



Artificial Intelligence's Place in Agricultural Development

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Abstract:

Artificial Intelligence (AI) has quickly become one of the 21st century's most revolutionary technologies, impacting almost every sector, including agriculture. Global agricultural systems are under pressure to boost production, enhance sustainability, and guarantee food security as the world's population is expected to reach about 10 billion by 2050. AI-driven solutions that increase productivity, maximize resource use, and allow precision farming at scale are supplementing—and occasionally replacing—traditional agricultural methods. This essay examines how AI has improved productivity, lessened environmental effects, and radically altered decision-making processes in agriculture. It uses both quantitative statistical data and qualitative insights to analyse the existing trends, acceptance rates, difficulties, and prospects of AI in agriculture. Important discoveries show that AI may boost crop yields by up to 20–25%, drastically cut down on the usage of pesticides and water, enhance forecasting accuracy, and provide farmers with great returns on investment. Through this extensive study, we offer a thorough examination of the revolutionary role artificial intelligence (AI) plays in contemporary agriculture and suggest evidence-based recommendations for practitioners, policymakers, and stakeholders.

Introduction:

Agriculture continues to be essential to human life, providing billions of people worldwide with food, fibre, and a means of subsistence. However, it has long had to deal with serious issues like labour shortages, resource depletion, climate change, and erratic weather patterns. Digital technology has started to help farmers better handle these difficulties in recent decades. Among these, artificial intelligence (AI) is particularly notable for its potential to change agriculture from labour-intensive, conventional methods to data-driven systems that optimize inputs and outputs in a sustainable manner. AI describes computer systems that, without explicit programming for every task, are able to learn from data, see patterns, make judgments, and constantly improve performance. Numerous applications of fundamental AI techniques, including robotics, computer vision, machine learning, natural language processing, and

predictive analytics, are being used in agriculture. These uses include supply chain optimization, predictive crop modelling, automated equipment, and precision farming.

What many experts refer to as "Agriculture 4.0" is a new ecosystem where smart devices, sensors, and data analytics come together to improve agricultural resilience and productivity. Higher crop yields, less input prices, more effective resource utilization, fewer negative effects on the environment, and higher farmer profitability are all potential advantages. However, adoption varies by location and farm size, and obstacles including digital literacy, infrastructural constraints, and data accessibility continue to be major obstacles.

Objectives of the Research:

1. To assess the degree of AI usage in agriculture worldwide and comprehend

adoption trends across farm sizes and regions.

2. To use empirical data to measure how AI technologies affect sustainability, resource efficiency, and agricultural productivity.
3. To determine the main AI applications such as supply chain management, robots, precision farming, and predictive analytics that are propelling agricultural progress.
4. To examine the obstacles and restrictions that AI adoption in agriculture faces, including those related to technology, the economy, society, and legislation.
5. To forecast agricultural AI trends and possibilities and offer practical advice to farmers, legislators, and industry stakeholders.

Research Methodology:

This study uses a mixed-methods approach, integrating qualitative analysis from scholarly and business literature with quantitative data from secondary sources. The methodology consists of Analysis of Secondary Data Reputable publications, industry studies, and reliable websites that offer current information on AI in agriculture were the sources of the data and figures. Among the important metrics examined are: Adoption rates of AI in agriculture Effects of productivity (e.g., yield increases, efficiency gains) Environmental results (such as decreased water and pesticide use).

Literature Review:

Anurag Chandra Mishra, Joydeep Das & Ram Awtar (2024) A basic summary of how AI is changing modern agriculture is given by Mishra and associates. Their study emphasizes the integration of robotics, market intelligence, predictive analytics, and precision agriculture as key components of contemporary farming. They contend that AI gives farmers the ability to make

data-driven decisions by providing in-depth insights into weather patterns, crop health, and soil conditions. Stakeholders can improve strategic planning and resilience by forecasting crop yields and anticipating climate concerns through the use of AI algorithms for predictive analytics. The authors come to the conclusion that AI's capacity to handle massive datasets and imitate human thought processes creates new opportunities for farmers to maximize resource use, lessen environmental effects, and improve the sustainability and efficiency of agricultural systems. Their research offers a comprehensive yet convincing case for AI as a driver of increased agricultural resilience and output.

Nand Lal Singh et al. (2024) concentrate on the socio-technical difficulties and real-world uses of AI in agriculture. Their analysis focuses on how automation and robotics lower labour intensity and operating costs, especially in labour-intensive settings. They explain how farmers may improve supply chain management, foresee market patterns, and control risks related to price and demand swings with the aid of predictive analytics. The assessment also critically identifies obstacles that prevent the widespread deployment of AI technology, including issues with data protection, interoperability, and the digital divide between rural and urban farming groups. Singh et al. come to the conclusion that although AI has revolutionary potential, particularly for sustainable farming, its adoption necessitates infrastructural investment and farmer digital literacy.

Michael Cabanillas-Carbonell & Joselyn Zapata-Paulini (2025) maps the landscape of AI applications in agriculture based on a large dataset of scholarly work. Using the PRISMA methodology, they identify machine learning and image processing as dominant tools in crop management, early pest and disease detection, agronomic decision-making, and climate change

adaptation. Their investigation highlights how AI improves customized agronomic techniques by detecting circumstances and microclimates unique to a plot, which lowers crop losses and the need for chemical treatments. This study is important because it compiles data from hundreds of investigations, demonstrating that artificial intelligence (AI) is not a specialized tool but rather a developing field of study with quantifiable effects on agricultural productivity and sustainability.

Analysis & Discussion:

Adoption of AI in Agriculture: AI technology adoption in agriculture varies greatly amongst farms of various sizes and geographical locations. Market research indicates that by 2025, more than 60% of big farms worldwide are expected to implement AI-powered precision agriculture, although adoption rates for small and medium-sized farms range from 20 to 36%. The availability of infrastructure, farm finance, digital literacy, and government regulations that encourage technology usage all have an impact on the adoption of AI. Despite these obstacles, farmers are becoming more interested in AI applications; according to a poll, 70% of farmers are confident that AI can enhance farm management and operational effectiveness.

Increases in Yield:

With targeted input application and real-time monitoring, AI-powered precision farming technology can boost crop yields by roughly 15–25%. When compared to conventional approaches, farms utilizing AI claim average output gains of about 20–25%.

Resource Optimization:

Without lowering agricultural output, AI-enabled irrigation systems can cut water use by as much as 30–40%. By increasing nutrient application efficiency by up to 30–40%, AI-

driven sensors contribute to the optimization of fertilizer use.

Agriculture with precision:

AI algorithms are used in precision agriculture to accurately direct planting, fertilizing, and irrigation schedules using data from field sensors, drones, and satellite imagery. This improves crop health and reduces waste.

Identification of Crop Diseases and Pests:

AI-powered image analysis technologies make it possible to detect pest infestations and agricultural illnesses with extremely high accuracy, frequently surpassing 85–90%. Early diagnosis facilitates quick tribal intervention and lowers pesticide use and crop losses.

Weather modelling and predictive analytics:

AI's capacity to evaluate large datasets contributes to more precise weather forecasts and crop production estimates for farming decisions. By increasing predicting accuracy by more than 70%, AI models can help with strategic planning and reduce the risks associated with extreme weather.

Automation and Robotics:

Robots, drones, and autonomous tractors with AI capabilities can carry out planting, monitoring, and harvesting duties. These technologies lower labor costs and boost productivity, often by as much as 30–65%.

Optimizing the Supply Chain:

AI also helps agricultural supply chains by enhancing demand forecasts and logistics planning, which can save food waste and spoiling by 15% to 25%.

Conclusion:

Agriculture is becoming a more intelligent, productive, and sustainable sector thanks to artificial intelligence. This study has demonstrated that farms of all sizes may significantly increase production, resource efficiency, and financial returns by implementing

AI. AI helps farmers enhance crop yields by up to 20–25% and significantly reduce resource usage by increasing forecasting accuracy, facilitating early identification of stress conditions, and optimizing input application. Adoption of AI is not without its difficulties, but the potential advantages from increased food security to environmental sustainability and economic growth make it an essential part of agricultural systems of the future. To fully realize AI's potential in agriculture, governments and stakeholders must concentrate on policy frameworks, farmer education, and reasonably priced technological solutions.

In the end, AI provides a solution to increase agricultural resilience in the face of changing global demands and climate change. AI's incorporation into agriculture will ensure that food production systems are more data-driven, resource-efficient, and sustainable for coming generations as the market grows.

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