Crimson Publishers
Wings to the Research

Mini Review

Artificial Intelligence in Agriculture: Enabling Smart and Sustainable Farming

ISSN: 2832-4463

Vinith Chauhan*

Department of Electronics and Communication Engineering, Sardar Vallabhbhai Patel University of Agriculture & Technology, India

***Corresponding author:** Vinith Chauhan, Department of Electronics and Communication Engineering, Sardar Vallabhbhai Patel University of Agriculture & Technology, India

Submission: July 14, 2025
Published: September 10, 2025

Volume 4- Issue 5

How to cite this article: Vinith Chauhan*. Artificial Intelligence in Agriculture: Enabling Smart and Sustainable Farming. COJ Rob Artificial Intel. 4(5). COJRA. 000599. 2025.
DOI: 10.31031/COJRA.2025.04.000599

Copyright@ Vinith Chauhan, This article is distributed under the terms of the Creative Commons Attribution 4.0 International License, which permits unrestricted use and redistribution provided that the original author and source are credited.

Abstract

Traditional farming has been completely transformed by the application of Artificial Intelligence (AI) in agriculture, which makes precise techniques and data-driven decision-making possible. Artificial intelligence (AI) tools including robotics, computer vision, and machine learning aid in crop production forecasting, disease detection, irrigation optimization, and industrial automation. An outline of the current uses, most recent developments, and potential future applications of AI in agriculture is provided in this mini review. In order to close the technology gap in rural farming communities, the study also identifies important implementation obstacles and offers solutions. All things considered, artificial intelligence holds promise as a tool to improve the productivity, sustainability, and efficiency of agriculture. This review highlights not only the technological progress but also the practical relevance of AI adoption in farming. It emphasizes that future agricultural growth will largely depend on how effectively AI innovations are made accessible to small and marginal farmers.

Keywords: Artificial intelligence; Precision agriculture; Disease detection; Crop monitoring

Introduction

Emerging technologies like Artificial Intelligence (AI), the Internet of Things (IoT), and big data are driving a digital revolution in agriculture. Of them, Artificial Intelligence (AI) is essential for enabling farming systems that are intelligent, adaptable, and predictive. By offering real-time insights and automation, it lessens reliance on manual labor and guesswork [1]. Growing populations, changing climates, and dwindling arable land are all contributing to an increase in the demand for food production. To address these issues and guarantee sustainability, resource conservation, and food security, creative solutions are needed. AI enables farmers to make decisions about irrigation, market trends, crop health, and soil conditions more quickly and accurately [2]. This mini review examines the expanding use of AI in agriculture, emphasizing its main uses, challenges, and future prospects. The integration of AI with IoT and big data analytics is creating a new era of smart and connected farming ecosystems. Such advancements have the potential to revolutionize global agriculture by ensuring higher productivity with minimal environmental impact.

Key Applications of AI in Agriculture

Artificial Intelligence is transforming agriculture by introducing more intelligent, data-informed, and sustainable practices. It facilitates automation, immediate decision-making, and effective resource management, tackling significant issues faced in contemporary farming [3]. The key applications of AI in agriculture are:

Precision farming

AI enables farmers to take prompt action by supporting real-time weather, crop health, and soil condition monitoring. Machine learning algorithms can make suggestions about

fertilizer dose, pesticide use, and irrigation based on data gathered by Internet of Things sensors [1,3]. These methods maximize output quality while reducing input expenses. Because precision farming minimizes the usage of chemicals, it also supports sustainable agriculture. A practical example is Microsoft FarmBeats, which integrates IoT devices, drones, and AI-driven analytics to help farmers in India and the U.S. manage soil moisture and fertilizer levels more effectively [1]. By combining aerial imagery with ground-based sensors, FarmBeats enables precise interventions that reduce costs, conserve resources, and significantly increase yields.

Crop monitoring and disease detection

Computer vision-based artificial intelligence systems evaluate images captured by drones or smart phones to identify plant diseases and pests in their initial stages. For instance, Convolutional Neural Networks (CNNs) are capable of accurately classifying infected leaves, which helps to mitigate crop losses [4]. Early detection allows for prompt treatment, enhancing crop health and decreasing reliance on pesticides [3] Additionally, AI assists in the classification of various crop types and their growth phases. For instance, Plantix, a mobile application powered by AI, enables farmers in India to detect over 300 plant diseases by simply uploading an image. Similarly, UAVs integrated with deep learning algorithms have been tested for large-scale disease surveillance, minimizing human intervention. Moreover, companies like IBM Watson Decision Platform for Agriculture combine AI with weather data, satellite imagery, and soil analysis to predict disease outbreaks before they spread [4]. These tools help reduce pesticide use and promote sustainable farming practices.

Smart irrigation systems

AI-driven irrigation controllers utilize environmental data, such as soil moisture and temperature, to automate watering schedules. This not only saves water but also ensures optimal growth for plants, particularly in areas susceptible to drought [5]. It encourages sustainable water usage and can incorporate weather forecast information to prevent overwatering or irrigation during periods of rain. For example, Netafim's smart irrigation platforms use predictive analytics to optimize water delivery, significantly reducing wastage while improving crop yield. Internationally, companies like CropX (New Zealand/USA) and Rivulis (Israel) use AI-powered soil sensors and cloud platforms to automate irrigation decisions, helping farmers save up to 25-30% water.

Yield prediction

AI systems evaluate past and real-time data to estimate crop yields. This enables farmers and policymakers to better organize storage, transportation, and market approaches. Reliable forecasts can decrease food waste, stabilize market prices, and enhance supply chain logistics [6]. Additionally, it aids in decisions related to crop insurance and policy formulation. For instance, IBM's Watson Decision Platform for Agriculture uses satellite data and AI models to predict yields for crops like corn and soybeans. Similarly, India's Mahindra Agri Solutions applies AI-based yield forecasting to support farmers with better planning and reduce post-harvest losses.

Agricultural robotics

AI technology is integrated into autonomous robots that carry out tasks such as planting, weeding, and harvesting. These robots minimize reliance on manual labor and boost efficiency, particularly in large farming operations. They enhance consistency in tasks and can operate effectively in difficult environmental conditions [7]. AI improves the capability of robots to adapt to various crops and field layouts. For example, John Deere's AI-enabled "See & Spray" robots distinguish weeds from crops and apply herbicides precisely, reducing chemical use. Similarly, Agrobot's strawberry-picking robots use computer vision to harvest ripe fruits with minimal damage [8].

Decision support systems

For farmers, especially smallholders, knowledge is power. AI-based decision support systems act as digital advisors, delivering personalized insights through mobile apps, SMS alerts, or voice assistants. These systems combine satellite data, local weather forecasts, and market information to suggest optimal sowing times, irrigation schedules, and pest control strategies [9]. In rural areas, AI-driven chatbots that communicate in regional languages are democratizing access to expert knowledge, ensuring that even the smallest farmers reap the benefits of digital transformation. Plantix, an AI-powered mobile app, helps small farmers diagnose plant diseases by simply uploading a photo. Internationally, platforms like IBM Watson Decision Platform for Agriculture offer predictive insights to farmers in the U.S. and Africa, while the Climate Field View system by Bayer provides AI-driven recommendations to optimize planting and harvesting in over 20 countries [8].

Smart agricultural supply chains

AI's influence does not end at the farm gate-it extends to the entire value chain. By analyzing consumption trends and predicting demand, AI ensures efficient storage, transport, and market delivery. AI-enabled grading systems automatically sort produce by quality, reducing disputes and ensuring fair pricing [10]. Blockchain-integrated AI systems add transparency, allowing consumers to trace the journey of their food "from farm to fork." Such integration strengthens farmer incomes, reduces food waste, and enhances consumer trust. For example, in Japan, NEC Corporation has developed AI-based vegetable grading systems that use computer vision to sort cucumbers with over 90% accuracy [11]. Walmart in the U.S. integrates blockchain with AI to track leafy greens from farms to shelves within seconds, ensuring food safety. Similarly, Alibaba's ET Agricultural Brain in China helps optimize logistics and supply chain efficiency by predicting demand and reducing food wastage (Table 1).

Copyright © Vinith Chauhan

Table 1: Applications of AI in agriculture.

Application Area	AI Role/Technology	Examples
Precision Farming	Real-time monitoring of weather, soil, and crop health. ML algorithms provide fertilizer, pesticide, and irrigation recommendations.	Microsoft FarmBeats (India and U.S.) integrates IoT, drones, and AI for soil and fertilizer management
Crop Monitoring and Disease Detection	Early detection of diseases and pests using computer vision, CNNs, UAVs, and deep learning.	Plantix app (India) detects 300+ plant diseases; IBM Watson Decision Platform predicts disease outbreaks
Smart Irrigation Systems	Automated irrigation scheduling through AI-driven controllers using soil moisture, temperature, and weather forecasts.	Netafim's predictive analytics for water delivery; CropX (New Zealand/USA) and Rivulis (Israel) AI soil sensors save 25-30% water
Yield Prediction	Forecasting crop yields using AI models with past and real-time data, and satellite imagery.	IBM Watson forecasts corn and soy yields; Mahindra Agri Solutions applies AI yield forecasting in India
Agricultural Robotics	Autonomous robots for planting, weeding, and harvesting using AI, robotics, and computer vision.	John Deere's "See and Spray" herbicide robots; Agrobot's strawberry-picking robots
Decision Support Systems	Digital advisors for farmers using AI chatbots, mobile apps, and satellite plus weather data integration.	Plantix mobile app; IBM Watson DSS (U.S. and Africa); Bayer's Climate Field View (20+ countries)
Smart Agricultural Supply Chains	Post-harvest grading, storage, and logistics supported by AI, blockchain, computer vision, and demand prediction.	NEC (Japan) AI grading system; Walmart (U.S.) AI and blockchain for leafy greens; Alibaba's ET Agricultural Brain (China)

Role of AI in Sustainable Agriculture

Sustainability lies at the heart of modern agricultural innovation. AI contributes to eco-friendly farming by minimizing the overuse of chemicals, optimizing water consumption, and promoting biodiversity [12]. For example, AI models help design crop rotation patterns that rejuvenate soil health, while predictive analytics reduce carbon emissions by eliminating unnecessary tractor runs. By treating agriculture as a closed-loop system, AI fosters a balance between productivity and ecological stewardship, paving the way for climate-smart farming [13]. For instance, Carbon Robotics (U.S.) uses AI-powered weeding robots that reduce herbicide usage, while EcoRobotix (Switzerland) employs AI to apply micro-doses of pesticides, minimizing environmental impact.

Challenges in AI Adoption

Although AI holds great promise for revolutionizing agriculture, implementing it effectively comes with its own set of challenges. Despite progress made, the integration of AI in farming encounters considerable obstacles, such as:

A. High Upfront Costs: Advanced machinery and AI technology are often unaffordable for smallholder farmers [8].

B. Digital Proficiency: Insufficient training hampers the effective utilization of AI tools in rural areas [1].

C. Data Limitations: Small-scale farms struggle with a lack of access to high-quality agricultural data [8].

D. Infrastructure Deficiencies: Limited internet connectivity and power supply impede the deployment of AI solutions [3].

Addressing these challenges necessitates collaborations between public and private sectors, education for farmers, and the development of affordable AI platforms that cater to rural demands [14]. Additionally, region-specific solutions are needed, as agricultural challenges vary widely across climates and crop systems. Governments must also provide supportive policies and subsidies to encourage wider adoption of AI technologies.

Future Outlook

The future of farming will depend on the effective integration of AI with other advancing technologies such as IoT, robotics, drones, and blockchain. As these technologies develop, they will facilitate immediate, data-informed decision-making right at the farm level, enhancing both precision and productivity [15]. The broad implementation of 5G and edge computing will further advance AI applications, allowing both small and large-scale farmers to take advantage of smart automation, predictive insights, and resource management [16]. In the years to come, AI is anticipated to be vital in promoting food security, climate resilience, and sustainable agricultural practices worldwide. Collaborative research and cross-border initiatives will play a crucial role in accelerating the adoption of these innovations [8]. Ultimately, AI will transform agriculture into a more efficient, transparent, and resilient sector for future generations.

Conclusion

AI has the ability to revolutionize agriculture through autonomous systems, disease detection, yield forecasting, and better irrigation. Technology can increase sustainability and efficiency, but in order to have a broad impact, issues with infrastructure, data access, training, and affordability must be resolved. For adoption to be inclusive, cooperation between governments, IT companies, and farming communities will be essential. Building trust through transparent policies and farmer-friendly platforms will further accelerate adoption. With the right ecosystem, AI can ensure not only higher productivity but also long-term food and livelihood security.

Copyright © Vinith Chauhan

References

1. Jha S, Mehta A, Kumar R (2024) Applications of artificial intelligence in precision agriculture: A comprehensive survey. IEEE Access 12: 45120-45138.
2. Singh M, Patel V (2024) AI-enabled crop disease detection using deep learning models and UAVs. IEEE Transactions on Industrial Informatics 20(5): 5012-5021.
3. Patel RD, Bhatt S (2022) Integrating AI and remote sensing for crop health monitoring. Proceedings IEEE International Conference on Computing for Sustainable Global Development (INDIACom), New Delhi, India, pp. 877-881.
4. Gupta A, Verma S, Malik H (2023) Role of AI in pest and disease management in horticulture. Journal of Agricultural Informatics 14(2): 22-30.
5. Sharma N, Bansal R, Chauhan PS (2024) Smart irrigation system using AI and IoT for sustainable agriculture. Proceedings International Conference on Smart Technologies in Agriculture (SmartAgriTech), Pune, India, pp. 115-120.
6. Zhang J, Wang Q, Chen L (2023) A machine learning-based model for yield prediction in rice crops. Computers and Electronics in Agriculture 207: 107740.
7. Ghosh K, Roy M (2022) Agricultural robotics: A pathway to smart farming. International Journal of Robotics and Automation 38(1): 45-52.
8. Alvarado S, Garcia MT (2021) Challenges in AI adoption for smallholder agriculture: A review. Agricultural Systems 196: 103298.
9. Lee H, Park T (2023) AI-based decision support systems for sustainable agriculture. Expert Systems with Applications 213: 118987.
10. Kumar P, Joshi D (2023) Blockchain and AI integration in agricultural supply chains. Journal of Cleaner Production 389: 135970.
11. Fernandez L, Silva J (2023) Climate-smart farming with artificial intelligence. Sustainability 15(8): 6235.
12. Anderson B, White C (2023) The role of 5G and edge computing in smart farming. IEEE Internet of Things Journal10(9): 7542-7553.
13. Rossi E, Marino F (2023) AI-driven approaches for sustainable water management in agriculture. Environmental Modelling & Software 162: 105592.
14. Nakamura T, Kato Y, Yamamoto S (2023) AI-based crop grading systems: Case study in Japan. Computers and Electronics in Agriculture 210: 107871.
15. Brown, Miller D (2022) Big data and AI for global food security. Nature Food 3(11): 900-909.
16. Singh R, Kumar P, Sharma A (2022) IoT and AI synergy in modern farming: A comprehensive review. Sensors 22(19): 7325.

Copyright © Vinith Chauhan