www.ijarp.com ISSN 2456-9992 Page: 01-15

International Journal Advanced Research Publications

Research Article

Volume: 02
Issue: 03

ECO-SMART FARMING: AUTOMATED IRRIGATION AND YIELD OPTIMIZATION USING AL & WEB DASHBOARD

[*1]Anto Salina S, [2]Mrs.Friska J

[1]Department of Electronics and Communication Engineering Francis Xavier Engineering College Tirunelveli - 627 003, Tamil Nadu, India.

[2]Professor - Department of Electronics and Communication Francis Xavier Engineering College Tirunelveli - 627 003, Tamil Nadu, India.

Article Received: 27 January 2026, Article Revised: 15 February 2026, Published on: 07 March 2026

***Corresponding Author: Anto Salina S**

Department of Electronics and Communication Engineering Francis Xavier Engineering College Tirunelveli - 627 003, Tamil Nadu, India.

DOI: https://doi-doi.org/101555/ijarp.2931

ABSTRACT

Agriculture plays a crucial role in ensuring food security and economic stability across the world. However, traditional irrigation methods often lead to inefficient water usage and lack of real-time monitoring of crop conditions. The advancement of modern technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and web-based monitoring systems has enabled the development of smart farming solutions. This paper presents an Eco- Smart Farming system designed to automate irrigation and optimize crop yield using IoT sensors, AI-based analysis, and a web dashboard for remote monitoring. The system continuously monitors soil moisture, temperature, and environmental conditions using sensors installed in the agricultural field. Based on the collected data, the system automatically controls irrigation by activating the water pump whenever soil moisture falls below the required threshold level. A web-based dashboard provides real-time visualization of field parameters, enabling farmers to monitor irrigation status and environmental conditions remotely. The proposed system helps in reducing water wastage, improving crop productivity, and supporting sustainable agricultural practices. The integration of automation and intelligent monitoring allows farmers to manage their fields more efficiently and make informed decisions regarding irrigation management.

KEYWORDS: Smart Agriculture, Internet of Things (IoT), Automated Irrigation, Artificial Intelligence, Precision Farming, Web Dashboard.

I. INTRODUCTION

Agriculture is one of the most important sectors for global food production and economic development. Efficient irrigation management plays a significant role in maintaining crop health and maximizing agricultural productivity. Traditional irrigation systems often rely on manual observation and fixed watering schedules, which may lead to excessive water usage or insufficient irrigation. These limitations affect crop growth and increase operational costs for farmers. With the rapid development of digital technologies, modern agriculture is gradually adopting smart farming techniques. Technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), wireless sensor networks, and cloud computing are transforming traditional agricultural practices. Smart agriculture systems enable real-time monitoring of environmental conditions and automated decision- making processes to improve farming efficiency. IoT sensors can be deployed in agricultural fields to measure parameters such as soil moisture, temperature, humidity, and light intensity. These sensors continuously collect environmental data and transmit it to a processing unit or cloud platform. Based on the collected information, intelligent algorithms can determine the optimal irrigation schedule required for crop growth. The Eco-Smart Farming system proposed in this project integrates IoT sensors, automated irrigation control, and a web- based dashboard to improve irrigation efficiency. The system automatically activates irrigation whenever the soil moisture level falls below a predefined threshold. Farmers can also access real-time data through a web interface, allowing them to monitor

field conditions from any location. By combining sensor-based monitoring and automated irrigation, the proposed system reduces water wastage, improves crop productivity, and promotes sustainable agricultural practices.

II. Related Work

The development of smart agriculture systems has gained significant attention in recent years as researchers attempt to address challenges related to water scarcity, inefficient irrigation, and limited real- time monitoring of crop conditions. Environmental engineering and agricultural technology are increasingly integrating digital tools such as Internet of Things (IoT) devices, cloud platforms, and machine learning algorithms to improve farming efficiency. Recent studies highlight the effectiveness of sensor networks, predictive analytics, and automated irrigation systems. However, several limitations still exist in transforming raw environmental data into intelligent decision-making systems that can autonomously optimize irrigation and crop productivity.

A. The Evolution of IoT in Smart Agriculture

The integration of Internet of Things (IoT) technologies in agriculture has significantly transformed traditional farming practices. Earlier irrigation methods relied heavily on manual observation, fixed schedules, and simple mechanical systems, which often resulted in water wastage and inconsistent crop growth. Modern IoT-based agricultural systems deploy sensor networks capable of monitoring soil moisture, temperature, humidity, and other environmental parameters in real time. Many research projects have utilized microcontroller platforms such as Arduino, ESP8266, and ESP32 to interface with environmental sensors. These systems collect analog signals from the field and transmit the data to cloud platforms using communication protocols such as HTTP, MQTT, or Wi-Fi. The collected data is then visualized through dashboards or mobile applications, enabling farmers to monitor agricultural conditions remotely. Despite the success of IoT in digitizing agricultural environments, many existing systems remain largely passive in nature. They primarily focus on collecting and displaying environmental data rather than performing intelligent decision-making. In most implementations, farmers must manually interpret sensor readings and decide when irrigation is necessary. As a result, there is a growing need for IoT architectures that not only monitor environmental conditions but also integrate automated control mechanisms capable of responding to real-time sensor data.

B. Artificial Intelligence and Predictive Irrigation Models

In order to improve irrigation efficiency, researchers have increasingly incorporated Artificial Intelligence (AI) and Machine Learning (ML) techniques into smart agriculture systems. Various supervised learning algorithms such as Support Vector Machines (SVM), Decision Trees, Artificial Neural Networks (ANN), and Random Forest classifiers have been used to analyze environmental datasets and predict irrigation requirements. Recent studies demonstrate that machine learning algorithms can effectively analyze complex relationships between environmental variables such as soil moisture, temperature, humidity, and rainfall patterns. These predictive models help determine the optimal irrigation schedule required for different crop types and environmental conditions. However, a critical limitation in many existing implementations is the restricted scope of prediction. Most machine learning models are trained offline using historical datasets and deployed as static models. These systems often provide simple outputs such as irrigation recommendations or generalized crop condition predictions. They rarely support dynamic learning or real-time model adaptation based on continuously changing environmental conditions. Furthermore, many smart irrigation systems still rely on simple threshold-based automation where irrigation is activated when soil moisture falls below a predefined value. Although effective to a certain extent, this approach does not consider multiple environmental variables simultaneously. Therefore, there is a need for more advanced predictive models capable of integrating multiple sensor parameters and continuously optimizing irrigation strategies.

C. Limitations in Automated Agricultural Monitoring Systems

While smart agriculture platforms have improved data collection and monitoring capabilities, several vulnerabilities remain in automated farm management systems. One of the major challenges is the lack of intelligent control mechanisms that can respond dynamically to environmental changes. Many existing systems rely on simple rule-based automation, where irrigation is triggered whenever soil moisture drops below a static threshold. Because agricultural environments are naturally dynamic, sensor readings often fluctuate due to environmental noise, rainfall variations, or sensor inaccuracies. As a result, these rigid threshold-based systems may activate irrigation unnecessarily or fail to respond appropriately during critical crop stress conditions. Another limitation is the absence of integrated monitoring and decision- support platforms. In several existing solutions, sensor data is transmitted to cloud dashboards that only display raw numerical values. Farmers must manually interpret these readings and decide the appropriate actions to take. This increases the cognitive load on farmers and reduces the overall efficiency of automated farming systems. Additionally, many systems lack intelligent notification mechanisms that can inform farmers about abnormal environmental conditions or system failures. Without timely alerts and automated control features, the effectiveness of smart agriculture systems remains limited.

D. Research Gap and Proposed Contribution

The analysis of existing literature reveals several technological gaps in current smart agriculture systems. While IoT-based sensor networks provide real-time environmental monitoring, many systems lack intelligent automation capable of converting raw data into actionable irrigation decisions. Similarly, machine learning models used in agricultural applications often operate as static prediction tools rather than adaptive systems capable of continuous learning. Another major limitation is the lack of integrated platforms that combine environmental sensing, automated irrigation control, and remote monitoring within a single architecture. Existing solutions either focus on sensor data collection or predictive analytics but rarely integrate both functionalities in a unified system. The proposed Eco- Smart Farming system addresses these limitations by integrating IoT sensors, automated irrigation control, and a web-based monitoring dashboard. The system continuously collects environmental data from soil moisture and temperature sensors and uses this information to automatically control irrigation systems. Unlike traditional monitoring platforms, the proposed system provides real-time data visualization through a web dashboard, allowing farmers to remotely monitor field conditions and irrigation status. By combining sensor-based monitoring, automated decision-making, and remote accessibility, the proposed architecture transforms conventional irrigation systems into intelligent agricultural management platforms capable of improving water efficiency and crop productivity.

III. Proposed System Architecture

The proposed Eco-Smart Farming system is designed to provide an intelligent irrigation management solution by integrating Internet of Things (IoT) sensors, automated control mechanisms, and a web- based monitoring platform. The architecture aims to improve water efficiency, enhance crop productivity, and enable farmers to monitor agricultural conditions remotely. The system consists of several interconnected hardware and software components that work together to collect environmental data, process the information, and automatically control irrigation based on real-time conditions.

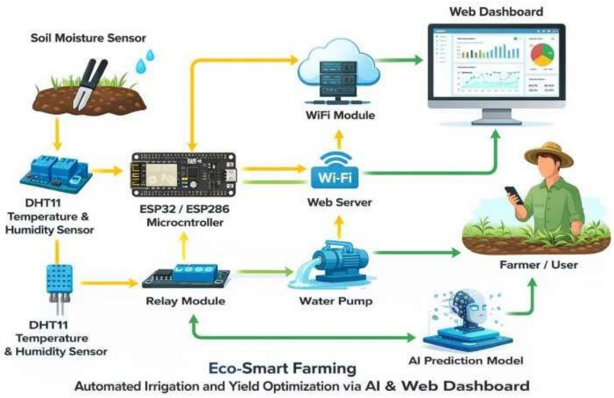

Fig 1: System Architecture Diagram.

A. Sensor Layer

The sensor layer forms the foundation of the system and is responsible for collecting real-time environmental data from the agricultural field. Various sensors are deployed to measure important parameters affecting crop growth. The soil moisture sensor continuously monitors the moisture level present in the soil. This parameter plays a crucial role in determining when irrigation is required. If the soil moisture level falls below a predefined threshold value, the system identifies that irrigation is necessary. In addition to soil moisture sensing, temperature and humidity sensors are used to monitor environmental conditions. These parameters influence plant growth and water requirements. The sensor layer continuously collects these measurements and sends them to the processing unit for further analysis.

B. Processing and Control Layer

The processing and control layer acts as the central intelligence of the Eco-Smart Farming system. A microcontroller unit such as Arduino or ESP-based controllers is used to receive and process data collected from the sensors. The microcontroller continuously analyzes sensor readings and compares them with predefined threshold values. If the soil moisture level drops below the required level, the controller automatically activates the irrigation pump through a relay driver circuit. Once the soil moisture reaches the optimal level, the irrigation system is automatically turned off. This automated decision- making process ensures efficient water usage and eliminates the need for manual irrigation management.

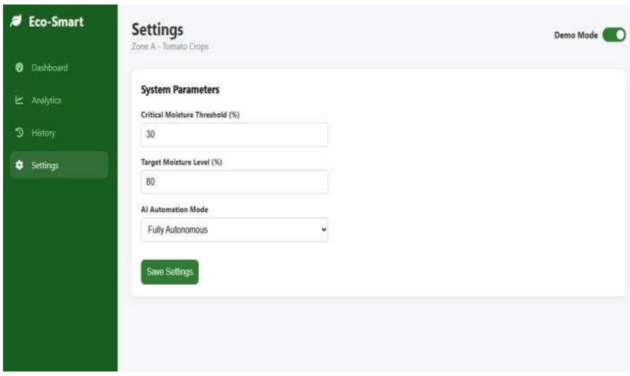

Fig 2: System Parameter.

C. IoT Communication Layer

The IoT communication layer enables the transmission of sensor data from the field to a remote server or cloud platform. Wireless communication technologies such as Wi-Fi modules or IoT communication interfaces are used to establish connectivity between the field devices and the monitoring platform. Sensor data including soil moisture level, temperature, humidity, and irrigation status is transmitted in real time to the web server. This continuous data transmission allows remote monitoring of agricultural conditions and supports data analysis for better irrigation management.

D. Web Dashboard and Monitoring Platform

The web dashboard serves as the user interface for the Eco-Smart Farming system. It provides farmers with a centralized platform to monitor environmental conditions and irrigation status in real time. The dashboard displays graphical representations of sensor data, including soil moisture levels, temperature, humidity, and pump activity. Farmers can access this information using internet-enabled devices such as smartphones, laptops, or tablets. The monitoring platform also allows farmers to track historical data trends and evaluate irrigation patterns over time. This helps in making informed agricultural decisions and optimizing crop management strategies.

Fig 3: Web Dashboard Page.

E. Automated Irrigation System

The automated irrigation subsystem is responsible for delivering water to crops when required. The system uses an electrically controlled water pump connected through a relay driver circuit. When the microcontroller detects that soil moisture is below the predefined threshold, it sends a signal to the relay module to activate the water pump. The pump supplies water to the irrigation system until the desired moisture level is reached. This automated irrigation mechanism ensures that crops receive the correct amount of water at the appropriate time, preventing both over-irrigation and under-irrigation.

F. System Advantages

The proposed system architecture offers several advantages compared to traditional irrigation methods. The integration of IoT sensors enables continuous monitoring of agricultural conditions. Automated irrigation control reduces manual labor and ensures optimal water usage. The web dashboard provides remote accessibility and real-time visualization of environmental data. Additionally, the system promotes sustainable farming practices by conserving water resources and improving crop productivity.

IV. Experimental Results and Performance Evaluation

The performance of the proposed Eco-Smart Farming system was evaluated by implementing the prototype in a controlled agricultural environment and analyzing its ability to monitor environmental parameters and automate irrigation effectively. The experimental setup consisted of soil moisture sensors, temperature and humidity sensors, a microcontroller-based control unit, a water pump driver circuit, and a web-based dashboard for remote monitoring. The system continuously collected environmental data from the sensors and transmitted the data to the monitoring platform through the IoT communication module. Based on the collected sensor data, the microcontroller executed the irrigation control algorithm to determine whether irrigation was required.

A. Sensor Data Monitoring

The sensor modules successfully captured real-time environmental parameters including soil moisture, temperature, and humidity levels. The collected data was continuously displayed on the web dashboard, enabling remote monitoring of field conditions. During the experimental observations, the soil moisture sensor accurately detected variations in soil conditions as water levels changed. The sensor readings were updated periodically and transmitted to the web platform without significant delay. The temperature and humidity sensors also provided stable readings that helped in understanding environmental influences on crop growth. The continuous monitoring capability ensured that farmers could observe field conditions at any time and take necessary actions if required.

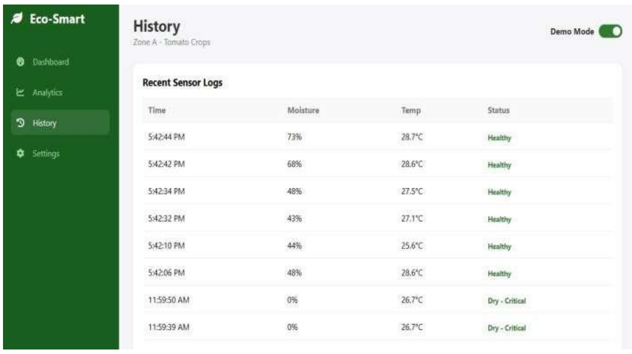

Fig 4: History Page.

B. Automated Irrigation Performance

One of the key objectives of the system was to automate irrigation based on soil moisture levels. The experimental results demonstrated that the irrigation system responded effectively to changes in soil moisture. When the soil moisture level dropped below the predefined threshold value, the microcontroller activated the relay module, which in turn started the water pump. The irrigation process continued until the soil moisture reached the optimal level. Once the desired moisture level was achieved, the system automatically deactivated the pump. This automated irrigation mechanism ensured that crops received the required amount of water without manual intervention. The system also prevented excessive watering, which is a common problem in traditional irrigation methods.

C. Web Dashboard Performance

The web-based dashboard successfully displayed real- time sensor data and irrigation status. The interface allowed users to visualize parameters such as soil moisture level, temperature, humidity, and pump status. Farmers could access the dashboard through internet-enabled devices and monitor field conditions remotely. The dashboard also provided a user-friendly interface with graphical representations of environmental data, which improved the usability of the system. The integration of the web platform enhanced transparency and allowed farmers to maintain better control over irrigation management.

D. Water Usage Efficiency

The experimental evaluation indicated that the automated irrigation system significantly reduced unnecessary water usage. By irrigating the crops only when soil moisture levels were below the required threshold, the system minimized water wastage. Compared to traditional manual irrigation methods, the proposed system demonstrated improved efficiency in water management. The ability to monitor soil conditions in real time ensured that irrigation occurred only when necessary. This efficient use of water resources is particularly beneficial in regions facing water scarcity and contributes to sustainable agricultural practices.

E. System Reliability and Performance Analysis

The overall performance of the Eco-Smart Farming system was found to be stable and reliable during experimental testing. Sensor readings were consistently transmitted to the web dashboard without significant communication delays. The microcontroller responded promptly to sensor inputs and executed irrigation control operations accurately. The integration of hardware components, IoT communication, and web monitoring created a robust system capable of operating continuously in agricultural environments. The automated irrigation mechanism reduced the dependency on manual supervision and improved the efficiency of farm management. The results confirm that the proposed system can effectively support smart farming applications by combining real-time monitoring, automated irrigation, and remote access capabilities.

Fig 5: Performance Analysis.

V. Discussion and Practical Implications

The implementation of the Eco-Smart Farming system demonstrates the potential of integrating Internet of Things (IoT) technologies with automated irrigation systems to improve agricultural efficiency. The experimental results indicate that real-time monitoring of environmental parameters such as soil moisture, temperature, and humidity can significantly enhance irrigation management and reduce unnecessary water consumption. One of the most important practical implications of this system is the improvement in water resource management. Traditional irrigation practices often rely on manual scheduling, which may lead to over-irrigation or under-irrigation. The proposed system addresses this issue by continuously monitoring soil moisture levels and activating irrigation only when required. This ensures that crops receive the optimal amount of water needed for healthy growth while minimizing wastage. Another important aspect is the ability to monitor agricultural conditions remotely. The integration of a web-based dashboard allows farmers to access real-time sensor data from any location using internet-enabled devices. This capability is particularly beneficial for large agricultural fields where constant physical monitoring is difficult. By providing real-time updates on environmental conditions and irrigation status, the system enables farmers to make informed decisions regarding crop management. The proposed system also contributes to reducing labor requirements in agricultural activities. Automated irrigation control eliminates the need for farmers to manually monitor soil conditions and operate irrigation equipment. This not only saves time but also improves operational efficiency, allowing farmers to focus on other important farming activities. From a technological perspective, the system demonstrates how IoT-based sensor networks can be effectively integrated with microcontroller platforms and cloud-based monitoring systems. The modular design of the system allows it to be easily expanded by incorporating additional sensors such as rainfall sensors, nutrient sensors, or weather monitoring devices. This scalability makes the system suitable for different types of agricultural environments. Furthermore, the adoption of smart irrigation systems can contribute to sustainable agricultural development. Efficient water usage helps conserve natural resources while maintaining crop productivity. In regions where water scarcity is a major challenge, automated irrigation systems such as the proposed Eco-Smart Farming model can play a crucial role in improving agricultural sustainability. Despite the advantages, certain practical challenges may arise during real-world deployment. Sensor accuracy may be affected by environmental factors such as soil composition and weather conditions. Additionally, reliable internet connectivity is required to ensure continuous data transmission to the web dashboard. Addressing these challenges through improved sensor calibration and robust communication networks can further enhance system performance. Overall, the Eco-Smart Farming system demonstrates a practical and scalable solution for modern agriculture. By combining real-time monitoring, automated irrigation, and remote accessibility, the system provides farmers with a powerful tool to optimize water usage, improve crop yield, and promote sustainable farming practices.

VII. CONCLUSION AND FUTURE WORK

A. Conclusion

The development of the Eco-Smart Farming system represents a significant advancement over traditional irrigation practices that rely heavily on manual monitoring and fixed watering schedules. By integrating Internet of Things (IoT) sensors, automated control mechanisms, and a web-based monitoring platform, the proposed system transforms conventional agricultural irrigation into an intelligent and data-driven process. The system successfully bridges the gap between environmental data collection and automated decision-making, enabling efficient irrigation management based on real-time field conditions. Through continuous monitoring of soil moisture, temperature, and environmental parameters, the system can accurately determine when irrigation is required. The automated irrigation mechanism ensures that water is supplied only when necessary, thereby reducing water wastage and improving crop productivity. The use of microcontroller-based control and sensor integration allows the system to operate reliably in agricultural environments with minimal human intervention. Furthermore, the integration of a web dashboard enables farmers to remotely monitor field conditions and irrigation status in real time. This capability significantly enhances transparency and control over agricultural operations. Farmers can observe environmental trends, evaluate soil conditions, and ensure that irrigation processes are functioning efficiently without physically visiting the field. The Eco-Smart Farming architecture also contributes to sustainable agricultural practices by promoting efficient water usage and reducing labor requirements. By combining sensor-based monitoring, automated irrigation control, and remote accessibility, the system provides a scalable solution capable of supporting modern smart agriculture applications. Overall, the proposed system demonstrates how digital technologies can improve agricultural productivity while conserving critical natural resources.

B. Future Research Directions

Although the proposed Eco-Smart Farming system demonstrates effective automation and monitoring capabilities, several opportunities exist for further research and system enhancement. First, the sensing layer of the system can be expanded by integrating additional environmental sensors. Advanced sensors capable of measuring parameters such as soil nutrient levels, rainfall intensity, sunlight exposure, and atmospheric pressure could provide more comprehensive data for agricultural decision-making. The inclusion of these sensors would enable the system to perform more precise irrigation management and improve crop health analysis. Second, future work may focus on incorporating advanced Artificial Intelligence and Machine Learning models to further optimize irrigation strategies. Predictive algorithms could analyze historical environmental data, weather forecasts, and crop growth patterns to determine optimal irrigation schedules. Such predictive capabilities would allow the system to anticipate irrigation requirements rather than simply reacting to current soil conditions. Another important research direction involves enhancing the system's communication and deployment infrastructure. The integration of low- power wireless communication technologies such as LoRaWAN or NB-IoT could enable large-scale deployment of sensor networks across extensive agricultural fields. These communication technologies would allow multiple sensor nodes to operate efficiently while consuming minimal energy. Additionally, renewable energy solutions such as solar-powered sensor nodes could be incorporated to ensure continuous and autonomous operation of the system in remote agricultural locations. Energy- efficient hardware design and intelligent power management techniques would further improve the sustainability of the system. Finally, future versions of the system could include mobile applications and advanced data analytics platforms that provide farmers with personalized recommendations for crop management. These intelligent decision-support tools could analyze environmental trends and provide actionable insights to maximize crop yield and optimize resource utilization. By expanding sensor capabilities, integrating advanced predictive models, and improving communication infrastructure, the Eco-Smart Farming system can evolve into a comprehensive smart agriculture platform capable of supporting large-scale precision farming applications.

Acknowledgement

The author would like to express sincere gratitude to the management and faculty members of Francis Xavier Engineering College for providing the necessary technical infrastructure, laboratory facilities, and a supportive academic environment that enabled the successful development of this project.

Special appreciation is extended to the project guide and faculty mentors for their valuable guidance, constructive suggestions, and continuous encouragement throughout the research and development process. Their expertise and support played an important role in improving the quality and direction of this work.

The author also acknowledges the availability of modern development tools, open-source platforms, and research resources that assisted in implementing the proposed system architecture, integrating the web dashboard, and optimizing the predictive analytics models used in this study.

REFERENCES

1. K. Ashton, “That ‘Internet of Things’ Thing,” *RFID Journal*, vol. 22, no. 7, pp. 97–114, 2009.
2. L. Ruiz-Garcia, L. Lunadei, P. Barreiro, and J. I. Robla, “A Review of Wireless Sensor Technologies and Applications in Agriculture and Food Industry,” *Sensors*, vol. 9, no. 6, pp. 4728–4750, 2009.
3. J. Gutierrez, J. F. Villa-Medina, A. Nieto- Garibay, and M. A. Porta-Gandara, “Automated Irrigation System Using a Wireless Sensor Network and GPRS Module,” *IEEE Transactions on Instrumentation and Measurement*, vol. 63, no. 1, pp. 166–176, 2014.

4. S. R. Nandurkar, V. R. Thool, and R. C. Thool, “Design and Development of Precision Agriculture System Using Wireless Sensor Network,” *IEEE International Conference on Automation, Control, Energy and Systems*, pp. 1–6, 2014.
5. N. Zhang and M. Wang, “Precision Agriculture – A Worldwide Overview,” *Computers and Electronics in Agriculture*, vol. 36, no. 2–3, pp. 113–132, 2002.
6. Ray, S. Jain, and S. Singh, “IoT Based Smart Agriculture Monitoring System,” *International Journal of Computer Applications*, vol. 180, no. 15, pp. 20–24, 2018.
7. R. Patel and M. Patel, “Internet of Things Based Smart Farming System Using Sensors,” *International Journal of Engineering Research & Technology*, vol. 7, no. 5, pp. 120–125, 2018.
8. S. Wolfert, L. Ge, C. Verdouw, and M. Bogaardt, “Big Data in Smart Farming – A Review,” *Agricultural Systems*, vol. 153, pp. 69–80, 2017.
9. J. A. T. Machado and M. F. Silva, “Application of Artificial Intelligence in Agriculture,” *Engineering Applications of Artificial Intelligence*, vol. 72, pp. 415–426, 2018.
10. K. Lakshmisudha, Swathi Hegde, Neha Kale, and Shruti Iyer, “Smart Agriculture System Using IoT,” *International Journal of Computer Science and Information Technologies*, vol. 7, no. 2, pp. 456–459, 2016.
11. Kamilaris and F. X. Prenafeta-Boldú, “A Review of the Use of Artificial Intelligence in Agriculture,” *Artificial Intelligence Review*, vol. 51, pp. 1–27, 2018.
12. J. Burrell, Z. Oreglia, and A. K. Gupta, “The Myth of the Digital Farmer: How Data Shapes Agriculture,” *Journal of Rural Studies*, vol. 64, pp. 28–36, 2018.
13. M. Bacco, P. Barsocchi, E. Ferro, and A. Gotta, “Smart Farming: Opportunities, Challenges and Technology Enablers,” *IEEE Internet of Things Journal*, vol. 6, no. 2, pp. 210–220, 2019.
14. S. Ramesh, R. Karthick, and P. Hariharan, “Smart Irrigation System Using IoT and Machine Learning,” *International Journal of Innovative Technology and Exploring Engineering*, vol. 8, no. 8, pp. 1600–1604, 2019.
15. K. S. Suresh and P. Daniel, “IoT Based Automated Irrigation System,” *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol. 6, no. 3, pp. 1500–1505, 2017.
16. Sharma, S. Singh, and R. Singh, “Machine Learning Approaches for Crop Yield Prediction,” *Procedia Computer Science*, vol. 167, pp. 234–242, 2020.

17. Mishra, A. Khan, and R. Tiwari, “Automated Irrigation System Using Soil Moisture Sensor and IoT,” *International Journal of Engineering Research and Applications*, vol. 9, no. 2, pp. 45–50, 2019.
18. R. Kamble and A. Deshmukh, “Cloud Based Smart Farming Using IoT Sensors,” *International Journal of Computer Science Trends and Technology*, vol. 6, no. 3, pp. 210–214, 2018.