IJRAR.ORG E-ISSN: 2348-1269, P-ISSN: 2349-5138

INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS (IJRAR) | IJRAR.ORG

An International Open Access, Peer-reviewed, Refereed Journal

Digitalisation of Agriculture in India: Trends, Impact, and Future Prospects

Dr. Navlata,
Assistant Professor,
Deptt. of Economics,
R.D. College, Sheikhpura,
Munger University, Munger

Abstract

Digitalization has emerged as a transformative force in Indian agriculture, addressing long-standing challenges related to low productivity, market inefficiencies, climate risks, and income instability. With the rapid expansion of digital infrastructure, mobile connectivity, and government-led initiatives such as digital agriculture platforms and electronic markets, Indian agriculture is undergoing a structural shift from traditional practices to data-driven, technology-enabled systems. This paper examines the major trends in the digitalization of agriculture in India, evaluates its economic and social impacts on farmers and markets, and explores future prospects for sustainable agricultural development. Using secondary data from government reports, industry surveys, and empirical studies, the paper analyses the adoption of digital tools such as e-markets, mobile advisory services, precision farming technologies, and artificial intelligence. The findings indicate that digitalization has significantly improved market access, price transparency, and resource efficiency, while also enhancing farmers' resilience to climatic and economic shocks. However, challenges such as the digital divide, inadequate digital literacy, infrastructure gaps, and data governance issues continue to limit its full potential. The study concludes that a coordinated policy framework, inclusive digital strategies, and investments in rural digital capacity are essential to ensure that digital agriculture contributes to equitable and sustainable growth in India.

Keywords: Digital agriculture, e-NAM, precision farming, agritech, Indian agriculture, digital transformation

Introduction

Agriculture has traditionally been the backbone of the Indian economy, providing livelihoods to nearly half of the population and contributing significantly to food security and rural development. Despite its importance, the sector has long been characterized by low productivity, fragmented landholdings, dependence on monsoons, and inefficient marketing systems. In recent years, digitalization has emerged as a powerful instrument to overcome these structural limitations.

Digitalization of agriculture refers to the application of digital technologies such as mobile applications, artificial intelligence (AI), Internet of Things (IoT), satellite imagery, big data analytics, and digital marketplaces to agricultural production, distribution, and governance. In India, the convergence of affordable smartphones, expanding internet penetration, and proactive government initiatives has created a favourable ecosystem for digital agriculture.

The relevance of digitalization has increased further in the context of climate change, rising input costs, and market volatility. Digital tools enable farmers to access real-time information on weather, prices, pests, and best practices, thereby supporting informed decision-making. This paper aims to provide a comprehensive analysis of the trends, impact, and future prospects of digitalization in Indian agriculture.

Objectives of the Study

The study is guided by the following objectives:

1. To examine the major trends in the digitalization of agriculture in India.
2. To analyse the impact of digital technologies on agricultural productivity, income, and markets.
3. To identify challenges and constraints in the adoption of digital agriculture.
4. To explore future prospects and policy measures for sustainable digital transformation in Indian agriculture.

Research Methodology

The study is based on secondary data collected from government publications, policy documents, agricultural surveys, research articles, and industry reports. Data from the period 2015–2024 has been used to capture recent developments. Analytical tools such as trend analysis, descriptive statistics, and comparative tables have been employed. Graphical representations are used to highlight adoption trends and growth patterns.

Trends in Digitalization of Agriculture in India

1. Growth of Digital Infrastructure

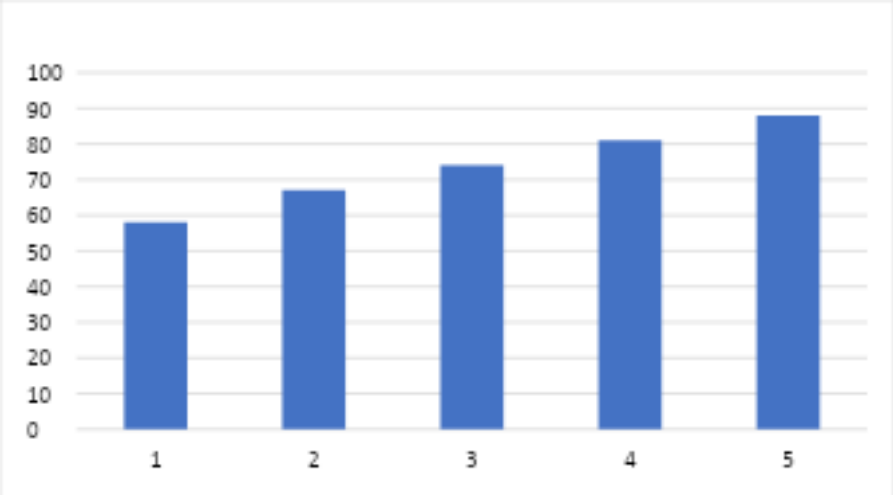
India has experienced a rapid expansion of digital infrastructure in rural areas, driven by rising mobile penetration, affordable data services, and targeted government initiatives for rural connectivity. These developments have significantly improved internet access, enabled widespread smartphone usage, and created a strong technological foundation for the adoption of digital tools, platforms, and services in agriculture.

Table 1: Growth of Digital Connectivity in Rural India

Year	Rural Internet Users (Million)	Mobile Penetration (%)
2015	120	58
2018	227	67
2020	299	74
2022	350	81
2024	400+	88

Source: Compiled from government and industry reports

The data clearly indicates a strong upward trend in rural digital access, enabling wider adoption of digital agricultural services.



The graph demonstrates a sharp increase in mobile penetration from 2015 to 2024, nearing saturation at around 90 percent by 2024. The rising figures from 120 million to over 400 million indicate parallel growth in both user share and total mobile subscribers. This expansion highlights the deepening integration of mobile technology across the population and its critical role in enabling digital services.

2 Digital Marketplaces and e-NAM

The introduction of the electronic National Agriculture Market (e-NAM) has significantly transformed agricultural marketing by linking dispersed physical mandis through a unified online trading platform. By enabling real-time price information and inter-market trade, e-NAM enhances transparency, increases competition among buyers, reduces information asymmetry, and supports more efficient and remunerative price discovery for farmers.

Table 2: Progress of e-NAM in India

Indicator	2017	2020	2024
Number of Mandis Integrated	250	585	1389
Registered Farmers (Million)	1.7	8.6	18+
Value of Trade (₹ Lakh Crore)	0.36	1.01	3.5

Source: e-NAM Official Portal – Dashboard & Annual Progress Reports

The table highlights the rapid expansion and growing impact of the electronic National Agriculture Market (e-NAM) between 2017 and 2024. The number of integrated mandis increased more than fivefold, from 250 in 2017 to 1,389 in 2024, indicating wider geographic coverage. Registered farmers rose sharply from 1.7 million to over 18 million, reflecting increasing acceptance of digital marketing platforms. Simultaneously, the value of trade expanded from ₹0.36 lakh crore to ₹3.5 lakh crore, demonstrating enhanced market participation, improved price discovery, and greater transaction efficiency enabled by e-NAM.

3. Precision Farming and Smart Agriculture

Precision farming and smart agriculture refer to the application of digital technologies such as GPS, IoT sensors, drones, artificial intelligence, and data analytics to optimize agricultural production. These technologies enable site-specific input application, real-time crop monitoring, and data-driven decision-making, improving efficiency and sustainability. In India, the precision agriculture market was valued at approximately USD 330 million in 2025 and is projected to grow steadily with rising technology adoption. According to studies by the Indian Council of Agricultural Research, precision practices can increase crop yields by 15–25% while reducing water and fertilizer use. Market estimates from IMARC Group further highlight strong growth potential driven by government support and digital infrastructure expansion.

4. Rapid but early-stage adoption of drones and aerial applications

The adoption of drones and aerial applications in Indian agriculture is progressing rapidly but remains at an early stage. Industry estimates indicate around 3,000 agricultural drones are currently in use, with projections reaching about **7,**000 by Fiscal Year 2025, mainly for spraying and crop monitoring. The Indian agriculture drones' market was valued at approximately USD 243.6 million in 2024 and is forecast to expand sharply in the coming decade, reflecting growing market interest and policy support (Source: global-agriculture.com).

5. Emergence of AI/ML and frontier tech for advisory, forecasting and supply-chain optimisation

The emergence of artificial intelligence (AI), machine learning (ML), and frontier technologies is enhancing digital agricultural advisory, forecasting, and supply-chain optimisation in India. The AI in agriculture market reached approximately USD 70 million in 2024 and is projected to grow to about USD 350 million by 2033 (CAGR ~19.5%), driven by AI-powered precision tools, predictive analytics, and logistics optimisation. AI systems analyse weather, soil, and yield data to deliver personalised crop advice, forecast risks, optimise irrigation, and improve supply-chain efficiency, reducing waste and enhancing market access for farmers (imarcgroup.com)

6. Growth of Farmer Producer Organizations (FPOs) & platform aggregation

Digital platforms are increasingly transforming how Farmer Producer Organizations (FPOs) and aggregators operate by enabling seamless access to inputs, credit, extension services, and markets. Through these platforms, farmers can compare prices, purchase inputs in bulk, and connect directly with lenders and buyers, reducing dependence on intermediaries. Portals such as **e-NAM** integrate FPOs with traders, warehouses, logistics firms, and quality-certification agencies, which strengthens bargaining power and transparency. Digital records and transaction data also enhance traceability, helping FPOs meet quality standards, build market credibility, and participate more effectively in organized value chains and contract-farming arrangements. (ResearchGate)

7. Financial digitalization & direct benefit transfer (DBT)

Direct benefit transfers such as PM-KISAN, along with wider adoption of digital payments, have helped normalize electronic receipts and bank-linked transactions for farmers. This shift has reduced leakages and transaction costs while improving the transparency and targeting of subsidies and welfare schemes. The emerging digital financial trail also enables better data analytics for policy design, credit assessment, and monitoring of farm support programs. However, concerns remain regarding the effectiveness of these systems for unbanked, remote, or digitally excluded farmers, who may face barriers related to connectivity, financial literacy, and access to banking infrastructure.

8. Uneven adoption: structural barriers and inclusion gaps

Despite growing enthusiasm for digital agriculture, adoption remains uneven and highly differentiated across farmer groups. Constraints such as fragmented landholdings, limited digital literacy, unreliable rural internet, language barriers, and affordability gaps restrict meaningful use of platforms and services. In many contexts, digital tools are accessed more frequently by younger, better-educated farmers, FPO-affiliated members, or commercially oriented producers**,** while marginal and resource-poor smallholders participate less. This creates risks of a widening digital divide within rural communities. Mainstreaming adoption therefore requires addressing socio-technical barriers—including usability, localized content, trust in technology, institutional support, and inclusive design—making it a central priority for policy, extension systems, and future research on equitable digital transformation in agriculture.

Impact of Digitalization on Indian Agriculture

Digitalization is reshaping Indian agriculture by improving productivity, efficiency, and market integration across the value chain. Digital tools such as mobile advisory apps, remote sensing, precision farming, IoT devices, drones, and GIS-based monitoring enable better crop planning, weather forecasting, soil-health assessment, and pest management, leading to more informed farm decisions. Platforms for e-NAM, e-commerce, and digital input markets strengthen price discovery, reduce middlemen dependence, and expand market access for farmers and FPOs.

1. Impact on Agricultural Productivity

Digital technologies in agriculture—such as mobile advisory services, satellite-based crop monitoring, IoT soil sensors, and precision input management—help farmers make data-driven decisions on irrigation, fertilizer use, pest control, and crop planning. These interventions typically lead to:

- **Higher crop yields** through timely and customized advisories
- **Lower input costs** due to optimized fertilizer, pesticide, and water usage
- **Improved resource efficiency** and sustainability
- **Reduced crop losses** through early-warning systems and weather alerts

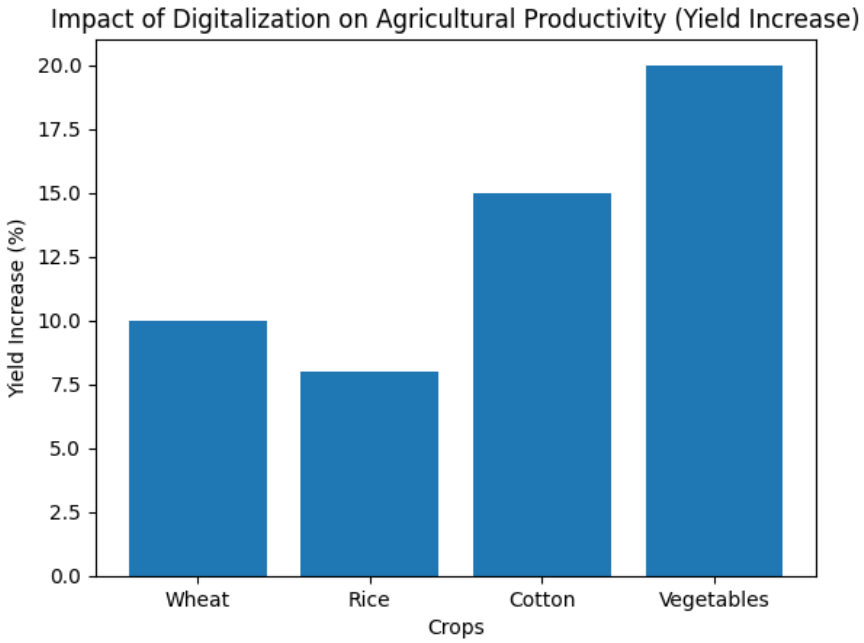
Overall, farmers experience **productivity growth alongside cost savings**, improving income stability and farm profitability.

Digital advisory services provide real-time information on crop management, leading to improved productivity.

Table 3: Productivity Impact of Digital Advisory Services

Crop	Yield Increase (%)	Reduction in Input Cost (%)
Wheat	8–12	10
Rice	6–10	8
Cotton	12–18	15
Vegetables	15–25	20

These improvements highlight the efficiency gains from digital interventions.



Digital advisory platforms, precision farming tools, and real-time data services have led to measurable improvements in crop performance. Studies on digitally supported farmers show yield gains and input-cost reductions due to better irrigation scheduling, pest management, fertilizer optimization, and market-linked decision-making. For example, field evidence indicates average yield increases of about **8–12% in wheat**, **6–10% in rice**, **12–18% in cotton**, and **15–25% in vegetables**, reflecting stronger responsiveness in high-value crops. These productivity gains translate into higher farm income and resource efficiency, supporting sustainable production outcomes.

2. Impact on Farmers' Income

Digital platforms allow farmers to connect directly with buyers, wholesalers, and processors, helping them bypass multiple layers of intermediaries and capture a larger share of the final price. Through online marketplaces and FPO-led trading platforms, farmers benefit from **transparent price discovery, reduced commission charges, and lower marketing costs**. Advisory services further support better decision-making on grading, timing of sales, and crop choice. Evidence from field studies shows that farmers using such platforms often achieve **income gains of 10–30%**, reflecting improved market access and bargaining power.

3. Impact on Risk Management

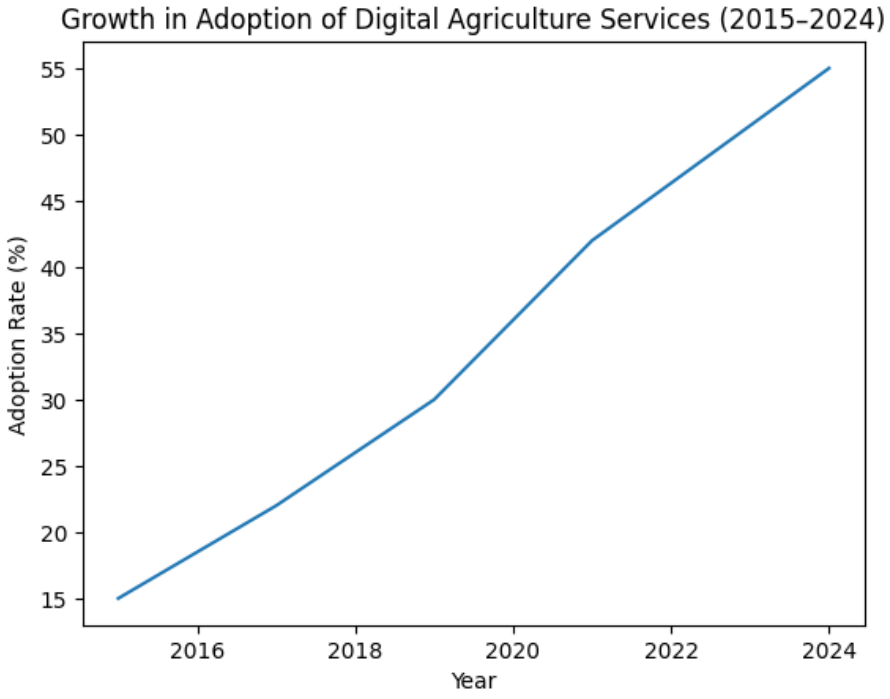
Weather forecasting apps, satellite-based monitoring, and digital insurance platforms play a crucial role in helping farmers manage production and market risks. Timely weather alerts and crop advisories enable farmers to adjust irrigation, planting, and pest-control decisions, reducing losses from unexpected climate events. Satellite data supports early detection of crop stress and disease outbreaks, while digital insurance systems streamline claim processing and offer quicker compensation. Together, these tools enhance **risk preparedness, resilience, and financial security** for farmers facing climate variability, pests, and price fluctuations.

Graphical Analysis

Table 4: Growth in Adoption of Digital Agriculture Services (2015–2024)

Year	Adoption Rate (%)
2015	15
2017	22
2019	30
2021	42
2024	55

The table shows a steady rise in adoption of digital agriculture services from **15% in 2015** to **55% in 2024**, indicating increasing acceptance of digital tools among farmers.



The line graph shows a steady and consistent rise in the adoption of digital agriculture services over the past decade. Adoption increased from **15% in 2015** to **55% in 2024**, reflecting growing awareness, expansion of mobile and internet connectivity, and wider availability of advisory, marketplace, and fintech platforms for farmers. The sharp increase after 2019 indicates stronger uptake driven by FPO initiatives, digital payments, and platform-based service integration.

Challenges in Digitalization of Agriculture

Digitalization of agriculture faces interlinked technical, economic, social, and governance challenges that particularly disadvantage small and marginal farmers in developing countries. These challenges slow adoption of digital tools and limit their potential to transform productivity and resilience.

1. **Infrastructure and Connectivity:** many rural areas, unreliable internet coverage, poor mobile networks, and inconsistent electricity supply make it difficult for farmers to access digital platforms or use precision tools that depend on real-time data.
2. **Cost and Technology**: The high cost of smartphones, IoT sensors, drones, and data services discourages small farmers from adopting new technologies. Most digital systems are designed for large farms, leaving smallholders unable to achieve the same return on investment.
3. **Digital Literacy and Awareness**: Many farmers are unfamiliar with mobile applications, data-driven advisories, or online marketplaces. A lack of technical knowledge and local-language support limits their ability to use available tools effectively.
4. **Data Privacy and Trust Issues**: Farmers often mistrust private or government digital platforms, worrying about who owns their data and how it might be shared or exploited. Limited awareness of data protection laws further increases hesitation.
5. **Policy and Institutional Gaps**: The absence of standardized frameworks, poor coordination among ministries, and weak support for startups restrict digital ecosystem growth. Fragmented supply chains and weak last-mile connectivity hinder integration between technology providers and rural users.
6. **Socioeconomic Barriers**: Poverty, small landholdings, and social exclusion restrict digital inclusion. Women farmers and marginalized groups often have less access to smartphones, credit, and training opportunities, deepening the digital divide.
7. **Localized Relevance:** Many digital models fail because they are not customized to local Agro-Climatic conditions or cropping patterns. Farmers lose interest when the advice or algorithms do not fit their real-world experience.

Overall, the digitalization of agriculture offers vast potential to improve productivity and sustainability, but addressing these infrastructural, financial, and institutional barriers is essential for inclusive and effective adoption.

Future Prospects of Digital Agriculture in India

1. The future of digital agriculture in India is highly promising as technology increasingly integrates with farming systems, markets, and governance. The expanding use of AI, IoT, remote sensing, drones, and big-data analytics is expected to enable more precise crop management, climate-smart advisory services, and efficient resource use**.** Predictive analytics and decision-support systems will help farmers reduce production risks, improve yields, and enhance resilience to climate variability.
2. The rapid growth of Farmer Producer Organizations (FPOs) will strengthen digital adoption at the grassroots level by acting as aggregation hubs for inputs, logistics, advisory services, and market linkages. At the same time, blockchain-based traceability and digital supply-chain platforms are likely to increase transparency, quality assurance, and price realization, particularly for high-value and export-oriented crops.

3. Strong momentum is also driven **by** government-led digital public infrastructure, including unified farmer databases, e-markets, geospatial platforms, and digitized land and subsidy systems, which will improve service delivery and foster innovation. Parallelly, rising private investment in agritech startup**s** is expected to scale solutions in precision farming, Agri finance, post-harvest management, and rural commerce.

Overall, digital agriculture is poised to transform Indian agriculture into a data-driven, market-linked, inclusive, and climate-resilient ecosystem**,** with significant potential to improve farm productivity, reduce transaction costs, enhance farmer incomes, and strengthen rural livelihoods.

Policy Recommendations

1. **Strengthen Digital Infrastructure and Connectivity:** Expand affordable broadband, mobile internet, and IoT coverage in rural areas to ensure farmers, FPOs, and service providers can fully participate in digital platforms.
2. **Promote Interoperable Digital Public Infrastructure:** Develop unified farmer databases, standardized data protocols, and open APIs to enable seamless integration across advisory services, credit systems, insurance platforms, and e-markets.
3. **Support Capacity Building and Digital Literacy:** Introduce farmer-centric digital training through FPOs, Krishi Vigyan Kendras, and extension services, ensuring women and smallholders are actively included.
4. **Encourage Innovation and Start-up Collaboration:** Provide fiscal incentives, incubation support, and sandboxes for agritech startups, while fostering partnerships between government, research institutions, and private players.
5. **Promote Climate-Smart and Inclusive Technologies:** Prioritize tools for weather-risk management, water-use efficiency, climate adaptation, and sustainable farming, ensuring solutions are affordable and scalable for marginal farmers.
6. **Improve Market Access and Supply-Chain Traceability:** Expand support for blockchain-based traceability, e-NAM integration, digital warehouses, and contract farming platforms to enhance transparency and price realization.
7. **Facilitate Access to Digital Finance and Insurance:** Integrate digital credit scoring, crop-insurance platforms, and payment systems to improve financial inclusion and reduce risk for small farmers.

Conclusion

Digitalization has the potential to fundamentally transform Indian agriculture by improving productivity, enhancing market efficiency, and strengthening farmers' resilience. While significant progress has been made in digital infrastructure and platform development, the benefits of digital agriculture must be broadened through inclusive policies and capacity-building initiatives. A balanced approach combining technology, institutional support, and farmer-centric design will be essential for realizing the full potential of digitalization in Indian agriculture.

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