

AI and AIoT's Potential to Revolutionize Contemporary Agriculture: A Review

Prof. Neha K. Patil
Assistant Professor
Electrical Engineering
NES's Gangamai College of Engineering
Nagaon, Dhule, 424005
Maharashtra, India
nhpatil2013@gmail.com

Prof. Kapil R. Patil
Selection Grade Lecturer
Automobile Engineering
Government Polytechnic Dhule
Dhule 424005
Maharashtra, India
kapilpatil4@gmail.com

Abstract-Agriculture is encountering escalating difficulties due to climate change, limited water resources, diminishing soil fertility, and rising food demand. Artificial Intelligence (AI) and the Artificial Intelligence of Things (AIoT) are becoming significant technologies for enhancing agricultural productivity and sustainability. This document examines the use of AI for predicting crop yields, analysing soil, implementing smart irrigation, recommending crop fertilizers, forecasting market prices, and managing resources. Through the incorporation of machine learning, IoT devices, drones, satellite imagery, and meteorological information, AI-powered systems facilitate real-time monitoring and data-driven decision-making minimize ecological footprint and promote sustainable agricultural methods. Although there are obstacles concerning expenses, infrastructure, and data handling, AI and AIoT present considerable opportunities to improve food security and revolutionize contemporary agriculture.

Keywords: AI, AIoT, Precision Farming, Smart Agriculture, Crop Yield Forecasting, Sustainable Farming.

I. INTRODUCTION

Agriculture is essential for guaranteeing food security and sustaining the livelihoods of billions globally. Nonetheless, the industry confronts major obstacles, such as swift population increase, climate alterations, water shortages, land degradation, diminishing arable land, and rising food demand. Conventional farming methods frequently lead to ineffective resource utilization, highlighting the need for innovative and sustainable approaches to address future agricultural demands [1,2].

Artificial Intelligence (AI) has developed into a groundbreaking technology that facilitates data-informed decision-making using machine learning, deep learning, IoT devices, drones, satellite images, and remote sensing methods. The combination of AI with the Internet of Things (AIoT) has enhanced precision agriculture by allowing real-time monitoring, predicting crop yields, facilitating intelligent irrigation, analysing soil, detecting pests and diseases, recommending crop fertilizers, and providing market insights [2]. These AI-driven technologies enhance resource efficiency, boost agricultural output, minimize ecological footprint, and promote sustainable agricultural methods. This paper examines how AI and AIoT are utilized in contemporary agriculture and emphasizes their ability to improve crop yields, resource use, environmental sustainability, and worldwide food security.

Focusing on precision agriculture, maximizing crop yields, smart irrigation, soil assessments, fertilizer recommendations for crops, predicting market prices, and managing resources sustainably, this research explores the use of artificial intelligence in farming. The article highlights how AI technologies enhance food security, promote environmental sustainability, and boost agricultural productivity [5].

II. Literature Review

The use of Artificial Intelligence (AI) in agriculture has received considerable focus recently because of its ability to enhance productivity, maximize resource use, and encourage sustainable farming methods. Researchers have investigated multiple AI-driven methods, such as machine learning, deep learning, computer vision, IoT, remote sensing, and predictive analytics, to tackle significant agricultural issues.

Numerous studies have shown the success of machine learning algorithms in forecasting crop yields. Through the examination of past crop data, weather patterns, soil properties, and management strategies, AI models have reached prediction accuracies over 90% in controlled settings. These forecasting systems allow farmers to make educated choices about crop selection, irrigation timing, and resource distribution, thereby enhancing farm efficiency and profitability.[4]

Technologies in deep learning and computer vision have demonstrated impressive achievements in monitoring agriculture and identifying diseases. Convolutional Neural Networks (CNNs) along with image-processing methods are commonly employed to detect crop diseases, nutrient shortages, and pest problems from images taken by drones, smartphones, and satellite technologies. Studies indicate disease detection rates exceeding 95%, allowing for timely intervention and minimizing crop losses.

Accurate nutrient management has gained significance for sustainable farming practices. Systems that recommend fertilizers based on AI assess soil characteristics, crop needs, and environmental factors to identify the best fertilizer application rates. Research results indicate that precise fertilizer management can decrease fertilizer usage by 15–25% while maintaining crop yield, which ultimately reduces production expenses and lessens environmental pollution.

In summary, the analyzed research validates that AI innovations are reshaping contemporary agriculture by improving efficiency, productivity, and sustainability. Nevertheless, obstacles like data accessibility, infrastructure constraints, implementation expenses, and model explainability continue to be fields needing more research and advancement.

Recent research has demonstrated the transformative role of Artificial Intelligence (AI) and the Artificial Intelligence of Things (AIoT) in modern agriculture. Muhammed et al. (2024) presented a comprehensive review of AIoT architectures for smart agriculture, proposing an integrated framework that combines Artificial Intelligence, Internet of Things (IoT), cloud computing, edge computing, and federated learning. Their study emphasized that AIoT enables real-time data acquisition, intelligent decision-making, and optimized resource utilization, thereby promoting sustainable agricultural practices and enhancing crop productivity.

Similarly, Senoo et al. (2024) reviewed the integration of AI technologies with IoT-based precision agriculture systems. The authors discussed various AI-enabled IoT solutions, including intelligent irrigation, automated crop monitoring, disease detection, and precision fertilization. They also highlighted several implementation challenges such as high deployment costs, inadequate rural communication infrastructure, data security concerns, and the need for standardized agricultural datasets.

In another significant contribution, Javed and Murad (2024) conducted a comprehensive review of machine learning and deep learning techniques for crop yield prediction. Their study compared various predictive algorithms, including Random Forest, Support Vector Machine (SVM), Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN), and Long Short-Term Memory (LSTM) networks. The authors concluded that deep learning models generally outperform traditional machine learning approaches when large and diverse datasets are available, offering higher prediction accuracy and better support for sustainable agricultural planning.

Expanding the scope of AI applications, Rathor et al. (2024) investigated the use of AI and IoT technologies in vertical farming and controlled environment agriculture. Their review demonstrated that AI-driven greenhouse automation systems can intelligently regulate environmental parameters such as temperature, humidity, lighting, irrigation, and nutrient supply. These technologies significantly improve crop yield, reduce energy consumption, and promote sustainable indoor farming practices.

Another comprehensive review published in Precision Agriculture (2024) focused on AI, machine learning, and IoT applications for plant disease forecasting under changing climatic conditions. The study emphasized that integrating sensor networks, remote sensing technologies, weather forecasting models, and AI-based disease prediction systems enables early disease detection, minimizes pesticide application, and improves crop health management, thereby contributing to environmentally sustainable agriculture.

More recently, Beena et al. (2025) reviewed cloud-assisted IoT-based intelligent systems for crop yield prediction. Their work explored the integration of IoT sensors, cloud computing platforms, and AI algorithms to provide real-time monitoring and predictive analytics for agricultural production. The authors highlighted that cloud-based AI frameworks facilitate scalable data processing, efficient resource management, and improved decision-making, making them highly suitable for precision agriculture applications.

Collectively, these studies demonstrate that AI and AIoT technologies are revolutionizing contemporary agriculture by enabling precision farming, intelligent crop monitoring, automated irrigation, disease prediction, yield forecasting, and sustainable resource management. Despite these advancements, the reviewed literature consistently identifies challenges related to infrastructure availability, implementation costs, data privacy, interoperability, and the need for explainable AI models. Addressing these issues will be crucial for achieving widespread adoption of AI-enabled smart agriculture, particularly in developing countries.

III. PROBLEM IDENTIFICATION

The literature review indicates that Artificial Intelligence (AI) and Artificial Intelligence of Things (AIoT) have significantly improved precision agriculture through applications such as crop yield prediction, disease detection, smart irrigation, and resource optimization. However, several challenges limit their large-scale adoption, particularly in developing countries. The major challenges include the high cost of AI-enabled farming systems, inadequate digital infrastructure in rural areas, poor internet connectivity, lack of standardized agricultural datasets, data privacy and security concerns, limited awareness and technical skills among farmers, and the complexity of AI models. In addition, many existing AI solutions are application-specific and have been validated only under controlled conditions, making their deployment across diverse crops and climatic regions difficult.

3.1 Research Gaps

The review also identifies the following research gaps:

- Lack of an integrated platform combining AI, IoT, drones, satellite imagery, GIS, weather forecasting, and market intelligence.
- Limited availability of affordable AIoT solutions for small and marginal farmers.

- Insufficient adoption of Explainable AI (XAI) for transparent and trustworthy decision-making.
- Limited use of Edge AI for real-time operation in areas with poor internet connectivity.
- Absence of standardized benchmark datasets, particularly for Indian agriculture.
- Limited long-term field validation under different crops, soil conditions, and climatic regions.

3.2 Problem Statement

Although AI and AIoT have great potential to transform modern agriculture, existing systems remain fragmented, costly, and dependent on reliable digital infrastructure. There is a need for an integrated, affordable, scalable, and explainable AIoT framework that supports real-time decision-making, improves resource efficiency, and is suitable for diverse agricultural environments, especially for small and marginal farmers.

IV. AI-DRIVEN PRECISION AGRICULTURE: OPTIMIZING CROP YIELD AND RESOURCE EFFICIENCY

Precision farming is an advanced agricultural approach that integrates Artificial Intelligence (AI), the Internet of Things (IoT), remote sensing, and data analytics to improve crop productivity while optimizing the use of natural resources. Unlike conventional farming practices, which apply uniform treatments across entire fields, precision agriculture employs site-specific management strategies based on real-time field conditions. AI-driven precision farming enables informed decision-making by analyzing large volumes of agricultural data collected from diverse sources, thereby enhancing productivity, reducing operational costs, and promoting environmental sustainability.

A. Data Collection for Precision Agriculture

The effectiveness of AI-powered precision farming depends on the availability of accurate and real-time agricultural data. Data are collected through multiple sensing technologies, including IoT-based soil sensors, weather stations, drones, satellite imagery, GPS-enabled agricultural machinery, and historical farm records. IoT sensors continuously monitor important soil parameters such as moisture content, temperature, pH, and nutrient concentrations. Weather stations provide localized climatic information, including rainfall, humidity, wind speed, and temperature, which assists in predicting crop growth and irrigation requirements. Drones equipped with thermal and multispectral cameras capture high-resolution images for monitoring crop health, detecting diseases, and identifying nutrient deficiencies. Satellite imagery provides large-scale spatial information useful for vegetation monitoring and long-term crop assessment. Additionally, GPS-enabled agricultural equipment records field operations, seed distribution, and harvesting performance, creating valuable datasets for AI-based analysis.

Machine learning and deep learning algorithms process these heterogeneous datasets to identify patterns, predict crop performance, and generate actionable recommendations for farmers.

B. Benefits of AI-Based Precision Farming

AI-powered precision agriculture offers significant advantages over traditional farming practices by improving resource efficiency and crop productivity. Intelligent irrigation systems utilize real-time soil moisture data and weather forecasts to optimize water application, thereby reducing water consumption while maintaining crop health. Similarly, AI-based fertilizer management enables variable-rate nutrient application according to crop requirements, minimizing fertilizer wastage and reducing environmental pollution.

Table I: Comparison of Traditional Farming and AI-Based Precision Farming

Category	Parameter	Traditional Farming	AI-Based Precision Farming
💧 Resource Optimization	Water Use	High, uniform watering	Precise, zone-specific irrigation schedules
💧 Resource Optimization	Fertilizer Use	Excessive, blanket chemical spraying	Targeted, controlled variable-rate applications
⚙️ Operational Efficiency	Yield Prediction	Low-accuracy crop forecasting	Highly accurate, data-driven volume projections
⚙️ Operational Efficiency	Labor Requirement	Heavy manual field dependencies	Reduced via automated sensor and drone monitoring
🌱 Environmental Impact	Sustainability	Moderate sustainability score	Highly eco-friendly, low-waste status

AI models also provide highly accurate crop yield predictions by integrating historical production data with environmental variables. Automation through sensors, drones, and autonomous machinery reduces labor requirements, improves operational efficiency, and enables continuous monitoring of field conditions. Furthermore, precision farming promotes sustainable agriculture by reducing excessive use of water, fertilizers, pesticides, and energy resources, thereby minimizing the environmental footprint of farming activities.

C. AI Applications in Intelligent Agriculture

Artificial Intelligence has become a key enabler of intelligent agricultural systems by supporting data-driven decision-making across various farming operations.

1) Soil Evaluation

AI-based soil evaluation systems analyze both physical and chemical properties of soil to determine its suitability for different crops. Parameters such as soil moisture, pH, organic carbon, nitrogen, phosphorus, and potassium are continuously monitored and analyzed using machine learning algorithms. These systems assist farmers in identifying nutrient deficiencies, recommending suitable crops, and optimizing fertilizer application, ultimately improving soil fertility and agricultural productivity.

2) Smart Irrigation

Water scarcity is one of the major challenges affecting global agriculture. AI-driven smart irrigation systems integrate soil moisture sensors, weather forecasting models, and crop water requirement data to determine the optimal timing and quantity of irrigation. Such intelligent systems minimize water wastage, reduce energy consumption, and enhance crop growth by supplying water only when required.

3) Crop and Fertilizer Recommendation

Machine learning algorithms utilize soil characteristics, climatic conditions, historical crop performance, and environmental factors to recommend the most suitable crops and fertilizer combinations for specific regions. These recommendation systems support precision nutrient management, improve crop yields, reduce production costs, and encourage sustainable farming practices.

4) Market Price Prediction

Artificial Intelligence also supports agricultural marketing by forecasting future crop prices using historical market data, demand-supply trends, weather conditions, and regional economic indicators. Predictive models provide farmers with reliable market intelligence, enabling them to make informed decisions regarding crop selection, harvesting schedules, storage, and marketing strategies to maximize profitability. Overall, AI-powered precision farming transforms conventional agriculture into an intelligent, data-driven ecosystem capable of improving productivity, optimizing resource utilization, reducing operational costs, and ensuring long-term agricultural sustainability.

V. AI-POWERED PRECISION FARMING: ENHANCING CROP PRODUCTION AND RESOURCE UTILIZATION

Precision farming is an advanced agricultural approach that integrates Artificial Intelligence (AI), the Internet of Things (IoT), remote sensing, and data analytics to improve crop productivity and optimize resource utilization. By analyzing data collected from IoT sensors, drones, satellite imagery, weather stations, and historical farm records, AI enables site-specific management practices that enhance productivity while reducing operational costs and environmental impact.

Figure 1 illustrates the comparison between conventional manual harvesting and AI-driven harvesting systems. In traditional harvesting, most activities such as crop inspection, harvesting, sorting, and transportation are performed manually, making the process labor-intensive, time-consuming, and prone to human error. In contrast, AI-driven harvesting employs intelligent robots, computer vision, sensors, and machine learning algorithms to identify mature crops, automate harvesting operations, and optimize resource utilization. This approach improves harvesting accuracy, reduces labor dependency, minimizes crop losses, and enhances overall agricultural productivity.

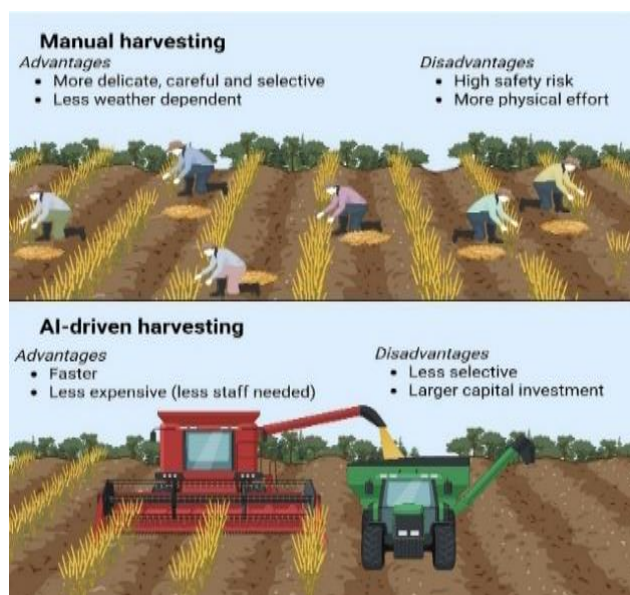


Fig.1 Manual vs AI driven Harvesting

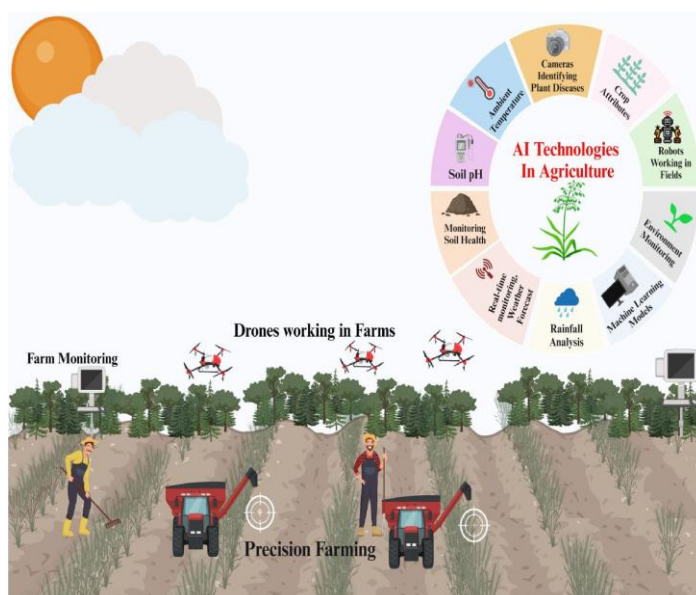


Fig.2 Farm Monitoring through Drones

Figure 2 depicts the use of drones for intelligent farm monitoring in precision agriculture. Drones equipped with high-resolution RGB, multispectral, and thermal cameras capture aerial images of agricultural fields to assess crop health, detect diseases, identify pest infestations, monitor irrigation requirements, and evaluate nutrient deficiencies. The collected data are analyzed using AI algorithms to generate real-time insights and support data-driven decision-making. Drone-based monitoring enables early problem detection, reduces field inspection time, improves resource management, and contributes to sustainable and efficient farming practices.

A. Data Collection

AI-powered precision agriculture relies on real-time data collected from soil sensors, weather stations, drones, satellite imagery, GPS-enabled farm equipment, and IoT devices. These technologies continuously monitor soil properties, climatic conditions, crop health, and field operations. Machine learning algorithms analyze the collected data to provide accurate recommendations for irrigation, fertilization, and crop management.

B. Benefits of Precision Agriculture

AI-based precision farming improves resource efficiency by optimizing water and fertilizer usage according to field conditions. It enhances crop yield prediction, reduces labor through automation, and supports sustainable farming by minimizing resource wastage and environmental pollution. Compared with traditional farming, precision agriculture enables more accurate, efficient, and environmentally friendly agricultural practices.

C. AI Applications in Intelligent Agriculture

AI is widely applied in modern agriculture to support intelligent decision-making. AI-based soil evaluation analyzes soil nutrients and fertility to recommend suitable crops and fertilizers. Smart irrigation systems use sensor data and weather forecasts to optimize water distribution and reduce water consumption. Machine learning models also recommend appropriate crops and fertilizer requirements based on soil and climatic conditions. Furthermore, AI predicts market prices by analyzing historical pricing, demand-supply trends, and weather conditions, helping farmers make informed production and marketing decisions.

VI. AIOT IN ECO-FRIENDLY AGRICULTURE

Artificial Intelligence of Things (AIoT) integrates Artificial Intelligence (AI) with the Internet of Things (IoT) to create intelligent and sustainable agricultural systems. AIoT enables real-time monitoring, automated decision-making, and efficient resource utilization by combining sensor networks with AI algorithms. This integration supports precision farming practices that improve productivity while minimizing environmental impact.

A. AIoT Architecture

The AIoT architecture consists of four layers: the Sensing Layer, Network Layer, Data Processing Layer, and Application Layer. The Sensing Layer collects real-time data on soil moisture, temperature, humidity, pressure, and other environmental parameters using sensors, RFID tags, microcontrollers, and actuators. These devices continuously monitor field conditions and transmit the collected information for further processing.

The Network Layer ensures reliable communication between sensing devices and cloud or edge computing platforms. Technologies such as Wi-Fi, Zigbee, Bluetooth, LoRaWAN, Ethernet, and satellite communication enable secure transmission of sensor data while supporting device connectivity, routing, and data forwarding.

The Data Processing Layer receives and analyzes sensor data using cloud computing, machine learning algorithms, and data analytics platforms. This layer processes raw data, identifies patterns, detects anomalies, and generates valuable insights for intelligent agricultural decision-making. It also stores agricultural data for future analysis and prediction.

The Application Layer provides user-friendly interfaces through mobile applications, web dashboards, and visualization tools. It enables farmers to monitor field conditions remotely, receive real-time alerts, manage connected devices, and integrate agricultural data with farm management systems for efficient decision-making.

B. Precision Water Management

AIoT-based precision water management systems continuously monitor soil moisture, weather conditions, and crop water requirements to automate irrigation scheduling. These intelligent systems supply water only when required, reducing water wastage,

lowering operational costs, improving crop productivity, and supporting sustainable groundwater management.

VII. PREDICTIVE ANALYTICS DRIVEN BY AI FOR OPTIMIZING CROP YIELD

Predictive analytics is one of the most important applications of Artificial Intelligence in modern agriculture. AI models analyze historical and real-time agricultural data to forecast crop yields, identify production risks, and support effective farm planning. These predictions enable farmers to optimize resource utilization and improve overall agricultural productivity. AI-based predictive models utilize data collected from multiple sources, including weather information, satellite imagery, soil characteristics, crop management records, and IoT sensor networks. By integrating these heterogeneous datasets, machine learning algorithms identify hidden patterns and provide accurate yield predictions under varying environmental conditions. Among various machine learning techniques, Artificial Neural Networks (ANNs) are widely used for crop yield prediction, weather forecasting, and irrigation scheduling. Their ability to model complex nonlinear relationships makes them highly effective for analyzing agricultural data and supporting intelligent decision-making in precision farming.

CONCLUSION & FUTURE SCOPE

By increasing crop yield, resource efficiency, and sustainability, artificial intelligence (AI) and the Internet of Things (AIoT) are transforming contemporary agriculture. Farmers can make data-driven decisions and maximize the use of water, fertilizer, and other resources thanks to technologies like precision farming, smart irrigation, soil analysis, crop yield prediction, and market forecasting. In addition to improving food security and environmental conservation, the integration of AI with IoT, remote sensing, and machine learning promotes sustainable farming practices. A more resilient, effective, and sustainable agricultural future is anticipated as a result of ongoing technological breakthroughs and supportive legislation, which will encourage broader adoption of AI in agriculture despite obstacles relating to cost, infrastructure, and data management.

The future of AI in agriculture lies in the development of advanced technologies such as Explainable AI (XAI), Edge AI, autonomous farming robots, digital twins, blockchain-enabled agricultural systems, and generative AI-based advisory platforms. These innovations will support real-time decision-making, improve transparency, enhance resource management, and increase automation in farming operations. Additionally, climate-smart agriculture systems will help farmers adapt to changing environmental conditions while ensuring sustainable food production. As these technologies continue to evolve, they are expected to significantly improve agricultural productivity, resilience, and sustainability.

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