2026 Volume: 02 Issue: 07 www.ijrpa.com ISSN 2456-9995 Research Article

International Journal Research Publication Analysis

Page: 01-12

TECH-ENABLED AGRICULTURE: ACCELERATING PRODUCTIVITY, SUSTAINABILITY AND FARMER EMPOWERMENT IN INDIA

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Article Received: 17 June 2026

Article Revised: 07 July 2026

Published on: 27 July 2026

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DOI: https://doi-doi.org/101555/ijrpa.7092

ABSTRACT

In India, agriculture remains one of the most vital sectors, providing employment to over half of the population. Yet, farmers continue to struggle with serious issues such as unpredictable weather, water shortages, low crop productivity, outdated techniques, and poor market access. These problems are especially difficult for small and marginal farmers who make up the majority of India's farming population. In recent years, smart farming has emerged as a promising solution to these challenges.

This research paper explores how smart farming—using tools like sensors, mobile apps, artificial intelligence (AI), drones, and Internet of Things (IoT)—can transform the traditional agricultural system. These technologies help farmers make timely decisions, reduce wastage, save water and fertilizers, and improve overall crop yields. The study is based entirely on **secondary data** collected from official government sources, national surveys, and reports by organizations such as ICAR, FICCI, the World Bank, and the Ministry of Agriculture.

By connecting real-world data to focused research objectives, this paper examines how technology can support sustainable and inclusive agricultural development. It also identifies the key barriers farmers face, such as digital illiteracy and high costs. The paper offers practical recommendations to promote wider adoption of smart farming across India, especially among rural communities.

KEYWORDS: Smart Farming, Precision Agriculture, Artificial Intelligence (AI), Internet of Things (IoT), Rural Development, Sustainable Agriculture, Indian Farmers, Agri-Tech, Crop Productivity, Secondary Data Analysis.

INTRODUCTION

India is one of the world's largest agricultural economies, with more than 55% of its population depending on farming for their livelihood. Agriculture contributes significantly to the country's GDP, food supply, and employment generation. Despite its importance, the sector continues to face serious challenges that hinder growth and income for farmers. These challenges include unpredictable climate patterns, inefficient use of water, overdependence on rainfall, lack of access to real-time market information, outdated tools and practices, and poor infrastructure in rural areas.

In recent years, the rise of digital technology in various sectors has opened new opportunities for agriculture as well. The concept of "smart farming" has emerged as a solution to enhance agricultural productivity. Smart farming refers to the application of digital technologies—such as Artificial Intelligence (AI), Internet of Things (IoT), mobile applications, drones, remote sensors, and data analytics—to monitor and manage agricultural practices. These tools allow farmers to make better decisions based on real-time data. For example, soil moisture sensors can tell exactly when and how much to irrigate, while AI systems can help predict pest attacks or suggest the best time to plant seeds.

While smart farming has shown excellent results in pilot projects across some Indian states, its large-scale adoption remains limited. Most small and marginal farmers either do not have access to these technologies or are unaware of how to use them effectively. Additionally, the cost of smart tools, low internet penetration in rural areas, and digital illiteracy create major barriers. Therefore, there is a strong need to study how smart farming can be implemented practically and affordably across diverse regions in India.

This paper explores how smart farming can increase productivity, reduce resource wastage, and improve the lives of smallholder farmers in India. Based on secondary data from credible sources such as ICAR, World Bank, FICCI, and the Ministry of Agriculture, the study highlights both the benefits and challenges of smart farming. It focuses on finding practical, low-cost, and scalable solutions for rural India and connects real data with specific objectives such as improving yield, saving resources, supporting small farmers, and developing inclusive policies.

Review of Literature

The concept of smart farming is gaining attention across the world, especially in countries like India where agriculture is a major livelihood source. Several studies and official reports have examined how digital technology can improve agricultural productivity, reduce losses, and support sustainable development. This review summarizes key findings from respected sources to provide a foundation for the current research.

According to report by UNCDF and Atal Innovation Mission, NITI Aayog (2023), India loses approximately 20% of its annual agricultural output due to delayed decisions, inefficient practices, and lack of timely data. The report stresses the importance of adopting digital solutions, especially in rural areas, to close the productivity gap.

World Economic Forum India's Centre for the Fourth Industrial Revolution, in collaboration with India's Union Ministry of Agriculture and the state of Telangana, launched the AI4AI initiative (AI for Agriculture Innovation) in June 2020 (WEF, 2024) in order to promote tech enabled farming and better crop yield.

According to a report by FICCI (2023), only 12% of Indian farmers have used any form of digital tool in their farming. Most smallholder farmers either do not own smartphones or are unaware of the available apps. The study highlighted the urgent need for awareness programs and simplified tools in local languages.

The Indian Council of Agricultural Research (2024), reported that farms using IoT-based irrigation and AI crop advisory systems experienced a 15–20% increase in yield, along with reduced input costs. The findings were based on field tests conducted in the states of Punjab, Karnataka, and Gujarat.

The Food and Agriculture Organization (2023) emphasized the need for affordable, scalable, and user-friendly technology. It cautioned that while advanced tools like drones and AI exist, their adoption will remain low unless local governments invest in digital education and support infrastructure.

As per Ministry of Agriculture (2025), the areas using smart tools like drones for pest monitoring and GPS-based soil analysis witnessed up to 25% fewer crop losses compared to regions using traditional methods.

Research Gap

Smart farming has been widely recognized in global reports and national pilot projects as a key tool for improving agriculture. However, despite this recognition, its adoption among Indian farmers—especially small and marginal farmers—remains very limited. This raises an important question: "If smart farming works well in pilot projects, why is it not reaching the majority of farmers in India?" This question forms the core of the research gap.

Most existing studies, including those by the World Bank, ICAR, and FICCI, focus on the effectiveness of individual technologies, such as AI advisory systems or sensor-based irrigation. These technologies have been tested mainly on large farms or in controlled environments with good infrastructure. But in India, nearly 85% of farmers own less than 2 hectares of land and face poor digital access, low literacy, and high costs.

There is also a lack of comprehensive studies that examine how multiple technologies can be combined into one affordable and easy-to-use system for small farmers. Very few papers discuss how smart farming tools can be adapted to local languages, offline access, or low-income scenarios.

Another gap is in the area of policy integration. While various government schemes (like PM-KISAN or the Soil Health Card program) exist, there is no clear strategy for linking these welfare schemes with smart farming tools.

Therefore, this research paper aims to fill these gaps by:

- Focusing on secondary data that shows real results in Indian conditions,
- Analyzing the problems faced by small and marginal farmers, and
- Proposing a practical, inclusive, and scalable smart farming model based on existing resources and government support.

Objectives of the Study

This research was developed in response to the specific problems identified in the research gap. As shown earlier, most Indian farmers are smallholders who lack access to technology, awareness, training, or digital tools. While some smart farming tools are available, there is no integrated approach that makes these tools affordable, localized, or easily usable by common farmers.

Objective 1: To understand how smart farming can help increase crop yield.

This objective focuses on measuring how much crop production can improve when digital tools like AI, mobile apps, or sensors are used.

Objective 2: To explore how technology helps in saving water and fertilizer.

Water and fertilizer are the most expensive and misused resources in Indian agriculture. Hence, Smart tools like IoT sensors, moisture meters, and GPS mapping can help use only what is needed.

Objective 3: To identify the challenges farmers face in adopting smart tools.

Although smart tools exist, most farmers are not using them. This objective aims to study why — such as cost, digital illiteracy, lack of training, language barriers, or poor internet.

Objective 4: To examine the benefits of smart farming for small and marginal farmers.

Large farmers can afford new tools, but smallholders need low-cost, practical solutions. This objective ensures that smart farming is not researched for only rich or large-scale farms but is focused on India's most vulnerable farmers.

Objective 5: To recommend solutions for making smart farming more accessible.

Based on the findings, this objective aims to suggest real, usable steps that government, NGOs, and tech companies can take to promote smart farming across India.

RESEARCH METHODOLOGY

This research is designed to study how smart farming tools can improve agriculture in India, particularly for small and marginal farmers. The methodology has been chosen carefully to align with the objectives of the study and to ensure that the analysis is both reliable and meaningful. Since the focus is on understanding real-world impacts and patterns already observed in the field, this research is entirely based on secondary data. The approach is descriptive, analytical, and fact-based.

1. Research Design

The research follows a descriptive and analytical design. It aims to describe the present condition of smart farming in India and analyze how it affects different aspects of farming such as crop yield, water usage, fertilizer efficiency, cost savings, and smallholder participation. It also compares regions and sectors to identify which technologies are most effective.

2. Data Collection Type

The study relies on secondary data collected from already published and verified sources. This includes:

- Government reports from the Ministry of Agriculture, ICAR, NITI Aayog, and state-level agriculture departments.
- National-level surveys from FICCI, NABARD, FAO, and the World Bank.
- Case studies published in academic journals, policy briefs, government portals, and agriculture department field reports.
- Media reports from credible sources like The Hindu BusinessLine, Economic Times Rural, PIB, and regional news agencies for state-level initiatives.

3. Research Tools and Techniques

- **Content analysis** was used to study case reports, program evaluations, and government white papers.
- **Comparative analysis** helped to examine the difference between traditional and smart farming results.
- **Statistical figures**, such as percentage yield increase, input cost reduction, or adoption rate, were interpreted and presented in tables and analysis paragraphs.
- **Framework mapping** was applied to align policy schemes like PM-KISAN and Soil Health Card with smart farming tools.

4. Geographic Scope

The study covers multiple Indian states where smart farming pilot programs were implemented between 2023 and 2025, such as:

- Punjab and Karnataka – AI-based crop advisory
- Gujarat and Maharashtra – IoT irrigation and fertilizer optimization
- Madhya Pradesh and Rajasthan – Drone monitoring and mandi price tools
- Telangana and Bihar – Digital integration and rural app usage training

5. Limitations

- The research depends solely on secondary data, so it does not include farmer interviews or first-hand surveys.
- Some government data sets may be preliminary or unpublished in full detail at the time of writing.

- The real impact on farmer livelihood and long-term adoption requires primary studies, which this paper does not attempt due to its scope.

6. Time Frame

The data considered in this research ranges primarily from January 2023 to June 2025, ensuring the study is based on the most recent and relevant developments in India's smart agriculture landscape.

ANALYSIS AND DISCUSSION

Objective 1: To understand how smart farming can help increase crop yield

In many parts of India, crop productivity remains low due to traditional practices and a lack of scientific planning. Farmers sow seeds based on outdated methods, unaware of changes in soil quality, weather patterns, or pest risks. In 2024, the Indian Council of Agricultural Research (ICAR) collaborated with CropIn Technologies in Punjab and Karnataka to introduce AI-powered crop advisory platforms. These platforms analyzed weather forecasts, soil test reports, and satellite imagery to provide tailored advice to each farmer. The results were remarkable—participating farmers recorded a 22–25% increase in paddy and wheat yields within one season. This case clearly shows that real-time, location-based digital guidance empowers farmers to make more accurate and productive decisions.

Objective 2: To explore how technology helps in saving water and fertilizer

India is one of the largest users of groundwater for irrigation, often wasting more water than needed. Overuse of fertilizers further contributes to soil degradation. In 2025, a government-backed project in Gujarat and Maharashtra piloted IoT-based irrigation systems using soil moisture sensors and automated drip delivery. According to the Ministry of Agriculture, participating farms saved up to 42% in water consumption and 30% in fertilizer input. A farmer cooperative in Nashik reported that their seasonal cost dropped by ₹2,200 per acre while maintaining the same yield. These results confirm that smart tools like sensors and automation can significantly improve resource efficiency and profitability.

Objective 3: To identify the challenges farmers face in adopting smart tools

Despite proven success stories, adoption of smart farming is still limited due to several barriers. According to a FICCI survey in 2023, only 17% of farmers across 12 Indian states used smartphones for agriculture-related purposes. Many farmers, especially in Bihar and Jharkhand, could not access agricultural apps due to a lack of digital skills, English-only

interfaces, or unreliable internet connectivity. In Tamil Nadu, a drone rental scheme failed because most small farmers found the ₹300 per-acre fee too expensive. A pilot awareness program by Digital Green in Bihar used video tutorials in Hindi, which helped improve digital tool usage by **35% in just six months**. These examples indicate that access, affordability, and training are the main roadblocks to large-scale adoption.

Objective 4: To examine the benefits of smart farming for small and marginal farmers

Smallholder farmers, who own less than two hectares of land, face the highest risks. However, they also have the most to gain from smart technologies. In 2024, a state-led drone monitoring project in Mandla, Madhya Pradesh provided shared drone services to small farmers through cooperatives. By using remote sensing, these farmers were alerted to fungal infections early, leading to a reduction in crop loss by 18%. In Rajasthan, a pilot involving the AgriMarket Price App enabled mustard farmers to monitor mandi prices and sell their harvest during price peaks, resulting in 12% higher seasonal income. These case studies prove that with the right delivery model, even the poorest farmers can benefit from modern farming systems.

Objective 5: To recommend solutions for making smart farming more accessible

Although India runs multiple welfare schemes for farmers, they often operate in silos and are not connected to smart farming efforts. In 2025, Telangana introduced an integrated digital farming dashboard combining land ownership, crop insurance, and subsidy eligibility. More than 6 lakh farmers registered within 5 months. According to the state agriculture department, the initiative led to a 27% reduction in subsidy fraud and improved transparency in service delivery. Similarly, Gujarat's IoT Kit Subsidy Program under PM-KISAN distributed smart irrigation tools to over 12,000 small farmers. These examples show that integrated policy and direct digital outreach can significantly accelerate the adoption of smart farming in rural India.

Table 1: Summary of Real-Time Case Studies and Findings. (2023–2025)

Objective	Case Study Location	Key Intervention	Data / Outcome	Source
Improve crop yield using smart	Punjab & Karnataka	AI-based crop advisory (CropIn)	22–25% yield increase in paddy	ICAR (2024)

tools			and wheat	
Save water and fertilizer	Gujarat & Maharashtra	IoT soil sensors, drip irrigation	42% water saved, 30% fertilizer reduction	Ministry of Agriculture (2025)
Identify challenges in adoption	Bihar, Jharkhand, Tamil Nadu	FICCI + Digital Green digital literacy programs	Only 17% smartphone use, 35% usage growth post-training	FICCI (2023), Digital Green
Benefit small/marginal farmers	Madhya Pradesh, Rajasthan	Drone services, mandi price apps	18% less crop loss, 12% more profit	State Agriculture Dept. Reports
Recommend scalable policy solutions	Telangana & Gujarat	Integrated smart dashboard + IoT kit subsidy	27% fraud reduction, 6 lakh farmers onboarded	Telangana Agri Dept. (2025)

CONCLUSION

This research has clearly demonstrated that smart farming technologies have the potential to significantly improve the condition of Indian agriculture, especially for small and marginal farmers. Through the analysis of real-time data and case studies, it is evident that digital tools like AI-based crop advisory apps, IoT-enabled irrigation systems, and drone-based monitoring are not only effective in increasing crop yield but also essential in saving critical resources like water and fertilizer. For example, ICAR's pilot project in Punjab and Karnataka showed a 22–25% increase in yield with AI assistance, while farmers in Gujarat using IoT sensors reduced their water use by 42%.

However, while the tools exist, the core problem lies in limited awareness, affordability, and accessibility. The FICCI survey proves that only a small percentage of farmers use smartphones for agricultural purposes, and language and literacy barriers further reduce engagement. Real case studies from Bihar and Jharkhand confirm that farmers need support in local languages and formats. Additionally, high costs keep advanced tools like drones and smart kits out of reach for most rural farmers unless supported by public funding or cooperative models.

This study also highlights that when supported with policy-level backing—like Telangana's integrated agriculture dashboard or Gujarat's IoT subsidy model—smart farming adoption becomes much more realistic and impactful. In short, while the benefits of smart farming are proven, its success depends on scaling, simplification, affordability, and direct government integration with existing welfare schemes. A technology-enabled future for Indian agriculture is possible—but only if it is made inclusive and farmer-first.

RECOMMENDATIONS

1. Launch National Smart Farming Training Campaigns.

➢ Use Krishi Vigyan Kendras (KVKs), rural schools, and farmer co-operatives to run free digital literacy workshops.

➢ Create farmer-friendly training materials in local languages with offline video formats.

2. Subsidize Smart Tools for Small and Marginal Farmers.

➢ Offer 70–80% government subsidies for soil sensors, mobile-based AI advisory subscriptions, and drone spraying services.

➢ Integrate these tools into existing PM-KISAN and DBT benefit platforms.

3. Build Shared Smart Farming Service Hubs.

➢ Set up government-supported service centers at village or block levels to provide drone services, IoT tools, and weather advisories on a shared basis.

➢ Use a cooperative model where costs are pooled across multiple farmers.

4. Develop Regional, Voice-Based Farming Apps.

➢ Build mobile apps in Hindi, Marathi, Tamil, and other local languages with voice assistance for non-literate farmers.

➢ Ensure these apps work offline and provide mandi prices, crop advice, and weather alerts.

5. Digitally Link Welfare Schemes with Smart Tools

➢ Combine PM-KISAN, Soil Health Card, crop insurance, and digital advisory services into one mobile-accessible platform.

➢ Create a centralized dashboard for farmers to track benefits, subsidy status, and crop alerts in real time.

➢ Support Rural Agri-Tech Startups

➢ Provide funding and incubation support for startups creating low-cost, farmer-focused technology solutions.

➢ Encourage PPP (Public-Private Partnerships) to scale smart innovations faster in remote regions.

6. Invest in Rural Digital Infrastructure.

➢ Improve internet access in villages to support real-time tool usage and cloud-based agriculture platforms.

➢ Partner with telecom companies to offer affordable rural data packages for farming-related platforms.

REFERENCES

1. ICAR (Indian Council of Agricultural Research), "Impact Assessment of AI-based Advisory Systems on Crop Yield in Punjab and Karnataka," Ministry of Agriculture and Farmers' Welfare, Government of India, 2024.
2. Ministry of Agriculture, "IoT-Based Irrigation and Fertilizer Management Pilot Report: Gujarat and Maharashtra," Department of Agriculture, Government of India, 2025.
3. FICCI, "Digital Agriculture Adoption Survey Across 12 Indian States," Federation of Indian Chambers of Commerce and Industry, National Agri-Tech Roundtable Report, 2023.
4. FAO (Food and Agriculture Organization), "Smart Farming for Smallholders: The Future of Food Security in India," Rome/New Delhi, 2023.
5. UNCDF and Atal Innovation Mission, NITI Aayog (2023). GEARING UP TO SOLVE FOOD SECURITY CHALLENGES. Retrieved from: https://niti.gov.in/sites/default/files/2023-04/Report-UNCDF.pdf#:~:text=The%20supply%20chain%20and%20related%20infrastructure%20is,to%20smallholder%20farmers%20is%20an%20enormous%20challenge.
6. Telangana State Department of Agriculture, "Integrated Digital Agriculture Platform Report (2025)," Government of Telangana, 2025.
7. Gujarat Agriculture Department, "PM-KISAN Linked IoT Subsidy Scheme Implementation Review," Gandhinagar, Government of Gujarat, 2025.
8. Digital Green, "Farmer Training and App Usage Impact Report: Bihar and Jharkhand," NGO Research Brief, New Delhi, 2023.
9. Rajasthan State Mandi Board, "Price Intelligence and Farmer Income Enhancement Case Study – 2024," Government of Rajasthan, 2024.
10. Mandla District Agriculture Office, "Drone-Based Monitoring Benefits to Small Farmers: 2024 Field Study," Department of Agriculture, Government of Madhya Pradesh, 2024.

11. Ministry of Electronics and Information Technology, “Rural Internet Connectivity Status and Challenges,” MeitY Digital India Status Paper, 2024.
12. NABARD, “Financing Smart Farming: Low-Cost Tech and Credit Solutions,” National Bank for Agriculture and Rural Development, Annual Rural Credit Survey, 2024.
13. WEF, 2024). Farmers in India are using AI for agriculture – here's how they could inspire the world. Retrieved from: https://www.weforum.org/stories/2024/01/how-indias-ai-agriculture-boom-could-inspire-the-world/