

DIGITAL AGRICULTURE AND INCOME ENHANCEMENT: A STUDY OF INDIAN FARMERS

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ABSTRACT

Digital technologies are increasingly transforming Indian agriculture by improving access to information, enhancing productivity, and strengthening market linkages. This study examines the impact of digital tools such as mobile apps, ICT platforms, AI systems, remote sensing, and e-marketplaces on farmers' income in India. These technologies help farmers make informed decisions on sowing, irrigation, pest management, and marketing, leading to higher yields, reduced input costs, and better price realisation. Government initiatives like the Digital Agriculture Mission, PM-Kisan (DBT), eNAM, Kisan Call Centres, and Soil Health Card Scheme have further supported digital adoption and improved service delivery. However, the adoption of digital technologies remains limited due to challenges such as low awareness, inadequate digital literacy, poor rural infrastructure, affordability issues, and unequal access among small and marginal farmers. Despite these constraints, digital agriculture holds significant potential to enhance income stability and promote sustainable rural development. The study concludes that strengthening infrastructure, expanding training programs, and promoting inclusive digital policies are essential to maximize the benefits of digital technologies and ensure equitable growth for farmers across India.

Keywords: Digital Agriculture, Farmers' Income, Mobile Apps, ICT Platforms, Artificial Intelligence (AI), E-marketplaces, Government Initiatives, eNAM, PM-Kisan, Digital Literacy, Agricultural Technology.

INTRODUCTION

Agriculture is a key sector in India, providing livelihoods to a large portion of the population and contributing significantly to national income and food security. However, the sector faces challenges such as low productivity, climate variability, fragmented land holdings, weak market systems, and limited access to timely information. These issues restrict income growth and increase economic vulnerability, especially among small and marginal farmers.

Recent advancements in digital technologies have created new opportunities to transform Indian agriculture. Tools such as mobile applications, ICT platforms, Artificial Intelligence (AI), remote sensing, and digital marketplaces help address information gaps, improve advisory services, and enhance market access. These technologies enable real-time data sharing, expert guidance, and transparent market mechanisms, allowing farmers to make better decisions about crop planning, resource management, and selling produce. They also support efficient monitoring of crop health and weather risks, reducing losses and improving productivity.

The Government of India has supported this shift through initiatives focused on e-governance, digital public infrastructure, and direct benefit transfers. These programs aim to improve service delivery, reduce inefficiencies, and ensure financial inclusion. Despite these efforts, adoption remains uneven due to low digital literacy, poor infrastructure, and affordability issues. This study examines the impact of digital technologies on farmers'

income in India, highlighting both benefits and challenges to understand their role in promoting sustainable and inclusive agricultural growth.

REVIEW OF LITERATURE

Gautam et al. (2021) found a positive relationship between digital technology adoption and farmers' income using panel data. Digital finance and ICT tools helped improve information access, reduce costs, and enhance market participation.

Kumar and Singh (2022) studied mobile-based advisory services and reported that users achieved higher yields and income. Timely weather and crop guidance improved farming practices, but adoption was limited by digital literacy and smartphone availability.

Reddy and Sharma (2023) evaluated the eNAM platform and found it increased price realization and reduced middlemen influence. However, limited internet connectivity and logistics issues restricted its reach, especially in remote areas.

Overall, these studies show digital technologies can increase productivity and income but highlight barriers like infrastructure, awareness, and equitable access.

RESEARCH GAP

Despite evidence that digital tools improve productivity and market access, most studies focus on specific technologies or regions, lacking a comprehensive national-level analysis. Limited research exists on long-term income effects and sustainability of digital adoption among small and marginal farmers. There is also inadequate understanding of barriers like digital literacy, infrastructure, and affordability across diverse agro-climatic zones. Finally, the unequal impact of digital agriculture on vulnerable farmers remains underexplored, requiring more inclusive evaluation.

STATEMENT OF THE PROBLEM

Indian agriculture continues to face persistent challenges such as low productivity, fragmented land holdings, climate uncertainty, and inefficient market systems, which restrict farmers' income growth and financial stability. Although digital technologies have the potential to address these issues through better access to information, improved market linkages, and efficient service delivery, adoption remains uneven and limited. The digital divide, low literacy, poor rural infrastructure, and affordability barriers hinder the effective use of digital tools, particularly among small and marginal farmers. Therefore, there is a need to assess the real impact of digital technologies on farmers' income and identify the key factors affecting adoption, to ensure inclusive and sustainable agricultural development.

OBJECTIVES OF THE STUDY

1. To examine the role of digital technologies in improving agricultural productivity and farmers' income in India.
2. To analyze the impact of digital tools such as mobile apps, ICT platforms, AI, remote sensing, and e-marketplaces on farm income and decision-making.
3. To evaluate the effectiveness of government policies and initiatives in promoting digital agriculture and enhancing farmers' benefits.
4. To identify the key challenges and barriers limiting the adoption of digital technologies among Indian farmers.
5. To recommend strategies for enhancing digital inclusion and ensuring equitable income growth for small and marginal farmers.

HYPOTHESES OF THE STUDY

H₁: Digital technologies increase farmers' income in India.

H₀: Digital technologies do not increase farmers' income.

METHODOLOGY OF THE STUDY

This study uses a descriptive research design based on secondary data from government reports, research articles, and credible agricultural sources to analyze the impact of digital technologies on farmers' income in India. It examines the role of digital tools like mobile apps, AI, remote sensing, and e-marketplaces across different farmer groups and regions. The analysis combines qualitative review of literature and policies with basic quantitative measures such as percentages and correlations to assess the relationship between digital adoption and income, while acknowledging limitations due to data availability and regional disparities.

SCOPE OF THE STUDY

This study focuses on the impact of digital technologies on farmers' income in India, covering key tools such as mobile apps, AI, remote sensing, ICT platforms, and e-marketplaces. It examines how these technologies influence productivity, cost reduction, market access, and access to government benefits. The study also reviews major government policies and initiatives supporting digital agriculture, while identifying challenges such as digital literacy, infrastructure gaps, and unequal adoption. The scope is limited to secondary data sources and general trends across India, without conducting primary field surveys.

LIMITATIONS OF THE STUDY

1. **Secondary Data Dependence:** The study relies only on existing reports and research, which may limit the accuracy and current relevance of findings.
2. **Regional Variations Not Covered Deeply:** India has diverse agricultural conditions, but the study may not fully represent every state or region.
3. **Limited Primary Evidence:** No direct field surveys or interviews were conducted, which may reduce real-time validation of digital adoption.

DIGITAL TECHNOLOGIES IN INDIAN AGRICULTURE

Digital technologies are transforming Indian agriculture by improving access to information, increasing efficiency, and supporting better decision-making. Tools such as mobile apps, ICT platforms, and AI systems address long-standing challenges like information gaps, market inefficiencies, and climate uncertainty. Mobile applications provide weather forecasts, crop advisories, and real-time market prices, enabling farmers to plan sowing, irrigation, and harvesting more effectively and reducing dependence on intermediaries. ICT platforms such as Kisan Call Centres and chatbots connect farmers directly with experts, helping them manage crop diseases, soil health, and improved farming practices, especially in remote areas.

Artificial Intelligence (AI) further enhances agriculture by analyzing large volumes of data to provide predictive insights on sowing time, suitable crop varieties, pest outbreaks, and yield forecasts. These AI-driven recommendations help farmers take preventive actions, optimize resource use, and plan better for storage and marketing, thereby increasing productivity and income. Overall, the integration of these digital tools improves productivity, transparency, and resilience in farming, helping farmers adapt to climate change and improve income stability. However, adoption varies across regions due to social and infrastructural constraints.

BENEFITS OF DIGITAL TECHNOLOGIES TO FARMERS' INCOME

Digital technologies boost farmers' income by improving productivity, lowering costs, enhancing market access, and ensuring timely financial support. Mobile advisories, AI tools, and remote sensing help farmers make informed decisions on sowing, irrigation, nutrient management, and pest control, leading to higher yields and reduced crop losses. Precision farming also optimizes land and water use, resulting in better output per hectare and increased farm income.

Digital tools also reduce production costs by guiding correct input usage and preventing unnecessary purchases, often lowering expenses by 15–25%. Market linkages through digital marketplaces and price information apps connect farmers directly with buyers, reduce intermediaries, and improve price transparency. This enables farmers to sell at better prices and reduce post-harvest losses. Overall, when combined with supportive government policies and training, digital agriculture strengthens financial stability and supports inclusive rural development in India.

ISSUES AND CHALLENGES IN ADOPTION OF DIGITAL TECHNOLOGIES

Despite the potential of digital technologies to improve farmers' income, their adoption in India remains limited due to several challenges. A major issue is low awareness, with over 86% of farmers reportedly unaware of modern digital tools or lacking access to them. Many still rely on traditional practices and informal advice networks, as targeted awareness programs and extension services are inadequate.

Additionally, digital literacy and infrastructure constraints hinder effective adoption, especially among small and marginal farmers. Poor internet connectivity, unreliable electricity, and limited smartphone access reduce the usability of digital solutions. High investment costs for advanced technologies like drones and sensors make them unaffordable for small landholders, limiting scalability. Furthermore, digital benefits are unevenly distributed, often favoring better-off farmers with more education and resources, which can widen income disparities and raise concerns about inclusive agricultural development.

GOVERNMENT POLICIES AND INITIATIVES

The Government of India has actively promoted digital agriculture through several key policies and initiatives aimed at improving productivity, transparency, and market access. The Digital Agriculture Mission focuses on building a comprehensive digital ecosystem, including Digital Public Infrastructure for crop management and advisory services. The PM-Kisan scheme uses Direct Benefit Transfer (DBT) to provide direct income support to farmers through digital payment systems, reducing delays and leakages. eNAM (National Agriculture Market) connects mandis across the country, offering real-time price information and online trading to reduce intermediary dependence and improve price realization. Kisan Call Centres (KCC) and mobile advisory services provide expert guidance, weather updates, and pest alerts, especially benefiting remote areas. The Soil Health Card Scheme offers digital soil testing records and fertilizer recommendations, supporting precision farming. To support these initiatives, the government has also strengthened rural connectivity through programs like BharatNet and expanded 4G coverage, while promoting digital literacy through training programs. Collectively, these policies aim to create an inclusive digital ecosystem that enhances farmers' access to information, financial services, and markets, thereby improving income and agricultural sustainability.

FINDINGS

1. **Digital tools improve farm decisions** through weather updates, crop advice, and market prices, helping farmers plan better and reduce losses.
2. **Productivity and yields increase** due to precision farming, early pest detection, and optimized input use.
3. **Costs decrease** as farmers use fertilizers, pesticides, and water more efficiently, saving up to 15–25%.
4. **Market access improves** through eNAM and price platforms, enabling better prices and reducing middlemen.
5. **Government support becomes faster and transparent** via DBT, Soil Health Cards, and digital advisory services.
6. **Adoption is uneven**, with small and remote farmers facing barriers like low digital literacy and poor infrastructure.
7. **Need for training and infrastructure** to make digital agriculture more inclusive and widely adopted.

SUGGESTIONS

1. **Increase digital awareness programs** through village-level workshops and agricultural extension services to help farmers understand and use digital tools effectively.
2. **Improve rural internet and power infrastructure** by expanding BharatNet and strengthening 4G/5G coverage in remote areas.
3. **Provide affordable access to devices** such as subsidized smartphones or shared community digital kiosks for small and marginal farmers.
4. **Strengthen digital literacy training** focusing on basic app usage, online marketplaces, and digital payments.
5. **Promote shared service models** (cooperatives, agri-tech hubs) for expensive technologies like drones and sensors to reduce costs.

CONCLUSION

Digital technologies have the potential to transform Indian agriculture by improving productivity, reducing costs, enhancing market access, and ensuring timely delivery of government support. Tools such as mobile apps, AI systems, and e-marketplaces help farmers make informed decisions, optimize resources, and receive fair prices for their produce. Government initiatives like PM-Kisan, eNAM, and Digital Agriculture Mission further strengthen the digital ecosystem and promote inclusive growth.

However, adoption remains uneven due to challenges like low awareness, limited digital literacy, poor infrastructure, and affordability issues. To fully realize the benefits of digital agriculture, it is essential to strengthen rural connectivity, expand training programs, and promote affordable access to digital tools—especially for small and marginal farmers. With sustained efforts and supportive policies, digital agriculture can significantly enhance farmers' income and contribute to sustainable rural development in India.

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