

Adoption of Smart Farming Technologies (AI and IoT) in Farm Mechanization and Post-Harvest Systems: Enhancing Agricultural Productivity and Sustainability in India

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Abstract

The adoption of smart farming technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) has significantly transformed Indian agricultural systems by enhancing farm mechanization and post-harvest management. These technologies enable precision agriculture, real-time monitoring, and data-driven decision-making, leading to improved productivity and sustainability. This study reviews the role of AI and IoT in modern agriculture, focusing on mechanization efficiency and post-harvest loss reduction. The findings indicate that smart technologies improve crop yield, optimize resource utilization, and enhance supply chain efficiency. However, challenges such as high implementation costs and lack of infrastructure persist.

Keywords: Artificial Intelligence, Internet of Things (IoT), Farm Mechanization, post-harvest, Sustainability.

1.Introduction

Agriculture is a major contributor to India's economy, providing sustenance, employment, and ensuring national food security. Despite its significance, the sector continues to face several critical challenges, including climate change, declining productivity, inefficient resource utilization, and substantial post-harvest losses (Choudhary et al., 2025). With the continuous growth of the population, traditional farming methods are increasingly inadequate to meet the rising demand for food (Sharma et al., 2025).

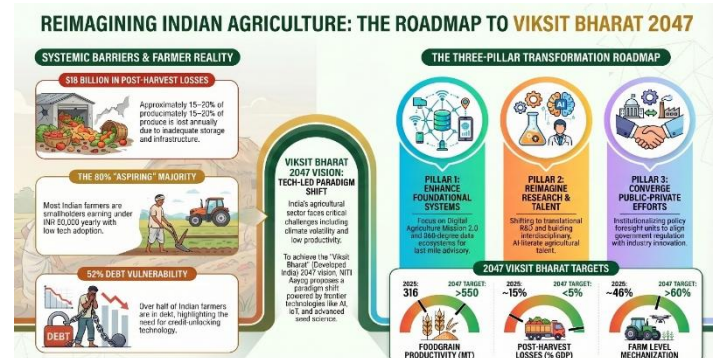
In recent years, agriculture has witnessed a shift toward digitalization and automation. The emergence of smart farming technologies, particularly Artificial Intelligence (AI) and the Internet of Things (IoT), has enabled data-driven decision-making, real-time monitoring, and automation across agricultural systems (Kour et al., 2025). These technologies support precision agriculture, enhance farm mechanization, and streamline post-harvest management processes (Choudhary et al., 2025).

AI and IoT provide valuable insights through predictive analysis, efficient resource management, and timely response strategies. As a result, these advancements are significantly improving agricultural productivity while promoting environmentally sustainable practices (Vedamurthy et al., 2026). This study focuses on examining the impact of AI and IoT on farm mechanization and post-harvest systems in India.

Several studies have explored the application of artificial intelligence in agriculture, highlighting its role in crop

monitoring, disease detection, and yield prediction (Sharma et al., 2025). IoT devices, such as sensors and drones, facilitate real-time data collection, enabling more informed and accurate decision-making (Choudhary et al., 2025). The integration of AI, IoT, and big data analytics has enhanced the sustainability and operational efficiency of smart farming systems, with studies reporting up to a 23% increase in crop yield and a 45% reduction in water usage (Adediran, 2025).

This study systematically reviews existing literature on AI and IoT applications in agriculture. Secondary data related to farm mechanization, post-harvest technologies, and smart agricultural systems were collected from peer-reviewed journals, research articles, and reports. The gathered information was analyzed qualitatively to assess the impact and effectiveness of these technologies.



2. Overview of AI and IoT in Agriculture

2.1 Artificial Intelligence (AI)

Artificial Intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think, learn, and make decisions. It involves the use of algorithms, data, and computational models to perform tasks that typically require human intelligence, such as problem-solving, pattern recognition, and decision-making. AI systems use techniques like machine learning, deep learning, and natural language processing to analyze large amounts of data and generate findings. These systems can improve their performance over time by learning from experience. In agriculture, AI plays a significant role in crop monitoring, disease detection, yield prediction, and precision farming. It helps farmers make data-driven decisions, optimize resource use, and improve productivity while promoting sustainability.

Overall, AI is a transformative technology with applications across various sectors, including healthcare, education, finance, and agriculture.

2.2 Internet of Things (IoT)

The Internet of Things (IoT) refers to a network of interconnected physical devices embedded with sensors, software, and communication technologies that enable them to collect, exchange, and transmit data over the internet. These devices can monitor and interact with their environment in real time without direct human intervention. IoT systems typically include sensors, actuators, connectivity (such as Wi-Fi or mobile networks), and data processing platforms. The data collected is analyzed to support informed decision-making and automation. In agriculture, IoT is widely used for monitoring soil moisture, temperature, crop health, and weather conditions. It enables precision farming, automated irrigation systems, and efficient resource management, leading to increased productivity and reduced wastage. Overall, IoT enhances efficiency, accuracy, and sustainability across various sectors, including agriculture, healthcare, smart cities, and industry.

2.3 AI and IoT in Farm Mechanization

AI- and IoT-enabled technologies have substantially advanced farm mechanization by facilitating precision agriculture and intelligent automation. IoT-based sensor networks continuously acquire real-time data on critical parameters such as soil moisture, temperature, and crop health, while AI-driven algorithms process and analyze these datasets to support optimized, data-driven agronomic decision-making (Choudhary et al., 2025; Sharma et al., 2025).

Furthermore, sensor-integrated machinery equipped with Global Positioning System (GPS) and automated control systems reduces labour dependency and enhances operational efficiency. Precision farming approaches enable the site-specific and variable-rate application of agricultural inputs, including water, fertilizers, and pesticides, thereby improving input-use efficiency, lowering production costs, and minimizing adverse environmental impacts (Zhang et al., 2024; Liakos et al., 2023).

2.4 Role in Crop Monitoring and Management

A major advancement in precision agriculture is the use of AI-powered systems that monitor crop health in real time, combining satellite imagery with unmanned aerial vehicles (UAVs) and advanced sensor networks. The use of these technologies enables the accurate and continuous recording of various crop parameters, such as leaf colour, canopy structure, soil moisture, and temperature. Through the use of artificial intelligence algorithms, farmers can obtain more detailed information about crop conditions and potential problems at an early stage using this data. As an example, AI models can detect subtle patterns related to plant pathogens, pests or nutrient outtakes that would not be visible to humans. Rapid identification facilitates the implementation of targeted measures to mitigate crop damage and prevent significant losses. Additionally, the utilization of UAVs and

satellite images improves spatial coverage, enabling efficient monitoring of vast agricultural fields. This allows farmers to use inputs more efficiently, manage crops better, and increase productivity overall (Zhang et al., 2024; Liakos et al., 2023).

2.5 Applications in Post-Harvest Systems

Post-harvest losses in India are significant, particularly in perishable commodities. AI and IoT technologies address this issue through:

- Smart Storage: IoT sensors monitor temperature and humidity to maintain optimal storage conditions
- Supply Chain Optimization: AI improves logistics, demand forecasting, and transportation efficiency
- Quality Assessment: Image processing systems enable automated grading and sorting of produce.

2.6 Benefits of Smart Farming Technologies

- Increased agricultural productivity
- Efficient use of water, fertilizers, and energy
- Reduction in post-harvest losses
- Improved farmer income and market access
- Enhanced environmental sustainability

Challenges in Adoption

Despite the benefits, several challenges limit adoption:

- High initial investment costs
- Limited digital infrastructure in rural areas
- Lack of awareness and technical skills among farmers
- Data privacy and security concerns

2.7 Recent Developments in India (2025–2026)

Recent initiatives by the Government of India and research institutions have accelerated the adoption of smart farming technologies. AI-based precision agriculture systems, IoT-enabled monitoring tools, and agri-startup innovations are being actively promoted to enhance productivity and sustainability (Government of India, 2026; NITI Aayog, 2025).

Future Prospects

- Integration of AI with robotics and drones (Sharma et al., 2025)
- Development of affordable smart devices for small farmers (NITI Aayog, 2025)
- Expansion of digital agriculture platforms (Government of India, 2026)
- Government initiatives promoting smart agriculture (FAO, 2024)
- Increased adoption of cloud-based farm management systems (Choudhary et al., 2025)

3. Conclusion

The adoption of AI and IoT in farm mechanization and post-harvest systems has the potential to revolutionize Indian agriculture. These technologies improve efficiency, reduce losses, and promote sustainable practices. However, addressing challenges related to cost, infrastructure, and awareness is essential for widespread adoption. Future efforts should focus on policy support, capacity building, and technological accessibility to ensure inclusive growth in the agricultural sector.

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