

REVIEW ARTICLE

ARTIFICIAL INTELLIGENCE AND IOT IN AGRICULTURE PRODUCTION AND SUSTAINABILITY

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ABSTRACT

The future of agriculture depends on several trends and drivers, including advancements in cutting-edge technologies, growing interest in sustainability, climate change, and shifts in consumer food habits. The evolution of production and conservation in agriculture involves multiple steps requiring human intervention. In this process, delays in communication and the omission of humans can impact the production and maintenance of paddy. To overcome these flaws, intelligent things were included to increase agricultural production. Managing paddy products is vital; inappropriate weather conditions can spoil the products within hours. To maintain paddy products at appropriate temperatures, IoT devices play a crucial role. Artificial intelligence can support a knowledge base for various paddy products under different weather conditions. To prevent the wastage of paddy products and increase cultivation and production, IoT and artificial intelligence can help farmers in a better way. Additionally, it will automate tasks and provide faster responses to overcome problems.

KEYWORDS

Sustainability, Artificial Intelligence, Machine Learning, IoT, Cloud computing.

1. INTRODUCTION

The backbone of the Indian economy is agriculture. Most people in India depend on agriculture for their livelihood; even now, 70% of farmers use conventional methods in agriculture. In recent days, the deployment of artificial intelligence and the Internet of Things in agriculture has shown promising results in production. Due to the enormous development of intelligent technology adopted in agriculture by developed countries, most grains are produced during this period. By using modern approaches, the production cost will be decreased and production enhanced. Additionally, we can also save the workforce. By adopting intelligent devices, they can easily monitor crops throughout the day, enabling the agro system to operate more effectively (Leong et al., 2025). Conventional farming is mainly dependent on the workforce, which is a costly, tedious, and time-consuming factor.

The adoption of artificial intelligence will enhance agricultural production, but when combined with IoT, it will further improve the production and quality of farm products. Both technologies enhance the intelligence of devices and sensors, advancing the sustainability of agriculture (Kumar et al., 2023). The implication of combining these technologies lies in the fact that the devices and sensors work automatically using machine learning algorithms and produce efficient results.

Sustainability of agriculture is an important domain, as monitoring the quality of soil, paddy, and maintenance are very much necessary (Sachithra and Subhashini, 2023). The latest technological advancements can be implemented in agriculture to ensure the paddy products and natural resources remain sustainable (Maroli et al., 2021). Crop health and pesticide usage are crucial for maintaining the quality of the soil and paddy

(Backman et al., 2023 ; Yadav et al., 2023). To fulfill all these objectives, the synergy between IoT, Artificial intelligence, and new-generation technologies helps overcome agricultural sustainability challenges. The cost of cultivating and maintaining the crop is expensive, as is the crop yield. By using artificial intelligence, quality services can be provided to farmers at a lower cost. By tracking the field in real-time, IoT-based smart framing improves the overall agriculture system (Kumar et al., 2024). By utilizing sensors and connecting devices, the Internet of Things in agriculture has reduced the wasteful use of resources, including water, power, and the valuable time and energy of farmers.

Agriculture is expected to contribute approximately ₹29.28 lakh crore to India's GDP by 2030, highlighting the need for a focus on upgrading this sector. The intermingling of IoT with agriculture can revolutionize the Indian agricultural scenario. With automation, the Internet of Things (IoT) holds great promise to revolutionize the methods employed and practices adopted, thereby increasing operational efficiency and yield. With the combination of IoT and AI, these devices eliminate the need for human intervention, becoming increasingly smart (Kumar et al., 2023).

IoT sensors can measure the temperature of soil, volumetric water content, photosynthetic radiation, soil water potential, and soil oxygen. Another use of IoT is monitoring climate conditions. With these IoT sensors, we can track and monitor existing weather conditions and then forward the information to the farmers. Sensors gather environmental data, which is used to select the crops most likely to thrive under the given climatic conditions. Big data and cloud computing are used together to store IoT data for further analysis. Artificial intelligence and machine learning techniques can be used to analyze these data and create patterns

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for agricultural purposes (Kumar and Singh, 2010). The AI-ML techniques gain insights from data, based on which they generate alerts for users. The IoT devices will act intelligently by using AI (Mishra and Sharma, 2023). The advancement in technology has led agriculture to a more profitable and sustainable business.

2. RELATED WORK

Most of the population relies on farming for their survival, making it one of the oldest occupations in human history. In many parts of the world, the traditional industry has only recently begun to embrace new technologies. The majority of farmers still rely on traditional methods and manual labor. Emerging technologies are replacing every profession and driving automation. Recent developments in technology can be utilized to provide more accurate and precise agricultural information (Javaid et al., 2023). Notably, artificial intelligence and computer vision approaches have experienced rapid growth in precision agriculture. Developed nations are utilizing these advanced approaches to improve paddy production and quality. We need to help farmers properly implement AI to enhance the positive impact on agriculture's future.

The global population and urbanization have continued to increase in recent times. To meet the demand of the food supply chain mechanism, paddy production needs to be improved (Leong et al., 2025). The produced paddy needs to be supplied worldwide through an appropriate mechanism, and it must be maintained in a sustainable environment. The IoT devices can track this by providing regular updates on temperature and the status to improve sustainability (Maroli et al., 2021). Most people are trying to increase paddy production, but they do not consider the sustainability of the products produced and the impact on natural resources. The sustainability of the Earth is essential for future generations. The use of harmful chemicals and pesticides poses a significant danger.

With the rise in disposable income and evolving consumption habits, farmers are facing significant pressure to meet the growing demand for food. Increasing productivity becomes essential in this scenario. Peering into the next three decades, the world's population is expected to continue growing, presenting a significant challenge to feed an increasing number of people. Integrating sustainable practices, technological innovations, and scientific breakthroughs is crucial for providing food for the growing population while reducing pressure on limited arable land (Leong et al., 2025). In this way, agriculture can evolve and adapt to meet future food needs more effectively and sustainably.

3. ARCHITECTURE OF SMART AGRICULTURE

The AI, with its machine learning backbone, has revolutionized the entire industry (Kumar et al., 2024). By adopting AI in agriculture, we achieve smart agriculture, which yields better results by incorporating AI into the majority of devices used for agricultural monitoring systems. The AI can manage the previous data on weather conditions, soil types, and the kinds of paddy to support future perspectives.

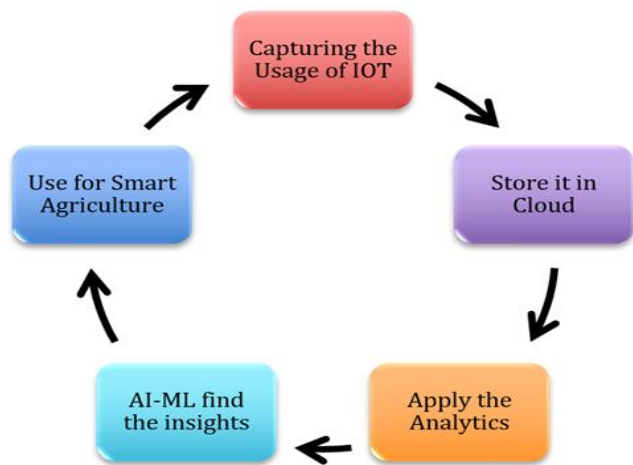


Figure 1: Architecture of the smart agriculture

The AI is combined with emerging technologies, such as cloud, IoT, and Big Data, for gathering and analyzing data from various sources, as shown in Figure 1. The primary source for AI is the data, which can be collected from IoT, cloud, and Big Data. While adopting AI in agriculture, we face

several challenges, including deployment costs, the education levels of farmers, and farm size. Here, we list some of the significant repercussions of AI in agriculture.

3.1 Utilising AI in Farming

Agriculture encompasses a wide range of actions and levels, many of which rely heavily on manual labour. However, by integrating AI technologies, these tasks can be streamlined and made more efficient. Artificial intelligence has the potential to collect and analyze vast datasets on digital platforms, enabling it to generate optimal solutions for various agricultural challenges. Furthermore, when combined with other technologies, AI cannot only initiate but also execute the recommended actions. This fusion of AI with existing agricultural technologies enhances productivity and minimizes the burden of complex and repetitive tasks. By harnessing the power of AI, the farm sector can unlock new possibilities, improve decision-making processes, and ultimately drive innovation in farming practices.

3.2 AI in agricultural information management

The AI has many approaches for computing patterns from the data. For this purpose, we utilize machine learning, which serves as the backbone of AI. These approaches are broadly divided into three groups:

- Supervised learning
- Unsupervised learning
- Reinforcement learning

Figure 2 presents an architectural framework for agribusiness based on sensors, AI, and software implementation support.

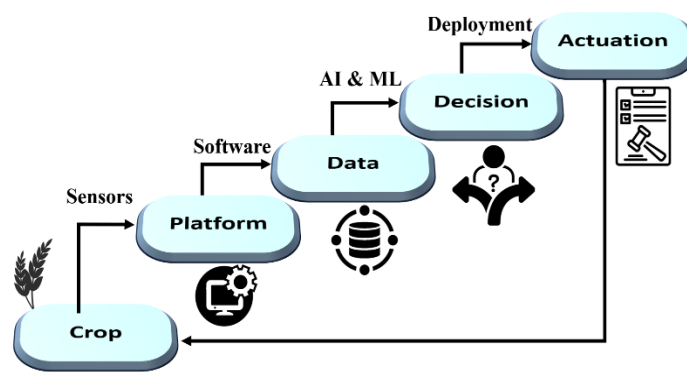


Figure 2: The architecture of agribusiness

3.3 The Advantages of AI

Deploying AI in agriculture offers several advantages. Some are as follows:

- Demand forecasting
- Automation
- Refined root cause analysis
- Smarter workforce
- Yield enhancement
- Reduce the operational costs
- The detection of the defect
- Quality assurance through computerised systems
- Increased effectiveness of the supply chain
- Improved design of power products or equipment (Leong et al., 2025)

The significant problems farms can face while adopting AI include:

- Misleading data
- The Protracted Adoption of New Technologies
- Insufficient familiarity with cutting-edge tech
- Concerns over confidentiality and safety

Any technology has both pros and cons, but utilizing it to improve production, supply chain, and sustainability for future generations is very important.

4. SUSTAINABILITY

This fusion of cutting-edge technologies like artificial intelligence, IoT, and

blockchain in agriculture is significant in making agribusinesses sustainable and survive amidst climate change. By implementing these new technologies, the sustainability of the soil, stock monitoring, and processing of the supply chain will be dealt with more suitably. The short-term sustainable products require constant checks on the right temperature, so there is a need to monitor and control the right temperatures. The AI and IoT equipment are assisting and notifying the user. Nowadays, farming is conducted in a pesticide-free and chemical-free manner for the sake of the environment. Organic farming is one solution for sustainability. Irreversible climatic change has a major effect on agriculture and addressing uncertain and sometimes harsh climatic conditions is of utmost significance.

Though modifying the weather is not possible for humans, observation and forecasting weather conditions can be of tremendous help to agribusinesses in their cost reduction. Utilizing these resources, agribusinesses are able to make conscious decisions, maximize their operations, and take proper measures to counterbalance the adverse effects of unfavourable weather conditions, ultimately protecting their financial resources. Farmers have traditionally been conditioned to accommodate the variability in weather from year to year.

Some of the potential developments in the future years to sustain are mentioned below:

- Sustainable Agriculture
- Dietary Supplements
- Farming Robotics
- Climate-Smart Agriculture

5. ARTIFICIAL INTELLIGENCE SUPPORT FOR SUSTAINABILITY IN AGRICULTURE

The application of AI in agriculture would go a long way towards enhancing food security. Farmers and the agricultural sector can enhance decision-making by employing cutting-edge technologies. By employing these strategies, the farmers can maximize resource utilization, enhance productivity, mitigate environmental degradation, and address numerous sustainability challenges. Some of the ways artificial intelligence and other technologies can help ensure agriculture remains sustainable are as follows:

- Precision agriculture
- Managing crop and soil
- Controlling pests and diseases
- Optimizing resource
- Controlling automated monitoring
- Managing supply chain
- Climate modelling and forecasting
- Vertical cultivation

AI can be very useful in examining the past climate records and creating predictive models to forecast the effects of climate change on agriculture. By doing so, farmers can be enabled to respond to changing circumstances, maximize planting dates, select suitable crop species, and mitigate the impacts of catastrophic weather (Kumar et al., 2023). The advancements in artificial intelligence may bring about revolutionary transformations in agriculture. By rendering useful information, promoting resource efficiency, and encouraging sustainable agriculture. However, to ensure responsible and equitable use in agriculture, it is necessary to consider the local and regional guidelines by the government, ethical implications, data privacy, and the potential biases of AI and machine learning algorithms.

6. IOT SUPPORT FOR SUSTAINABILITY IN AGRICULTURE

The Internet of Things plays a crucial role in promoting sustainability in agriculture by enabling effective resource management, enhancing monitoring and control systems, and improving overall agricultural practices. Following is some of the ways IoT can assist in sustainable agriculture.

- Smart irrigation
- Precision agriculture
- Livestock monitoring
- Environmental monitoring
- Supply chain optimization
- Energy governance
- Decision support systems

IoT systems must be scalable, reliable, and designed specifically for farmer' needs in order to maximize their sustainability value. It can

improve efficiency, save waste, and enhance sustainability in agriculture. The likely impact on privacy, as well as data security, and the necessity for ensuring the responsible and ethical use of IoT are also concerns.

7. CONCLUSION

The development in the agricultural sector is significantly needed to meet the growing population's needs. Smart agriculture practices minimize human intervention and maximize crop sustainability and yield by monitoring them properly. The basic demands of the agricultural sector, with the new development of artificial intelligence and IoT devices, can make the system more advanced. The future of farming is reliant mainly on the incorporation of IoT and artificial intelligence. According to the AI's predictions, we can expect to develop in the sector. In response to the need for renewable energy, the process can maintain the quality of the system's products. Implementing these technologies in agriculture will increase production while also sustaining the environment. Apart from crop anomaly detection, stock management, and supply chain management, this also helps achieve improved sustainability. In the future, such technologies will enable agribusinesses to do more and also safeguard the environment for future generations.

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