensors, intelligent tools, satellites, the Internet of Things (IoT), remote sensing and data collection. Integration of sensors enables farmers to react quickly and dynamically maximize crop performance. DA entails using computer and communication technologies to increase profitability and sustainability in agriculture (Shen et al., 2010).

DA contributes to realizing water-saving, intelligent, high-quality, high-efficiency, non-polluting agriculture (Yane, 2010). The DA is an information-based farming model that provides interpreting digital data based on the agricultural production and management systems (Liang et al., 2002). Data

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

related to various aspects of agriculture is collected using digital technologies like remote sensing and Geographic Information System (GIS). This process is more efficient, cost-effective and reliable when it is done (Food and Agriculture Organization, 2018).

Digital agriculture comprises various digital and geospatial technologies for monitoring, assessing and managing multiple factors such as soil, water, climate and genetic resources. Digital agriculture also addresses the challenges in a sustainable agricultural production system by maintaining the proper balance between its multiple dimensions, i.e. socio-economic and environmental (Basso & Antle, 2020).

DA entails three types of technologies: crop system-based technologies, resource conservation-based technologies, digital interventions for improving governance of the agriculture sector (Committee on doubling farmers' income, 2017). Further, digital technologies can promote the SDG in agriculture by enabling the participation of many people in the markets (leading to inclusiveness). They increase the productivity of soil, reducing the wastage of input resources (efficiency), and results in innovation by providing new alternatives for the traditional production practices and adoption of best practices present elsewhere (Deichmann, Goyal, & Mishra, 2016).

3. Results and Discussion

Having seen the dimensions of sustainable agriculture, let us discuss some of the significant policy interventions by the GoI in this regard. The National Agriculture Policy (2000) focused on promoting the efficient use of resources, conservation of soil, water and biodiversity, and growth with equity. This policy also emphasized promoting sustainability in agriculture (Bhaumik, 2008).

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

The Department of Agriculture and Farmers' Welfare implemented e-governance initiatives in the agriculture sector under the National e-Governance Plan (known as NeGP-A) in 2005. During the Tenth Plan period (2002-07), the Government of India (GoI) launched a scheme, i.e. "Strengthening/Promoting Agricultural Information Systems' to promote e-governance in agriculture and provide support to states/Union Territories (UT). This scheme has the following components: (i) Development of Agricultural Informatics and Communication; (ii) Strengthening of IT apparatus in agriculture and cooperation in states and UTs; (iii) IT apparatus at Department headquarters and its field offices; (iv) Agricultural Resources Information Systems (AgRIS); and (v) Kisan Call Centres (Department of Agriculture and Farmers Welfare, 2007). Few organizations other than the government also started the application of ICT in agriculture, such as E-Choupal by ITC, Gyandoot project by Madhya Pradesh government (World Bank, 2003), and Information Village project of M.S.Swaminathan Research Foundation

(MSSRF), Kisan Call centre, Bhoomi Project, and Village knowledge centre, etc.

National Agricultural Research System (NARS) was created to carry out research related to agriculture. NARS consists of the Indian Council of Agricultural Research (ICAR), agriculture universities, and national bureaus. Non-Governmental Organizations (NGOs) and private-sector Research and Development (R&D) institutions are also included under the NARS umbrella. NARS is expected to ensure accessibility and social inclusion in new technologies and public investment in agricultural research (Press Information Bureau, 2016). National Agriculture Market (e-NAM) provides an integrated platform for the farmers to know the food grain prices at various agriculture markets in the country. e-NAM helps the farmers to make proper decisions at different stages of the production process (Department of Agriculture and Farmers' Welfare, 2020).

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

The Government of India established the Digital Agriculture Division under the Ministry of Agriculture and Farmers Welfare to accelerate digital technologies in agriculture. This newly formed division emphasizes the creation of a central database related to farmers. The database is linked with the land record for proper synchronization of different agriculture-related welfare schemes. It enables better and targeted service delivery to the farming community by doubling farmers' income.

The Government of India has started the process to build a National Digital Agriculture Ecosystem (NDAE), “to elevate Indian agriculture sector to higher levels of efficiency and productivity, and to improve the welfare and income of farmers” (Department of Agriculture and Farmer Welfare, 2021). The objectives of NDAE includes the realization of higher income and profitability, access to correct information, better planning and execution of government initiatives, enhance resource efficiencies, location-specific extension services and generation of unique farmer IDs for individualization of service delivery. With the help of this ecosystem, farmers get accurate and updated information related to various aspects of farming (such as which crop to grow, what type of seed to use, when to sow and what best practices to adopt to maximize yield and the marketing of agri-produce). NDA helps them make informed decisions and maximize their income (Department of Agriculture and Farmer Welfare, 2021).

Barriers to the adoption of Digital Agriculture Technologies

Despite the availability, the country is lagging in the adoption of digital technologies in agriculture. Some of the barriers to unlocking the full potential of digital technologies in the agriculture sector in rural areas are discussed below.

Weak IT infrastructure and networks

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

Weak technological infrastructure, high costs of technology lead the farmers to lag in the digitalization process. Despite the increased access to computers and the internet in India, many rural and remote areas remain offline. The network coverage in rural areas is also limited. Despite the increase in the number of mobile phones, not all of them are web-enabled smartphones.

Low level of digital literacy

It is to be noted that the application of digital technologies requires basic literacy and numeracy, specialized technical knowledge, and computer skill. Farmers without such competencies will be marginalized in an increasingly digitally-driven society. Lack of basic literacy and numeracy is a significant barrier to using digital technologies.

In many rural areas, youth go to work, which leaves little time for school. Rates of educational attainment are, therefore, usually lower in rural areas than urban areas. In addition to this, the lack of infrastructure and resources in rural areas limits the quality of education.

Lack of policy framework

The linkage between public policy and technologies cannot be neglected. Public policy plays a significant role in promoting the development and adoption of digital technologies for more sustainable agricultural practices.

Expansion of government e-services has often been particularly slow in the agricultural sector. Lack of standardization in the format and ownership of data could create disparities, particularly when large international companies pursue digital agriculture for agribusiness. In contrast, smallholders and local agripreneurs simultaneously use technologies to tackle societal challenges in rural and farming areas. Designing and managing a digital government program requires a high level of

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

administrative capacity. In addition to this, there is a lack of published research on government digitalization policies (Food and Agriculture Organization, 2017).

Issues related to entrepreneurship

Despite the rapid growth of digital agricultural technologies, most ICT-enabled solutions should be operational on a large scale. Companies – especially Small and Medium Enterprises (SMEs) and small start-ups – often struggle to move from the stage of application development to fully realized businesses. The lack of guidance for entrepreneurs on scaling strategies in the under-served market is a significant challenge (Trendov, Varas, & Zeng, 2019).

A wider gap exists between the proportion of the technologies generated by the public agricultural research system and those adopted by Indian farmers. Such a wide gap is due to the lack of an appropriate extension/technology transfer model in agriculture that could establish better linkage between Scientists and farmers to promptly facilitate effective dissemination of location-specific appropriate technologies (Karthikeyan, 2018).

There is a need for making digital technologies reliable, updated, location-specific message content for a diverse agricultural sector. The government should increase digital literacy coverage, teach farmers, and provide knowledge in regional languages. In addition to this, the government should evaluate the impact of interventions on users' lives (Goswami & Lele, 2017).

Concluding Remarks

SDG in agriculture can be promoted through digital technologies in various practices related to food production and supply chain. Digital agriculture technologies enable the stakeholders to make better decisions and enhance transparency in the process of decision making. Digital

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

transformation appears to be essential in advancing existing practices (Trendov, Varas, & Zeng, 2019).

The challenge for the GoI is how to coordinate policies related to the technologies at the national level to speed up the process of innovation and adoption. An appropriate mix of technology services and public policies will safeguard the income and livelihood security of farmer families, food, and health of the people (Department of Agriculture and Farmers Welfare, 2007).

Successful adoption of new technology requires coordinated action from every actor, both public and private. Continuous support for research and development, education policy, and adequate investment is also needed to apply new technologies.

In India, due to the spread of low-cost telecommunication, there is an increase in the accessibility of digital technologies such as mobile phones. But some barriers prevent people from using the full potential of these technologies, like lack of proper connectivity in rural areas, high costs for services, lack of basic computer knowledge and literacy. Investment in physical infrastructure, power, broadband, and transportation is also not adequate. Due to the low level of literacy among farmers and the digital divide, new intermediaries have emerged to provide ICT services to farmers. Sometimes, language also becomes a barrier while complying with advanced technologies. The government needs to fill this gap.

Though technology in agriculture was started in India a few years ago, it is limited in terms of applications and coverage. Small and marginal farmers neither can access advanced technologies nor afford to buy in the market. The policy should address these challenges regarding the adoption of technologies.

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

India should increase investments, particularly in backward regions, for providing necessary digital infrastructure and promote digital literacy among farmers. There is a need to create social media platforms for the farmers, such as 'Agri-Google,' 'Krishi Facebook,' and 'Krishi-LinkedIn.' For these bottom-up approaches in policymaking, investments in physical investments, human and institutional capital and farmer-friendly e-platforms are required. In contrast, those policies and institutional norms that hinder the adoption of digital technologies need to be removed.

With increasing emphasis on a user-friendly digital platform, the development of content in local languages is necessary for linking the farmers with digital initiatives taken by the government. There is scope for successfully reassessing the existing policies and priorities to adopt digital technologies in the agriculture sector. The focus of policy should be on social induced development by employing IT in various developmental programmes and projects. The government has to develop an overall strategy for local organizations like Panchayat Raj institutions to take the ICT to the masses.

ACKNOWLEDGEMENTS

Authors thank Professor. SN Ambedkar for his insights and inputs for finalizing the draft.

References

1. Bali, S., Kajal, & Chaudhari, J. (2016). Best practices in sustainable agricultural practices. Mumbai: Tata Institute of Social Sciences.
2. Basso, B., & Antle, J. (2020, April). Digital agriculture to design sustainable agricultural systems. Nature Sustainability, 3, 254-256.
3. Beheraa, B. S., Das, T., Jishnu, K., Behera, R., Behera, A., & Jena, S. (2015). E-Governance Mediated Agriculture for Sustainable Life in India. Procedia Computer Science, 623 – 629. https://doi.org/10.1016/j.procs.2015.04.144

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

4. Bhaumik, S. K. (2008). Reforming Indian Agriculture- towards employment generation and poverty reduction. New Delhi: Sage Publication.
5. Committee on doubling farmers' income. (2017). Sustainability concerns in agriculture. New Delhi: Ministry of Agriculture and Farmers' Welfare, Government of India.
6. Deichmann, U., Goyal, A., & Mishra, D. (2016). Will digital technologies transform agriculture in developing countries? Washington DC USA: World Bank Group. https://doi.org/10.1111/agec.12300
7. Department of Agriculture & Farmer Welfare. (2021). Consultation Paper on IDEA (India Digital Ecosystem of Agriculture). New Delhi: Government of India.
8. Department of Agriculture and Farmers' Welfare. (2020, January 13). eNAM Overview. Retrieved from National Agriculture Market: https://enam.gov.in/web/
9. Department of Agriculture, Cooperation & Farmer Welfare. (2021). Consultation Paper on IDEA (India Digital Ecosystem of Agriculture). New Delhi: Government of India.
10. Department of Agriculture, Cooperation and Farmers Welfare. (2007). National Policy for Farmers. New Delhi: Ministry of Agriculture and Farmers' Welfare, Government of India.
11. Food and Agriculture Organization. (2017). National e-agriculture strategy. FAO. Retrieved from www.fao.org/in-action/e-agriculture-strategy-guide/en/
12. Food and Agriculture Organization . (2018). SDG Indicator 2.4.1: proportion of agricultural area under productive and sustainable agriculture. Rome, Italy: FAO, United Nations.
13. Goswami, S., & Lele, U. (2017, December 6). Agriculture: How new technologies can raise farm productivity. Retrieved from Ideas for India: https://www.ideasforindia.in/topics/agriculture/how-new-technologies-can-raise-farm-productivity.html

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

14. Hakkim, V., & Joseph, E. (2016). Precision Farming: The Future of Indian. Journal of Applied Biology & Biotechnology, 4 (06), 068-072. DOI:10.7324/JABB.2016.40609
15. Karthikeyan, C. (2018, June- December). A case of e-Velanmai model of Agricultural Extension service in Tamil Nadu. International Journal of Development Extension, 9(2).
16. Liang, Y., Lu, X., Zhang, D. G., & Liang, F. (2002). The Main Content, Technical Support and Enforcement Strategy of Digital Agriculture. Geo-Spatial Information Science, 5(1), 68-73. https://doi.org/10.1007/BF02863497
17. Mondal, P., & Basu, M. (2009). Adoption of precision agriculture technologies in India and in some developing countries: Scope, present status and strategies. National Science Foundation of China and Chinese Academy of Sciences. https://doi.org/10.1016/j.pnsc.2008.07.020
18. Overseas Development Institute. (2003, August). Sustainable Agriculture Key issues in decision making. Retrieved June 2020, from www.odi.org: https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/3143.pdf
19. Press Information Bureau. (2016, July 26). Ministry of Agriculture & Farmers Welfare. Retrieved from https://pib.gov.in/newsite/mbErel.aspx?relid=147766
20. Project Breakthrough. (2017, May 24). Digital Agriculture: Feeding the future. Retrieved from breakthrough.unglobalcompact.org: http://breakthrough.unglobalcompact.org/disruptive-technologies/digital-agriculture/
21. Schroeder, K., Lampietti, J., & Elabed, G. (2021). What's cooking: Digital transformation of the agrifood system. Washington, DC: World Bank.
22. Shen, S., Basist, A., & Howard, A. (2010). Structure of a Digital Agriculture System and Agricultural Risks Due to Climate Changes. Agriculture and Agricultural Science Procedia, 42-51.

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13

23. Trendov, N. M., Varas, S., & Zeng, M. (2019). Digital Technologies in Agriculture and Rural areas. Rome: Food and Agriculture Organization of the United Nations.
24. World Bank. (2003, January 1). Publications: Documents and Reports, Gyandoot Project : ICT initiative in the district of Dhar, Madhya Pradesh. Retrieved from worldbank.org: http://documents.worldbank.org/curated/en/621851468267614396/Gyandoot-Project-ICT-initiative-in-the-district-of-Dhar-Madhya-Pradesh
25. Yane, D. (2010). Research and Analysis about System of Digital Agriculture Based on a Network Platform. International Conference on Computer and Computing Technologies in Agriculture, 274-282. https://doi.org/10.1007/978-3-642-18336-2_33

DOI: https://doi.org/10.53338/ADHIPA2021.V08.Si01.13