CHAPTER-23

TRANSFORMING RURAL LIVELIHOODS AND ENHANCING FARMER RESILIENCE

Sukanta Sarkar[1]
[1]Department of Economics, Gambella University, Ethiopia
Corresponding author: sukantaeco@gmail.com

Cite this chapter as: Sarkar, S. Transforming Rural Livelihoods and Enhancing Farmer Resilience. In: Bhat, A., A. Sultan, D. Kolhe & P. Banerjee. 2026 Digital Agriculture and Economic Transformation. The AgEcon Frontiers, Faisalabad, Pakistan, pp: 314-324. https://doi.org/10.66529/book.9786277945022.2026.ch23
A Publication of The AgEcon Frontiers Received: 26-May-2026 Revised: 05-June-2026 Accepted: 07-June-2026

Abstract

The operations of the farmers in the rural areas of India have been transformed by the implementation of new technologies such as artificial intelligence, Internet of Things, remote sensing, and mobile advisory. The purpose of this study is to evaluate the impact of digital agriculture on the rural development in India. This research paper is based on secondary sources. These farmers would be able to make sound decisions about their crop cultivation, irrigation, pest control, and marketing using these technologies. The government has introduced several initiatives to help the farmers, including the Digital India Initiative and the e-NAM initiative. The application of mobile applications and digital platforms in terms of predicting weather forecasts, quality of soils, and provision of banking and insurance services will reduce the level of uncertainty, leading to increased productivity. Precision farming will lead to efficient resource management, thereby reducing costs and environmental impact. In addition, the provision of credit facilities by farmers through digital payments and fintech technologies makes the agriculture sector resilient against climatic change and economic changes. However, there are challenges such as low levels of digital literacy, inadequate internet services in rural areas, and cost issues that should be taken into consideration.

Keywords: Digital Agriculture, Smart Farming, Precision Agriculture, e-Agriculture, & e-NAM.

1. Introduction

The digital transformation in agriculture has begun to alter the rural economy of India through the integration of cutting-edge technology such as artificial intelligence, remote sensing, mobile applications, and decision-making using data-driven advice with the farming system. Small and marginal farmers in the country cause issues like climatic changes, low production rates, poor market access, and irregular income from traditional agriculture. Therefore, digital agriculture will be able to provide solutions to the above challenges in agriculture by increasing efficiency and profitability (Wolfert et al., 2017). There are reasons why digital agriculture is important for India. The climate in India is quite unpredictable. One could expect rains, droughts, and even floods. It is essential for the farmers to know what is going on in terms of climate, and digital agriculture will help in this case. There are a lot of marginal and small farmers in India, and the productivity of agriculture should be increased (Zhang et al., 2016).

Digital agriculture in India is an evolving concept, with advancements being made due to developments in ICTs and agricultural policies. During this initial stage, which occurred during the period of the 90s and early 2000s, there have been attempts at using ICTs in relation to computerization of the land records and rural information centers. This can be exemplified by the case of e-Choupal where farmers could access pricing of their produce and expert opinion. This was the first step towards integrating ICTs into the sector. The second phase, which took place between mid-2000s and 2010s, involved the use of mobile telephones to enable mobile agriculture through SMS for information on weather forecasts and crops among others. There was also an effort towards digital inclusion and connectivity using government schemes during this phase (Sirilakshmi et al., 2025).

2. Conceptual Framework

The digital agriculture conceptual framework combines technology innovation with agriculture operations to boost efficiency and sustainability by harnessing data and using IoT, artificial intelligence, and drones. It is not only a tool that utilizes precision farming but a socio-technical system involving data management, farmers' information requirements, and startups.

Key Components of the Conceptual Framework are:

1. **Technological Infrastructure:** Comprises Internet of Things (IoT) sensors, artificial intelligence, robotics, drones, and satellite imagery for monitoring soil health, water quality, and crop status.
2. **Data Management and Analytics:** Requires data collection and analysis of enormous amounts of data (big data) with the aim of drawing out information through predictive analytics.
3. **Socio-Technical System:** Focuses on the synergy between technology and people, appreciating digital agriculture as a, “smart farming system” with economic, social, and environmental dimensions.
4. **Governance and Ecosystems:** Addresses issues related to data privacy and security, policy, and startup ecosystem involvement.

3. Objectives

The primary objective of the research paper is to explore the effect that digital agriculture has on rural development and resilience amongst Indian farmers. In addition to that, the research paper further explored the effects of digital tools on improving resilience among farmers to cope with climatic changes. It also looks at the contribution of government programs such as Digital Agriculture Mission and e-NAM towards promoting digital agriculture.

4. Methodology

In this study, qualitative research methodology has been applied to investigate the effects of digital agriculture on the life of rural communities and resilience-building among Indian farmers. Qualitative research methodology emphasizes the importance of considering the context in which the farmers are facing during digital agriculture adoption. Case studies of initiatives such as e-NAM and Digital Agriculture Mission are also part of this research methodology. Thematic analysis is used to identify relevant themes such as adoption, advantages, obstacles, and resilience mechanisms.

5. Growth of Digital Agriculture in India

There has been an increase in the development of digital agriculture in India in the last two decades, owing to various reasons such as technological improvements, government policies, and the rise in demand for effective and sustainable agriculture practices. The use of digital technology in Indian agriculture was initiated when the use of ICTs in agriculture was introduced. The first instance of ICTs being used in agriculture involved offering advisories by way of using mobile phones, e-Choupal project which helped farmers with market advisories and guidance. From this stage onward, the use of digital technology in agriculture was initiated, and the use of mobile technology has widened the ambit thereof. The Digital India project has done much to foster rural connectivity (Shehrawat et al., 2024).

Over the past few years, the application of technology such as AI, IoT, drones, and satellite remote sensing has helped in the acceleration of the growth process. The application of technology is not only limited to precision agriculture, where data such as soil health and weather conditions related to agricultural practices can be monitored. Apart from that, developments in the agritech sector have facilitated innovative approaches to farm advisories, supply chain management, digital financing, and crop insurance. For example, technology-driven policies like the Digital Agriculture Mission entail creating an ecosystem through technological advancements along with the public-private partnership approach (Palaniswamy and Bargavi, 2025).

Table 1: Merits and Demerits of Digital Agriculture in India

Category	Merits (Benefits)	Demerits (Challenges)
Infrastructure	**Improved Planning:** Government initiatives such as AgriStack assist in decision making using reliable information.	**Connectivity Challenges:** Internet connectivity problems in remote rural settings restrict data transmission in real time.
Social	**Empowerment:** Offers real-time climate and agricultural advice through smartphone applications.	**Literacy Problem:** The low literacy rate of the farmers makes it difficult for them to operate the tools.
Market Access	**Direct Connections:** Links farmers directly to buyers without middlemen.	**Knowledge Gap:** Misperception about data or any form of manipulation may result in incorrect decisions.
Resource Use	**Precision Agriculture:** Ensures effective use of water, fertilizer, and pesticides, minimizing wastage.	**Dependency on Technology:** An overdependence on digital technology makes farmers vulnerable to technology failures.
Productivity	**Higher Yield:** Can increase yield by 8 to 25 percent based on crop variety.	**Sophistication:** It is difficult to learn how to use the sophisticated tools.
Economic	**Higher Earnings:** Increases income for farmers by 15 to 35 percent.	**Costly to Acquire:** It is expensive to acquire the necessary hardware and software.

Source: Kumar, A., Kumar, A., & Vineeth, M. R. (2021).

From Table 1, it is evident that there are many benefits that accrue from using digital technologies in agriculture in India. These include increased productivity due to more informed decisions from the information generated; increase in efficiency of resource utilization such as irrigation and fertilizers, as well as early warnings regarding weather conditions and pests. The other benefit is the ability to easily access the market through the creation of platforms like the electronic National Agriculture Market (e-NAM). Others include increased price transparency and financial inclusion through digital finance.

Nevertheless, despite the significant amount of success that has been achieved, there are still various issues that require urgent attention. These include the issue of the digital divide, lack of digital literacy skills, infrastructural problems, as well as limited financial resources that pose challenges to the adoption of digital technologies, including the use of digital technologies by smallholder farmers. However, in this case, additional efforts towards rural connectivity can help in overcoming these problems. Overall, the process of digital agriculture development in India is rather promising (Sharma et al., 2025).

6. Impact on Rural Livelihoods & Economics

There are various ways through which the adoption of E-commerce linkages and platforms such as e-NAM has contributed to better price realization by small farmers in India. For instance, first, it increases the access to markets, meaning that farmers can reach out to more potential buyers, hence increasing competition, leading to increased prices. Secondly, digital platforms ensure that there is real-time information concerning price levels, and thus, farmers are able to choose the appropriate time and place to sell their agricultural outputs. It also eliminates the cases of information exploitation and asymmetry. Thirdly, it ensures the sale of produce directly to consumers, retailers, and bulk buyers, increasing farmers' ability to earn a higher proportion of the price realized from the sale of the produce. In addition, some digital platforms allow for quality-based pricing of the produce sold (Babu et al., 2025).

The impact of using AI advisory on the income of Indian farmers throughout the year can be calculated and generally has a positive influence regardless of the region, type of crop, and level of implementation. According to various research studies, AI advisory contributes to a 10% to 30% increase in farmers' income on average. This result can be obtained owing to several aspects, namely, increasing productivity, decreasing expenses, due to the proper use of fertilizers, pesticides, and water, as well as receiving better prices owing to market analysis. The use of artificial intelligence technology enables farmers to avoid losses that may arise from lack of warnings about possible pest infestations, diseases, and adverse weather conditions. Sometimes, the use of AI advisory in the digital market environment allows increasing farmers' income through successful sales of products (Ashokkumar and Naik, 2021).

Table 2: Impact of Digital Agriculture on Rural Livelihoods & Economics

Impact Area	Specific Impact / Technology	Economic / Livelihood Benefit
Information Gap	Mobile Apps (Kisan Suvidha)	Current weather information, price changes, and pests reduce dependence on local intermediaries.
Rural Employment	Agri-tech Startups & DPI	Employment generation through drone operation, data analysis, and entrepreneurship at the village level.
Risk Management	Digital Insurance & Satellite Monitoring	Less impact of climate change due to losses being reduced; rapid insurance claim settlement using satellite data.
Financial Access	Fintech & UPI / KCC	Easier access to credit facilities; direct transfer of funds; reduction in transaction costs; increase in online transactions.
Productivity	AI-based Advisories & Satellite Imagery	Increases in productivity by 15-25% through customized advice and identification of pests.
Cost Savings	Precision Farming	Saving of input costs by 20-30%; labor costs lowered by 40% by Kisan Drones.
Farm Income	e-NAM & Private Marketplaces	Income increases by 10-30% by cutting out middlemen, discovering prices, and lowering marketing expenses

Source: Madrewar et al., (2024)

According to Table 2, the digital agriculture revolution in India is gradually picking up pace. As per the plans of the Indian government, there will be digital service connectivity for 11 crore farmers in the country by 2026-27 under the Digital Agriculture Mission. Technology has enabled farmers to enhance their production by 15-25% and decrease their costs by 20-30%.

Precision farming through digital technologies has played an essential role in lowering input expenses in agricultural operations in India, depending on their adoption level and other conditions. Digital technologies such as IoT devices, drones, and AI advisory systems allow for input utilization in the most effective and efficient manner possible. The fertilizer and pesticide requirements can be reduced by 15% to 25%, while advanced irrigation practices increase water-use efficiency by 25% to 30%. Additionally, in certain situations, the use of innovations like drone spraying technology may reduce pesticide usage by up to 30% to 40% and decrease water expenses. In contrast to using the same level of input in every place, the use of precision agriculture technology guarantees that the inputs are used precisely when needed. Digitization of agriculture leads to reduced costs and improved efficiency in use of resources and sustainability (Balkrishna et al., 2025).

There are several barriers that restrict agricultural digitisation including high capital costs, low levels of digital literacy and insufficient infrastructure. Digital technologies have also been a very helpful resource for Farmer Producer Organizations (FPOs) to improve their bargaining strength and gain access to financing. To start with, such organizations use such online platforms like e-NAM to facilitate collective marketing of their products to a wider network of potential buyers. The increased bargaining power is complemented by greater price discovery capacity and reduced reliance on local intermediaries. Secondly, digital technologies can be used to keep track of the production process, marketing process, and transactions. Such traceability increases the credibility of the organization and enhances access to financing services from banks and other fintech institutions. Thirdly, some of these platforms allow the integration of logistics and planning processes, which facilitates efficient storage, transportation, and selling. Finally, fintech companies are offering fast and collateral-free loans to organizations like FPOs using digital lending platforms (Klerkx et al., 2021).

7. Farmer Resilience & Climate Adaptation

The introduction of Krishi-DSS would greatly improve the farmers' capacity to cope with climate variability through data conversion to effective decision making. To begin with, the tool can generate current weather forecasts and early warnings. Consequently, farmers will be able to decide when to plant crops even during delays in monsoon, or effectively irrigate their crops, thus changing from decisions that were made following calendar seasons. Secondly, using AI and data analysis, Krishi-DSS can provide advice to farmers concerning their crops. If there is any chance of pests due to an anomaly in weather, then the farmers will be alerted and advised accordingly, thus avoiding any loss. Finally, the platform uses information on soils, climate, and crop trends to generate adaptive approaches in relation to selection of climate-resilient crops among other measures (Reji et al., 2024).

The use of drones and artificial intelligence-based remote sensing technology is pivotal in improving resilience at real-time farm levels, especially for climate-responsive agriculture in India. To begin with, drones assist in the real-time monitoring of crops through the capture of images in high resolution. Through AI, analysis of the images captured will aid in identification of any signs of stress in the crops, which can be due to lack of nutrients or any form of pest attack, sometimes even before the human eye can observe these conditions. Farmers will be able to take care of these problems in due course. In addition, artificial-intelligence-enhanced remote-sensing technologies provide an important tool for delivering reliable measurements through the combination of satellite data along with current weather data as well as to assess soil quality. This will allow farmers to receive precise guidelines for irrigating or fertilizing appropriately and at the right time (Lioutas et al., 2021).

Digital insurance systems and Direct Benefit Transfer (DBT) programs such as the PM-KISAN program have significant contributions to making marginalized farmers less vulnerable in India. DBT systems provide timely financial support by transferring money directly to the bank accounts of farmers. This system eliminates the problems of delay and corruption since money is credited directly in the bank accounts of farmers, which helps them decide for their daily expenditures and purchase seeds and fertilizers. Digital insurance platforms, which are often connected with programs such as the Pradhan Mantri Fasal Bima Yojana, can help farmers receive compensation in case there is a loss in crops due to natural factors. This is because technology such as remote sensing is used in the assessment process. In general, such technologies are useful for providing stability for farmers in case of financial shocks (Eastwood et al., 2019).

The utilization of digital technologies becomes increasingly important in terms of achieving sustainability in agriculture and maintaining a healthy soil state in India, depending on the extent to which that technology can be accessed and used. First of all, digital applications for soil testing and other platforms related to the Soil Health Card Scheme provide the farmers with data about the nutritional state of their lands; thus, they apply fertilizers in a purposeful manner and avoid using chemicals excessively. Moreover, online advisory services and applications give personalized suggestions to the farmers on crop rotation and using nature elements and water in such a way that the condition of soil becomes sustainable. Finally, the use of remote sensing technology and the Internet of Things technology helps to maintain the health of soil, thereby ensuring proper irrigation and conservation of soil. Awareness programs through digital means also help in promoting conservation farming (Rotz et al., 2019).

8. Adoption Challenges & Digital Divide

There are many barriers existing for implementation of IoT and AI among small and marginal farmers (with 1–2 acres land holding) in India. The primary reason is the high cost involved with regard to hardware like sensors, devices, and software platforms. This makes it difficult for small farmers who have low income to buy these technological advancements. Poor digital literacy levels of the farmers affect their capability of using the available digital platform and tools. Insufficient infrastructure in terms of internet facility and electricity availability prevents proper implementation of these technologies in real time. Fragmented landholdings make the use of advanced technology less feasible for farmers who hold a small land area. Lack of awareness and institutional support makes the process of adapting these technologies difficult.

Digital divide in terms of internet connectivity and smartphones affects the usage of technology in different areas. Advanced states, where smartphone usage is high, broadband connectivity is available, and digital literacy among the people is high, experience higher adoption rates of technology as opposed to poor or remote areas where internet connectivity is low, few digital devices are available, and devices are expensive. This means that farmers from such states could be using their smartphones for information about weather, pricing, and advice. In contrast, poor and/or remote areas suffer from lack of connectivity, few available digital devices, and high costs associated with digital devices. Therefore, farmers from such areas will find it hard to get relevant information (Carolan, 2020).

Low level of digital literacy is a significant constraint to the effective use of agricultural apps and platforms among farmers in India despite availability of smartphones and the internet. The inability to perform basic tasks such as operating smartphones, using applications or interpreting what goes on at the interface is likely to limit access to information about the weather, crop prices, and advice on crops among others. The lack of adaptation to local language is another challenge since some of these applications are still difficult to interpret. In such cases, the farmer would be compelled to seek help from other people, which could make it harder to benefit from digital technologies. Low digital literacy level is also likely to influence farmers' trust in such applications due to doubts on the accuracy of recommendations made through these apps. This means that there will be low adoption rates because most farmers do not utilize these applications.

Table 3: Primary challenges of implementing digital agriculture in India

Category	Primary Challenges	Impact on Farmers & Adoption
Governance	Issues relating to data privacy and data security in agriculture, as well as weak policies.	Absence of standardized guidelines will cause mistrust in the systems that generate and control agricultural data.
Technological	Absence of applications tailored for regional languages and poor customisation for agro climatic zones.	The motivation of farmers might decrease if the information provided is not consistent with their soil type, climate conditions, or local wisdom.
Structural	Small and fragmented farm sizes (< 2 hectares on average).	Advanced technologies tend to work better on large-scale land because they cost more.
Educational	Digital illiteracy, difficulty learning new technologies, and insufficient training opportunities.	Large segments of the farming community face problems using complicated computer systems.
Financial	Expensive cost of acquiring technology such as sensors, drones, and equipment relative to low farmers' income levels.	This factor makes it very difficult for poor farmers to use modern technologies.
Infrastructure	Poor broadband/5G connection and irregular electricity in rural hinterlands.	It hampers the process of sending data instantaneously.

Source: Goswami et al., (2023).

Digital farming in India faces the following challenges, as reflected in Table 3 such as low Internet penetration among the rural populace, high capital investment for the initial stages of farming, especially for small-scale farmers, and lack of digital literacy. Moreover, due to fragmentation of farmlands, investing in technologically advanced systems becomes unfeasible from an economic standpoint.

The attitude of Indian farmers towards issues such as data privacy and security in relation to AI-based agriculture platforms is determined by a combination of lack of knowledge, issues related to trust, and confusion regarding how the data is used. Farmers have insufficient knowledge concerning data collection and storage procedures, especially when referring to the collection of such data types as land records, crop data, or inputs used by farmers. In addition, it should be noted that farmers may fear potential misuse of data by companies, including data use for commercial purposes, price manipulation, and marketing. Trust plays an important role in the process as well. While farmers show increased interest in government-based platforms, their mistrust of private applications cannot be underestimated (Bertoglio et al., 2021).

9. Government Policy and Future Roadmap

The improvement of the Digital Public Infrastructure (DPI) of India would need consideration regarding the issues of accessibility, affordability, and inclusivity. Broadband connection should be improved in rural areas through public-private cooperation and the use of community networks. Digital literacy could be boosted through training sessions conducted at the local level to allow rural populations to make use of digital platforms. Inclusiveness in DPI could be facilitated through the creation of regional language interfaces. Affordability of the technology can be achieved through subsidies in the purchase of devices and services for the poor. The security of the data and the protection of privacy would boost confidence among users (Fleming et al., 2021).

Table 4: Key Government Policies & Initiatives for Digital Agriculture

Policy/Mission	Focus Area	Key Features/Targets
National Mission on Edible Oils - Oilseeds	Sector Specific	Using digital tools to boost self-reliance in oilseeds.
Sub Mission on Agricultural Mechanisation	Farm Technology	Promoting Custom Hiring Centres for machinery access.
National Pest Surveillance System	Pest Management	Real-time AI-based advisories for pest management covering 66 crops.
Digital General Crop Estimation Survey	Yield Assessment	Connecting Aadhaar IDs to a banking system in order to provide direct benefits transfers (DBT) for agriculture-related purposes.
Krishi Decision Support System	AI & Data Integration	Using satellite imagery, weather information, and soil details for precision farming and risk management.
Digital Financial Services (JAM Trinity)	Financial Inclusion & Subsidies	Connecting Aadhaar card with bank accounts in order to enable Direct Benefit Transfer to farmers.
AgriStack	Foundational Digital Registry	A database including Farmer Registry, Geo-reference Villages and Crops sown registry.
Digital Agriculture Mission	Digital Infrastructure (AgriStack)	Making farmer ID for 11 crore farmers; creation of Krishi DSS, Digital crop survey, and Soil mapping.

Table 4 illustrates that India is revolutionizing its agriculture industry with the help of the Digital Agriculture Mission. Important areas include the Digital Crop Survey, use of drones called NAMO Drone Didi to promote adoption of technology among women, and usage of AI in pest management, insurance, and weather forecasting. These activities are aimed at creating AgriStack and Krishi-DSS, which uses satellite imagery for crop surveys.

Government programs such as BharatNet have achieved some success in solving the problem of last mile connectivity, although their efficiency is not satisfactory. BharatNet has managed to provide extensive infrastructure for internet connectivity through the installation of optical fiber connections between gram panchayats, thus paving the way for applications such as e-governance, telemedicine, and distance learning. The program has helped improve connectivity to institutions such as schools and hospitals and facilitated access to other services offered by the private sector. Yet, in terms of last mile connectivity, the situation is still inadequate. Problems that prevent BharatNet from achieving greater success include implementation delays, poor maintenance, unstable electricity supply, and lack of private sector engagement in the last mile connectivity issue. There is also an instance where infrastructure has been established but underutilized because of low digital literacy or unaffordability of internet connections (Kadam et al., 2023).

There is an urgent need to protect farmers from exploitation using data while ensuring that agricultural technology is used effectively and fairly in India. The need exists for having effective laws and institutional arrangements. There is first the need for having a good policy on how data is to be governed, with the purpose being that there should be clarity on who owns such data. The implementation of policies that ensure informed consent and the establishment of clear agreements governing the utilization of the data by the companies should be put in place. There is also the need to enhance the existing data protection laws, which will ensure compliance with the provisions of relevant laws, including the Digital Personal Data Protection Act, 2023. Secondly, fair access policies that avoid the formation of monopolies among the big agritech companies are necessary. There is also the need for establishing open digital systems to foster innovation and competition while keeping costs low (Kamilaris et al., 2017).

Coordination, between agritech start-up companies and traditional agricultural extension agencies should be established. Governments should put in place systems of cooperation between agritech companies and public agricultural extension agencies. Through such mechanisms, agritech companies would be able to provide digital solutions like advisory applications, weather data, and market linkages through extension service providers, who are trusted by the farmers. Secondly, Public-Private Partnerships may be developed to ensure incentive compatibility.

Table 5: SWOT Analysis of Digital Agriculture in India

Strengths (Internal, Positive)	**Weaknesses (Internal, Negative)**
Higher Connectivity and Rapid Adoption of Technology: A large population of rural India now has access to mobile phone technology which assists with the speed of delivery of agri-info. **Innovation in Agri-Technology**: Many agri-tech organizations have created new and innovative ways to solve agriculture-related problems. **Government Agri-Tech Initiatives**: There are several major government initiatives that support the country's goal of integrating ai, drone and blockchain technology into food production. **Data Analysis:** With big data, ai and remote sensing technology available, decision-making on the farm will be greatly improved. **Market Access**: The availability of digital hubs like E-nam has enabled farmers to connect to their market directly via the internet.	**Low Digital Literacy:** Small and marginalised farmers are unable to fully understand and use digital devices. **Small Farm Sizes**: Many small and marginalised farmers own fragmented parcels of land and do not have land sizes that allow for large investments in expensive equipment. **Poor Infrastructure:** Accessing new technological innovations are made difficult due to poor internet connection and non-existent access to electricity in remote rural communities. **High Cost of Investment:** Many technologies have a huge initial investment cost (such as drone and sensor technology) as well as few financing options available to small farmers. **Lack of Skill Development:** Skill development programs and technical support to sustain technological equipment are both severely lacking.
Opportunities (External, Positive)	**Threats (External, Negative)**
Climate-Smart Agriculture: Utilizing the power of AI to predict weather patterns, regulate water consumption, and detect crop diseases. **Supply Chain Optimization:** Enhancing the process of the supply chain and reducing wastage due to loss after harvest through monitoring systems. **Precision Agriculture:** Using drones and Internet of Things for precision agriculture (micro-irrigation, pesticide sprays). **Drones Hiring Centers:** Promoting drone hiring service as an alternative to help smallholder farmers use such technologies. **Job Creation:** Technology is creating jobs for youngsters who know how to work on drones.	**Security Risks:** Possibility of misappropriation or leaking the information of farmers, thus necessitating strict privacy policies. **Digital Divide:** The possibility that there would be an increasing gap between wealthy farmers who could afford to acquire the technology and poor farmers who could not. **Interoperability Problems:** Failure of the various technological platforms and devices to work together. **Inconsistent Information:** Availability of false information or contradictory suggestions from various unauthenticated sources. **High Operating Expenses:** Expensive maintenance costs associated with data services, artificial intelligence subscriptions, and software upgrades.

In this regard, extension officers can serve as intermediaries who verify and demonstrate agritech startups' products, while agritech startups can provide capacity-building support through training programs. Interoperability is critical since digital platforms used by agritech startups must be integrated with national agricultural digital platforms, such as Digital Agriculture Mission. Additionally, capacity building must be emphasized by providing training programs to agritech startups on local agricultural conditions and extension officers on digital agricultural tools (Lowenberg-DeBoer and Erickson, 2019).

From Table 5, it can be seen that there is tremendous potential in digital agriculture within India, where advantages include improved efficiencies, instant access to information about weather and markets, and improved market linkage as a result of the Digital India and e-NAM initiatives. These developments will assist farmers in making decisions without having to take any chances. Nevertheless, disadvantages of this technology include low technological literacy, lack of good internet connectivity, and high cost of adopting technologies, amongst many others. On the positive side, several opportunities are apparent regarding the growth in use of artificial intelligence, Internet of Things, and precision agriculture methods. Additionally, there are better financial and insurance opportunities in the digital era for strengthening the capacities of farmers. As for threats, data security is one of the main problems, alongside cybersecurity dangers, growing digital divide across regions, and dependence on technology.

10. Conclusion

Digitization of Agriculture is increasingly changing the face of rural economies by incorporating technology into agricultural activities in India. Since most of these farmers are small and marginal farmers, many opportunities present themselves as far as improving their efficiency, reducing risks, and stabilizing income sources are concerned. These technologies include things like artificial intelligence, Internet of Things, mobile applications, and remote sensing which help provide real-time data on weather conditions, soil conditions, farm conditions, and price conditions. The contribution of government programs like Digital Agriculture Mission and e-NAM in advancing the concept of digitalization cannot be overlooked. Such programs not only improve digital infrastructure but also help in achieving data-driven farming and accessing wider markets for better price discovery and eliminating the involvement of middlemen. Apart from this, digital technologies also assist in ensuring financial inclusion through access to credit, insurance, and direct benefit transfers.

Farmers who use digital farming techniques can create a stronger basis for adapting to different climate conditions. Digital farming will provide farmers with clear information about what is going to happen in terms of weather and whether or not they need to be cautious regarding pests and diseases. Using precision agriculture will guarantee that production will be done in a way that uses fewer amounts of water, fertilizer, and pesticides in order to ensure long term sustainability. However, it is important to note that these benefits do not apply equally everywhere due to factors like poor Internet connection, lack of digital literacy, costs of implementation, etc. Although there are barriers to overcome, continued investments in the improvement of infrastructure will certainly bring considerable advancements in this field. Digital agriculture has immense opportunities in India.

References

Ashokkumar, B., & Naik, A. (2021). Transforming Indian agriculture with digital technologies. *Asian Journal of Agricultural Extension, Economics & Sociology, 39*(6), 76–90. https://doi.org/10.9734/ajaees/2021/v39i630596

Babu, J. M., Yadav, A., & Shivnani, T. (2025). A step toward digital inclusion in agriculture: Managing ICT capacity-building and measuring outcomes among smallholder farmers. *Indian Journal of Finance, 19*(8). https://doi.org/10.17010/ijf/2025/v19i8/175234

Balkrishna, A., Singh, S. K., Pathak, R., & Arya, V. (2024). E-governance paradigm in the Indian agricultural sector. *Discover Agriculture, 2*(1). https://doi.org/10.1007/s44279-024-00012-7

Bertoglio, R., Corbo, C., Renga, F. M., & Matteucci, M. (2021). The digital agricultural revolution: A bibliometric analysis literature review. *IEEE Access, 9*, 134762–134782. https://doi.org/10.1109/ACCESS.2021.3115258

Carolan, M. (2020). Automated agrifood futures: Robotics, labor and the distributive politics of digital agriculture. *Journal of Peasant Studies, 47*(1), 184–207. https://doi.org/10.1080/03066150.2019.1584189

Eastwood, C., Klerkx, L., Ayre, M., & Dela Rue, B. (2019). Managing socio-ethical challenges in the development of smart farming: From a fragmented to a comprehensive approach for responsible research and innovation. *Journal of Agricultural and Environmental Ethics, 32*(5–6), 741–768. https://doi.org/10.1007/s10806-017-9704-5

Fleming, A., Jakku, E., Lim-Camacho, L., Taylor, B., & Thorburn, P. (2018). Is big data for big farming or for everyone? *Agronomy for Sustainable Development, 38*, Article 24. https://doi.org/10.1007/s13593-018-0501-y

Kadam, D. M., Chouhan, D., Roy, T., Prajapati, H. A., Tiwari, N., Nandeha, N., & Mishra, R. (2023). Digital agriculture: The future of Indian agriculture. *International Journal of Environment and Climate Change, 13*(11), 3963–3976. https://doi.org/10.9734/ijecc/2023/v13i113577

Kamilaris, A., Kartakoullis, A., & Prenafeta-Boldú, F. X. (2017). A review on AI in agriculture. *Computers and Electronics in Agriculture, 138*, 70–90. https://doi.org/10.1016/j.compag.2017.09.037

Klerkx, L., Jakku, E., & Labarthe, P. (2019). A review of social science on digital agriculture. *NJAS–Wageningen Journal of Life Sciences, 90–91*, 100315. https://doi.org/10.1016/j.njas.2019.100315

Lioutas, E. D., Charatsari, C., & De Rosa, M. (2021). Digitalization of agriculture: A way to solve the food problem or a trolley dilemma? *Technology in Society, 67*, Article 101744. https://doi.org/10.1016/j.techsoc.2021.101744

Lowenberg-DeBoer, J., & Erickson, B. (2019). Setting the record straight on precision agriculture adoption. *Agronomy Journal, 111*(4), 1552–1569. https://doi.org/10.2134/agronj2018.12.0779

Palaniswamy, V., & Bargavi, R. (2025). Leveraging EdTech to drive AgriTech innovation for farmers in India. *Journal of Entrepreneurship and Innovation in Emerging Economies*. https://doi.org/10.1177/20438869251315189

Reji, S. K., Rajeswari, P. S., & Moulya, B. (2024). Green fields, smart tech: The digital transformation of rural farming. *Qubahan Academic Journal, 5*(2). 22-23. https://doi.org/10.48161/qaj.v5n2a1632

Rotz, S., Gravely, E., Mosby, I., Duncan, E., Finnis, E., Horgan, M., & Fraser, E. (2019). Automated pastures and the digital divide. *Journal of Rural Studies, 68*, 112–122. https://doi.org/10.1016/j.jrurstud.2019.01.023

Sharma, K., Katoch, S., Mohapatra, S., Kaur, M., & Kumar, A. (2025). Access to digital services and its impact on farm income: Empirical evidence from Eastern India. *Agricultural Economics Research Review, 38*(2). https://doi.org/10.1177/09713441251395494

Shehrawat, P. S., Arulmanikandan, B., Singh, S., & Aditya. (2024). Farmers' awareness and adoption of digital agricultural technologies for sustainable crop production. *International Journal of Economic Plants, 11*(2). https://doi.org/10.23910/2/2024.5694a

Sirilakshmi, Y., Gogoi, B. P., Ashwini, T., Gogoi, R., & Khongsai, V. (2025). Transforming Indian agriculture: The emerging era and benefits of digital agriculture. *Journal of Experimental Agriculture International, 47*(10), 51–61. https://doi.org/10.9734/jeai/2025/v47i103788

Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M. J. (2017). Big data in smart farming: A review. *Agricultural Systems, 153*, 69–80. https://doi.org/10.1016/j.agsy.2017.01.023

Zhang, Y., Wang, L., & Duan, Y. (2016). Agricultural information dissemination using ICT. *Information Processing in Agriculture, 3*(1), 17–29.https://doi.org/10.1016/j.inpa.2015.11.002

Declaration: AI-assisted tools (LLMs) were used to improve the language and grammar of this chapter. The authors reviewed and approved all content and assume full responsibility for its accuracy.