



Use of Artificial Intelligence in Agriculture

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Abstract

Artificial Intelligence (AI) is revolutionizing the agricultural sector by enabling data driven decision making, improving resource use efficiency and enhancing crop productivity. The integration of AI with technologies such as machine learning, computer vision, robotics, drones, sensors and the Internet of Things (IoT) has accelerated the development of precision agriculture. AI applications in agriculture include crop monitoring, disease and pest detection, irrigation management, yield prediction, agricultural automation and supply chain optimization. As the global population is projected to reach approximately 9.7 billion by 2050, food production must increase significantly while ensuring environmental sustainability (Food and Agriculture Organization). AI driven technologies have demonstrated substantial potential in addressing these challenges through intelligent resource management and predictive analytics. This article discusses the major applications, benefits, challenges and future prospects of AI in agriculture, supported by scientific evidence and real world examples.

Keywords: Artificial Intelligence, Precision Agriculture, Machine Learning, Smart Farming, Agricultural Automation, Sustainable Agriculture

Introduction

Agriculture plays a crucial role in ensuring food security, economic development and rural livelihoods worldwide. However, the sector faces numerous challenges, including climate change, water scarcity, declining soil fertility, labor shortages and increasing food demand. The adoption of advanced technologies has become essential to address these challenges and improve agricultural sustainability. Artificial Intelligence (AI), which enables machines to simulate human intelligence and decision-making processes, has emerged as a transformative technology in modern agriculture (Liakos *et al.*, 2018). By analyzing large volumes of data collected from sensors, satellites, drones, weather stations and farm machinery, AI helps farmers make informed decisions regarding crop management, irrigation, fertilization and pest control. Consequently, AI has become a key component of precision agriculture, contributing to

improved productivity, resource efficiency and environmental sustainability.

Applications of AI in Agriculture

One of the most significant applications of AI is precision farming, where data from drones, satellites and field sensors are analyzed to monitor crop growth and field conditions in real time. AI-powered systems can identify nutrient deficiencies, water stress, weed infestations and pest attacks, enabling site-specific management practices that improve productivity while reducing input costs (Bongiovanni & Lowenberg-Deboer, 2004). Computer vision and deep learning technologies further enhance crop monitoring by providing accurate and timely information about crop health (Kamilaris & Prenafeta-Boldú, 2018).

AI is also extensively used for disease and pest detection. Crop diseases and insect infestations are responsible for significant yield losses

globally. Advanced machine learning algorithms can analyze images captured through smartphones, drones, or cameras to identify disease symptoms at an early stage with high accuracy (Liakos *et al.*, 2018). Early detection allows farmers to take preventive measures, reducing crop losses and minimizing pesticide use. Applications such as Plantix have successfully demonstrated the practical utility of AI-based disease diagnosis for farmers.

Another important area is irrigation management. Water scarcity has become a major concern in agriculture, accounting for increasing pressure on available freshwater resources. AI-based irrigation systems utilize soil moisture data, weather forecasts and crop growth information to determine the optimal amount and timing of irrigation (Talaviya *et al.*, 2020). Studies have shown that smart irrigation systems can reduce water consumption by up to 30% while maintaining crop productivity, thereby contributing to sustainable water management (Shamshiri *et al.*, 2018).

Yield prediction and forecasting represent another valuable application of AI. Machine learning models analyze historical production records, weather conditions, soil properties and crop management practices to estimate future yields with high accuracy (Zhai *et al.*, 2020). Accurate yield forecasting assists farmers, agribusinesses and policymakers in planning production, storage, transportation and marketing activities, thereby enhancing food security and economic efficiency.

AI has also facilitated the development of agricultural robotics and automation. Autonomous tractors, robotic harvesters, drones and automated spraying systems are increasingly being used to perform agricultural operations with minimal human intervention (Talaviya *et al.*, 2020). These technologies improve operational efficiency, reduce labor dependency and enhance precision in field operations. For example, John Deere's autonomous tractor system combines AI, machine vision and GPS technologies to conduct field activities efficiently and accurately.

Furthermore, AI contributes significantly to soil and nutrient management. Intelligent systems analyze soil characteristics and nutrient status to recommend precise fertilizer applications based on crop requirements (Wolfert *et al.*, 2017). Such recommendations help prevent excessive fertilizer use, reduce environmental pollution and improve nutrient-use efficiency. AI also supports agricultural supply chain management by facilitating demand forecasting, inventory management, logistics planning and

market intelligence. Through the analysis of large datasets, AI can reduce post-harvest losses and improve the profitability of agricultural enterprises (Zhai *et al.*, 2020).

Real-World Examples and Impact

Several successful initiatives demonstrate the practical benefits of AI in agriculture. Microsoft's AI Sowing App, implemented in Andhra Pradesh, India, provided personalized sowing recommendations based on weather data, soil conditions and crop requirements. The project reportedly increased crop yields by nearly 30% compared to conventional farming practices. Similarly, IBM Watson Decision Platform for Agriculture integrates AI and weather analytics to provide farmers with recommendations on irrigation scheduling, disease management and crop planning.

AI-powered "See & Spray" technology developed by Blue River Technology uses computer vision algorithms to identify weeds and apply herbicides only where required. This targeted approach significantly reduces chemical usage and environmental impacts. Additionally, the use of drones equipped with AI-based image analysis enables real-time monitoring of crop health, field variability and resource requirements, further enhancing farm productivity (Zhang & Kovacs, 2012).

The global AI in agriculture market reflects the growing importance of these technologies. According to market estimates, the global AI in agriculture market was valued at approximately USD 1.7 billion in 2023 and is expected to grow rapidly in the coming years due to increasing adoption of precision farming technologies and smart agricultural solutions.

Benefits and Challenges of AI in Agriculture

The adoption of AI offers numerous benefits, including increased crop productivity, improved resource-use efficiency, reduced production costs, enhanced environmental sustainability and better decision-making capabilities (Talaviya *et al.*, 2020). AI-driven systems enable precise application of water, fertilizers and pesticides, reducing waste and minimizing environmental impacts. Moreover, automation reduces labor requirements and improves operational efficiency, making agriculture more profitable and resilient.

Despite these advantages, several challenges hinder the widespread adoption of AI in agriculture. High implementation costs, limited digital infrastructure, inadequate internet connectivity and lack of technical expertise remain significant barriers, particularly for smallholder farmers in developing countries

(Wolfert *et al.*, 2017). Data quality, privacy concerns and the need for large datasets to train AI models further complicate adoption. Therefore, investments in digital infrastructure, farmer training and supportive policies are essential to maximize the benefits of AI technologies in agriculture.

Future Prospects

The future of AI in agriculture is highly promising. Advances in machine learning, robotics, remote sensing, cloud computing and IoT technologies are expected to further enhance agricultural productivity and sustainability. Emerging innovations such as autonomous farm management systems, digital twins, predictive climate adaptation tools and AI-powered decision support systems will play a crucial role in addressing future agricultural challenges (Shamshiri *et al.*, 2018). As technology becomes more affordable and accessible, AI is likely to become an integral component of agricultural systems worldwide.

Conclusion

Artificial Intelligence has emerged as a transformative force in modern agriculture, offering innovative solutions to some of the most pressing challenges facing the sector. Through applications such as precision farming, disease detection, smart irrigation, yield forecasting, robotics and supply chain management, AI enhances productivity, resource efficiency and sustainability. Real-world examples demonstrate the significant potential of AI to improve agricultural outcomes and support food security. Although challenges related to infrastructure, affordability and technical capacity remain, continued technological advancements and policy support are expected to accelerate adoption. As global food demand continues to rise, AI will play a pivotal role in building resilient, efficient and sustainable agricultural systems for the future.

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