20

Chapter

SHAPING TOMORROW'S AGRICULTURE: THE IMPACT OF ARTIFICIAL INTELLIGENCE IN SMART FARMING

Dr. Nitesh Rawat*
Assistant Professor, Faculty of Commerce and Management, SGT University, Gurugram
**Correspondence to: rawatnitesh564@gmail.com*

Dr. Vijay Kumar
Dean & Associate Professor, Glocal School of Business & Commerce, Glocal University, Saharanpur, U.P.
E-mail: dean.management@theglocaluniversity.in

DOI: https://doi.org/10.52458/9789388996969.nsp2023.eb.ch-20
Ch.Id:-GU/NSP/EB/ESTDCI/2023/Ch-20

ABSTRACT

The agricultural sector is facing unprecedented challenges due to increasing global population, climate change, and resource limitations. Smart farming, which integrates modern technologies like artificial intelligence (AI) and the Internet of Things (IoT) into traditional agricultural practices, offers innovative solutions to address these challenges. This research paper examines the evolving role of AI in smart farming, its applications, benefits, challenges, and potential impact on agricultural efficiency and sustainability. Through a comprehensive review of literature as well as analysis of case-studies, this study emphasizes on how AI-driven systems can revolutionize various aspects of farming, including precision agriculture, crop management, livestock monitoring, disease detection, and resource optimization. Furthermore, it discusses ethical considerations and the necessity for data privacy and security in AI-enabled farming systems. This study underlines the transformative capacity of AI in reshaping the future of agriculture and ensuring food security in a rapidly changing world.

Keywords: *Artificial intelligence, Internet of Things, crop management, livestock monitoring*

20.1 INTRODUCTION

In the recent times, the agricultural sector has witnessed a transformative shift with the adoption of Artificial Intelligence (AI) technologies. Smart farming, an innovative approach that combines AI, Internet of Things (IoT) & data analytics, has emerged as a promising solution to address the challenges faced by traditional farming practices. This integration of AI with smart farming has paved the way for increased efficiency, sustainability, and productivity in agriculture. Smart farming, also known as precision agriculture, encompasses a range of technologies and practices that utilize AI and advanced data analytics to optimize various aspects of agricultural operations. This includes real-time monitoring, data-driven decision-making, automated machinery, and predictive analytics (Michael and Fu, 2016). By harnessing the power of AI, smart farming aims to maximize yields, minimize resource wastage, and enhance overall farm management. AI-driven sensors and drones play a crucial role in monitoring crop health, soil conditions, and weather patterns. These devices collect vast amounts of data, which AI algorithms then process to provide insights into the optimal planting times, irrigation schedules, and disease detection. This real-time data-driven approach enables farmers to make timely and informed decisions, leading to improved crop yields and resource efficiency (Mekala et al., 2019). AI enables precision agriculture by tailoring farming practices to specific field conditions. Machine learning algorithms analyze data from sensors and satellites to create detailed maps of fields, highlighting variations in soil composition and nutrient levels. This information guides the precise application of fertilizers, pesticides, and water, reducing waste and environmental impact. The integration of artificial intelligence with robotic machinery is transforming traditional farming practices. Autonomous tractors, drones, and robotic harvesters can perform tasks with high precision, speed, and consistency. AI algorithms enable these machines to navigate through fields, identify crops ready for harvest, and perform intricate tasks that were previously labour-intensive. This not only reduces the need for manual labour but also enhances the quality of produce (Mckinion and Lemmon, 1985; Sowmiya and Prabavathi, 2019).

20.2 LITERATURE REVIEW

Employing scientific and technological advancements in agriculture is pivotal for combating dire poverty and famine. Microsoft Corporation, in collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), has been actively engaged in Andhra Pradesh, India, since 2018, delivering services and solutions to 175 farmers (Senbetu et al., 2019). As part of this initiative, Microsoft developed an AI-powered sowing App using machine learning and business intelligence from the Microsoft Cortana Intelligence Suite. This innovative application employs robust cloud-based predictive analytics to equip farmers with vital information and insights, thereby reducing crop failures, enhancing yields, mitigating stress, and improving income prospects (Mythili, 2019).

The integration of AI-based automated irrigation significantly enhances the efficiency of the current agricultural supply chain. With the escalation in food demand, there is a corresponding rise in the need for freshwater resources. Consequently, the role of artificial intelligence becomes pivotal in facilitating smart irrigation, monitoring water levels, soil temperature, nutrient content, and predicting weather conditions (Priyadharsnee and Rathi, 2017). Artificial Intelligence, a field within computer science, finds numerous applications across various domains (Popa, 2011). It involves teaching computers how to exhibit intelligent behavior and parallels the task of using computers to comprehend human intelligence.

20.3 OBJECTIVES

i. Enhancing the precision and effectiveness of applying agricultural inputs.

ii. Guaranteeing elevated crop yield.

iii. Decreasing reliance on pesticides, fertilizers, and water.

iv. Alleviating environmental burden.

v. Minimizing the release of chemicals into groundwater and rivers.

vi. Widely disseminating this technology among local researchers, environmentalists, farmers, and agro economists.

20.4 SIGNIFICANCE OF ARTIFICIAL INTELLIGENCE IN AGRICULTURE

Artificial Intelligence (AI) holds the potential for widespread applications and has the capacity to revolutionize the agricultural landscape as we currently perceive it. Leveraging AI-driven solutions not only empowers farmers to achieve more with fewer resources, but also facilitates enhanced crop yields, mirroring the increasing integration of advanced technologies in various aspects of life, such as education, healthcare, and governance. Among these domains, agriculture stands out as a particularly impactful area for AI implementation due to its emphasis on efficiency and intelligent operations. The integration of AI into agricultural practices should be cost-effective and user-friendly, streamlining processes. Through the application of Artificial Intelligence, agricultural challenges can be rapidly addressed. AI employs various techniques, including optimizing harvest quality and introducing indoor farming for improved crop production rates (Kok et al., 2002; Gertsis et al., 1997). Multiple AI applications hold genuine promise for assisting farmers. Analyzing farm data to enhance crop quality and accuracy, employing AI sensors to identify weeds, diseases, and pests, and addressing labor shortages by deploying agricultural bots are some notable examples. These bots are designed to collaborate with farmers, significantly augmenting harvesting capacity and speed. Noteworthy instances include agricultural robots employed by Blue River Technology for weed control and Harvest CROO Robotics for automated crop harvesting. Robotics also facilitate tasks like crop picking and packaging. AI's diagnostic capabilities extend to satellite-based weather prediction and crop sustainability assessment, providing crucial insights into impending weather changes. Driverless tractors represent another AI advancement, functioning autonomously without human presence inside the tractor, thereby reducing the burden on farmers. An innovative technology to highlight is the "Farmer’s Alexa," an AI-based assistant capable of conversing with farmers, much like chatbots, to address complex problems. Additionally, the utilization of drones for crop spraying results in a fivefold increase in efficiency compared to traditional machinery (Banerjee et al., 2018). A standout application is the introduction of the agri-E Calculator, an AI tool that assists farmers in selecting suitable and economically viable crops, offering pricing calculations. While numerous applications are available, cost and complexity remain challenges. In essence, the integration of AI into agriculture is enabling global farmers to operate with greater efficiency.

20.5 APPLICATIONS OF AI IN SMART FARMING

- **Precision Agriculture:** AI-powered sensors and drones facilitate data collection for soil health, moisture levels, and nutrient content. This data aids in creating personalized irrigation and fertilization plans, leading to optimal resource utilization and increased yields.
- **Crop Monitoring and Management:** AI-driven image recognition and computer vision systems enable the detection of pests, diseases, and nutrient deficiencies in crops. Farmers can respond promptly with targeted interventions, reducing the need for widespread chemical applications.
- **Livestock Monitoring:** AI-equipped devices monitor the health and behavior of livestock, providing early detection of illnesses, estrus, and stress. This real-time data enhances animal welfare and productivity.
- **Supply Chain Optimization:** AI algorithms predict market demand, enabling farmers to make informed planting and harvesting decisions. This minimizes waste and ensures a steady supply of produce to consumers.

20.6 AI FARMING COMPANIES

These AI technologies collectively contribute to optimizing agricultural practices, increasing productivity, reducing resource waste, and promoting sustainable farming methods in the context of smart farming.

- **Indigo Ag:** Indigo Ag is known for developing technology that aims to enhance the health and productivity of crops. Their platform combines AI, satellite imaging, and agronomic insights to assist farmers in optimizing their planting and crop management decisions.
- **Climate Corporation (owned by Bayer):** Climate Corporation offers a digital platform that provides real-time data and insights to farmers. Their technology uses AI and data analytics to help farmers make data-driven decisions about planting, irrigation, and harvesting.
- **Blue River Technology (John Deere):** Acquired by John Deere, Blue River Technology focuses on precision agriculture. They developed the "See & Spray" system, which uses computer vision and machine learning to identify and precisely apply herbicides to individual plants, reducing chemical usage.

- **Taranis:** Taranis uses aerial imagery, weather data, and machine learning algorithms to monitor crops and detect potential issues such as pests, diseases, and nutrient deficiencies. This helps farmers take timely action to protect their crops.

- **Farmers Edge:** This company combines data analytics, AI, and IoT (Internet of Things) technology to provide farmers with insights into their fields. They offer solutions for precision agriculture, helping farmers optimize their inputs and increase yields.

- **Agrible (Nutrien):** Agrible focuses on predictive analytics for agriculture. They offer a platform that integrates weather forecasts, satellite data, and machine learning to provide farmers with recommendations for planting, pest management, and other decisions.

- **Gamaya:** Gamaya specializes in hyperspectral imaging and AI for agriculture. Their technology helps farmers assess crop health, monitor fields, and make decisions related to irrigation, fertilization, and disease control.

- **Granular (Corteva Agriscience):** Granular offers a farm management platform that incorporates data analytics and AI. It helps farmers with tasks like field mapping, planning, and financial management.

20.7 CHALLENGES OF PRACTICAL APPLICATION OF AI-BASED TECHNIQUES IN AGRICULTURE

- **Data Collection and Quality:** AI algorithms, particularly deep learning models, require large amounts of high-quality data for training. In agriculture, collecting accurate and diverse data can be challenging. Factors like weather conditions, soil quality, crop health, and pest infestations contribute to the complexity of data collection. Moreover, data might be unevenly distributed across regions and timeframes, leading to biased models. Ensuring data quality, consistency, and sufficiency is crucial for training reliable AI models.

- **Lack of Infrastructure and Connectivity:** Many agricultural regions, especially in developing countries, lack proper internet connectivity and technological infrastructure. AI-based systems often rely on real-time data transmission, which becomes difficult when there's limited access to the internet or power sources. Without proper infrastructure, farmers might not be able to utilize AI tools effectively, limiting the reach of these technologies.

- **Adaptation to Local Contexts:** AI models developed in one context might not be directly applicable to another. Agricultural practices vary widely based on factors like climate, soil types, and cultural practices. Pre-trained models might need to be fine-tuned or adapted to specific local conditions, which requires domain expertise and additional data collection. Building models that can generalize across different contexts while still providing accurate insights poses a significant challenge.

- **Cost and Accessibility:** Implementing AI technologies often comes with costs related to hardware, software, and training. Small-scale farmers, who make up a significant portion of the agricultural sector, might find it challenging to invest in these technologies due to financial constraints. Ensuring that AI solutions are affordable and accessible to all farmers is crucial for equitable adoption.

- **User-Friendly Interfaces:** Many farmers might not be familiar with complex AI systems or comfortable using technology. Designing user-friendly interfaces and tools that are intuitive and require minimal technical expertise is essential for widespread adoption. Without such interfaces, the benefits of AI might remain out of reach for those who could benefit the most.

- **Ethical and Regulatory Concerns:** AI systems in agriculture can raise ethical concerns related to data privacy, ownership, and bias. Additionally, there might be regulatory challenges in terms of data sharing, intellectual property rights, and compliance with existing agricultural practices and regulations. Striking a balance between innovation and ethical considerations is necessary for the responsible deployment of AI in agriculture.

  Overcoming these challenges requires collaboration between AI researchers, agronomists, policymakers, and farmers themselves. By addressing these issues, we can harness the full potential of AI to revolutionize the agricultural sector and contribute to food security and sustainable development.

20.8 DEVELOPMENT OF AGRICULTURAL ROBOTS

The development of agricultural robots or agri-bots or agri-robots, is an innovative field that combines robotics and automation with agriculture. These robots are designed to perform various tasks in farming and agriculture, with the aim of improving efficiency, reducing labor requirements, and optimizing crop yield and quality. Here's an overview of the development of agricultural robots:

Different Types-Agricultural Robots: Following are the different types of robots in agriculture field:

- **Harvesting Robots:** These are fabricated to autonomously or semi-autonomously harvest crops, such as fruits, vegetables, and grains.
- **Planting Robots:** These can plant seeds or seedlings with precision and consistency, ensuring optimal spacing and planting depth.
- **Weeding Robots:** Weeding robots use cameras and sensors for identifying and removing weeds from fields without the need for chemical herbicides.
- **Monitoring and Sensing Robots:** These are furnished with different sensors (such as cameras, spectrometers, and drones) to monitor the health of crop, condition of soil, and other environment-based factors.
- **Spraying and Fertilizing Robots:** These robots apply pesticides, fertilizers, and other agrochemicals with precision, reducing wastage and environmental impact.
- **Autonomous Tractors:** These are self-driving tractors which can do tasks such as ploughing, tilling, and cultivating fields.

20.9 BENEFITS

The development of agricultural robots offers several benefits to farmers and the agriculture industry as a whole:

- **Labor Savings:** Robots can perform repetitive and labor-intensive tasks, reducing the need for manual labor and addressing labor shortages in agriculture.
- **Precision Agriculture:** Agricultural robots can operate with high precision, leading to more efficient resource usage and increased crop yields.
- **Reduced Environmental Impact:** Precision application of agrochemicals and reduced tillage can lead to lower chemical usage and soil erosion, benefiting the environment.
- **Data-Driven Insights:** Sensing robots and drones can provide real-time data on crop health, allowing farmers to make informed decisions.
- **24/7 Operations:** Some robots can work day and night, allowing continuous operations in time-sensitive activities like harvesting.

- **Safety:** Robots can perform dangerous tasks, such as applying pesticides, without exposing human workers to potential hazards.

20.10 CHALLENGES

- **Technical Complexity:** Designing robots that can operate effectively in varied and complex outdoor environments is a technical challenge.
- **Cost:** The initial investment and maintenance costs of agricultural robots can be high, limiting their adoption by small-scale farmers.
- **Adaptation to Crop Variability:** Crops can vary significantly in terms of size, shape, and growth patterns, requiring adaptable and versatile robot designs.
- **Regulation and Safety:** Ensuring that robots comply with safety standards and regulations while operating around humans and animals is crucial.
- **Data Management:** Managing and interpreting the large amounts of data generated by sensing robots can be challenging for some farmers.

20.11 CURRENT STATUS

1. **Data Collection and Analysis:** AI-driven sensors and drones are used to collect various data points from the field, such as soil moisture, temperature, and crop health. Machine learning algorithms process this data to provide insights and recommendations for farmers.
2. **Predictive Analytics:** In this historical data and current conditions are analysed by AI algorithms for making predictions about weather patterns, crop yields and disease outbreaks. This helps farmers make informed decisions about planting, irrigation, and pest control.
3. **Crop Monitoring and Management:** AI-powered image recognition and computer vision technologies can identify specific plant diseases, pests, and nutrient deficiencies. This allows for targeted interventions, reducing the need for blanket treatments.
4. **Precision Application of Resources:** AI-driven machinery and equipment can precisely apply fertilizers, pesticides, and water only where they're needed, minimizing waste and environmental impact.

5. **Autonomous Vehicles:** Self-driving tractors and drones equipped with AI technology can perform tasks like planting, spraying, and harvesting with high precision and minimal human intervention.

20.12 FUTURE TRENDS

1. **Advanced Robotics:** More sophisticated AI-powered robots could be designed to perform delicate tasks such as fruit picking and pruning, reducing labor costs and improving efficiency.
2. **Climate Resilience:** AI can help farmers adapt to changing climatic conditions by providing real-time weather data and suggesting appropriate actions to mitigate risks.
3. **Data Integration:** As more data is collected from various sources, AI systems can become more accurate and adaptive by integrating diverse datasets for better decision-making.
4. **Collaborative Platforms:** AI-driven platforms could facilitate knowledge sharing among farmers, allowing them to learn from each other's experiences and best practices.
5. **Genetic Optimization:** AI could aid in the development of crops with improved yields, disease resistance, and nutritional content by analyzing genetic data and simulating breeding scenarios.
6. **Regulatory Compliance:** AI systems could help farmers navigate complex agricultural regulations and ensure their practices align with environmental and safety standards.
7. **Edge AI:** The deployment of AI processing at the edge, directly on devices or machinery, could reduce the need for constant internet connectivity and accelerate real-time decision-making.

20.13 CONCLUSION

This review provides an overview of how AI technology is being utilized in the field of agriculture. Given the current societal context of reduced manual labor availability, limited arable land, and the growing disparity between food production and global population, AI has emerged as a viable solution to these challenges. Scientists worldwide have dedicated years to its development and enhancement. The review commences by introducing the definitions of AI, with a particular focus on the Turing

Test. It subsequently highlights two key areas in which AI has played a significant role: soil management, weed management, and the utilization of Internet of Things (IoT) technology for data analysis and storage in agriculture.

Additionally, the review outlines three primary practical challenges associated with implementing AI in agriculture. Firstly, due to factors such as geography, social dynamics, or politics, the distribution of modern technology is uneven, potentially limiting the application of AI in certain regions. Secondly, despite substantial progress, transitioning AI-based machinery and algorithms from controlled experiments to real agricultural settings necessitates further research. Managing large datasets and accurately and swiftly interpreting them stand as pivotal challenges that must be addressed for successful implementation. Lastly, the security of devices deployed in open agricultural spaces and the safeguarding of collected data's privacy pose significant concerns.

The review then delves into the evolution of agricultural robots. It presents several instances of robots tailored to diverse tasks within the agricultural sector. These include autonomous mobile robots for greenhouse pesticide application, GPS and machine vision-equipped tractors with predetermined routes, Cartesian-coordinate-based apple-picking robots, innovative weed management robots with enhanced mobility and crop-weed differentiation capabilities, and a flexible gripper-equipped apple harvesting machine. The review proceeds to discuss the challenges associated with deploying agricultural robots, largely centered around the unpredictability of real-world conditions. However, it emphasizes the substantial progress made in this realm and the promising outlook for further advancements.

REFERENCES

1. *Banerjee, G., Sarkar, U., Das, S., & Ghosh, I. (2018). Artificial Intelligence in Agriculture: A Literature Survey. International Journal of Scientific Research in Computer Science Applications and Management Studies, 7(3), 1-6.*

2. *Food and Agriculture Organization of the United Nations. (2020). 2050: A Third More Mouths to Feed. Retrieved from www.fao.org/news/story/en/item/35571/icode/*

3. *Food and Agriculture Organization of the United Nations. (2020). Hunger and Food Insecurity. Retrieved from www.fao.org/hunger/en/*

4. *Gertsis, A. C., Galanopoulou - Sendouca, S., Papathanasiou, G., & Symeonakis, A. (1997). Use of GOSSYM-A Cotton Growth Simulation Model to Manage a Low Input*

Cotton Production System in Greece. In First European Conference for Information Technology in Agriculture.

5. *Kok, J. N., Boers, E. J. W., Kosters, W. A., et al. (2002). Artificial Intelligence: Definition, Trends, Techniques, and Cases. In International Symposium on Southeast Asia Water Environment.*
6. *M. Sowmiya, & S. Prabavathi. (2019). Smart Agriculture Using IoT and Cloud Computing. International Journal of Recent Technology and Engineering (IJRTE), 7(6S3), 2277-3878.*
7. *Mckinion, J. M., & Lemmon, H. E. (1985). Expert Systems for Agriculture. Computers & Electronics in Agriculture, 1(1), 31-40.*
8. *Mekala Srinivasa Rao, Erukala Suresh Babu, P. Siva Naga Raju, & Ilaiah Kavati. (2019). Smart Agriculture: Automated Controlled Monitoring System using Internet of Things. International Journal of Recent Technology and Engineering (IJRTE), 8(3), 2277-3878.*
9. *Michael, C., & Fu, E. (2016). Google Deep Mind's AlphaGo. OR/MS Today.*
10. *Popa, C. (2011). Adoption of Artificial Intelligence in Agriculture. Bulletin of the University of Agricultural Sciences & Veterinary.*
11. *Priyadharsnee, K., & Rathi, S. (2017). An IoT based smart irrigation system. International Journal of Scientific & Engineering Research, 8(5).*
12. *R. Mythili, Meenakshi Kumari, Apoorv Tripathi, & Neha Pal. (2019). IoT Based Smart Farm Monitoring System. International Journal of Recent Technology and Engineering (IJRTE), 8(4), 2277-3878.*
13. *Senbetu, T. H., Kishore Kumar, K., & Karpura Dheepan, G. M. (2019). IoT Based Irrigation Remote Real-Time Monitoring And Controlling Systems. International Journal of Innovative Technology and Exploring Engineering (IJITEE), 8(7), 2278-3075.*