Chapter 12
AI-Driven Decision-Making and Optimization in Modern Agriculture Sectors

D. Joel Jebadurai
https://orcid.org/0000-0002-6947-8497
St. Joseph's College of Engineering, Chennai, India

Mary V. V. Sheela
Aarupadai Veedu Institute of Technology, Vinayaka Mission's Research Foundation, India

L. Rajeshkumar
https://orcid.org/0009-0007-8513-206X
St.Joseph's College of Engineering, India

M. Soundarya
https://orcid.org/0000-0001-7018-7972
Sathyabama Institute of Science and Technology, India

Rathi Meena
Dr. Umayal Ramanathan College for Women, India

Thirupathi Manickam
https://orcid.org/0000-0001-7976-6073
Christ University, India

Arul Vethamanikam G. Hudson
Ayya Nadar Janaki Ammal College, India

K. Dheenadhayalan
Mepco Schlenk Engineering College, India

M. Manikandan
SRM University, India

ABSTRACT

AI-driven decision-making tools have emerged as a novel technology poised to replace traditional agricultural practices. In this chapter, AI's pivotal role in steering the agricultural sector towards sustainability is highlighted, primarily through the utilization of AI techniques such as robotics, deep learning, the internet of things, image processing, and more. This chapter offers insights into the application of AI techniques in various functional areas of agriculture, including weed management, crop management, and soil management. Additionally, it underlines both the challenges and advantages presented by AI-driven applications in agriculture. In conclusion, the potential of AI in agriculture is vast, but it faces various impediments that, when properly identified and addressed, can expand its scope. This chapter serves as a valuable resource for government authorities, policymakers, and scientists seeking to explore the untapped potential of AI's significance in agriculture.

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INTRODUCTION

Digital technologies have breathed new life into traditional sectors through innovative updates (Bhardwaj et al., 2021). This digital innovation not only enhances productivity but also minimizes adverse environmental impacts (Bacco et al., 2019). Digitalization encompasses a wide array of phenomena and technologies, including big data, the Internet of Things (IoT), augmented reality, robotics, sensors, 3D printing, system integration, ubiquitous connectivity, artificial intelligence, machine learning, digital twins, and blockchain, among others (Tilson et al., 2010). One of the swiftly advancing technologies making its mark in agriculture is Artificial Intelligence (AI). Through automation, predictive analysis, robotics, and optimization techniques, digital technology, especially AI, has breathed fresh vitality into the agriculture sector. Agriculture has become more cost-effective by embracing AI-associated tools. The journey of AI in agriculture began with its introduction in the 1960s to 1990s when it worked with limited data for decision-making. Then, from 2000 to 2010, precision agriculture emerged, solving agricultural issues such as diseases in the crops, soil fertility, and so on through AI-based Global Positioning System (GPS) and machine learning techniques. Subsequently, in the 2010s, satellites and drones were employed in agriculture to predict and address various agricultural challenges such as irrigation, pesticide spraying, weed identification, and so on by using predictive analysis. Presently, AI tools such as robotics, automation, big data, predictive analytics, and the Internet of Things (IoT) are applied in agriculture to effectively tackle complex problems such as harvesting, climate risks, and diseases in crops (Anyoha, 2017).

AI is of utmost importance in automating and optimizing farming operations. For instance, robots equipped with computer vision systems can perform tasks like selective harvesting or weed control with high precision and efficiency. AI-powered systems can monitor livestock health and behavior, detect diseases, and provide early warnings to farmers, leading to improved animal welfare. AI's integration into agriculture can transform the industry, making it more sustainable, productive, and resilient. By enabling farmers to make informed decisions, optimize resource allocation, and reduce environmental impact, AI can contribute to global food security and address the challenges faced by the agricultural sector in the 21st century.

With a predicted increase of 25.5% Compound Annual Growth Rate (CAGR) between 2020 and 2026, it is anticipated that the agriculture sector will see significant investments in AI in the upcoming years (marketsandmarkets.com 2021). AI has the potential to alter how agribusinesses are organized, compete, and participate in the food chain (Mhlanga, 2021). AI will also be able to address some of the most prominent societal issues, like workforce shortages and the urgent need to increase output while reducing damaging environmental emissions. This chapter is structured into five parts. The initial section covers the objectives and methodology. The second part delves into AI techniques applied in agriculture. The third part explores AI techniques as they relate to specific functional aspects of agriculture. The fourth part addresses both the advantages and hurdles associated with AI in this field. Lastly, the fifth part encompasses case studies, success stories, future trends, and concluding remarks regarding the role of AI in agriculture.

This chapter comes out with the following objectives. They are.

1. The first objectives of this study are to understand AI tools in agriculture such as Deep learning, Robots, Internet of Things (IoT), Image Processing, Artificial Neural Networks (ANN), Wireless Sensor Networks, Machine Learning (ML) Unmanned Aerial Vehicle/ Drones