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ADVANCED IoT-DRIVEN AGRICULTURAL SOLUTIONS

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ABSTRACT

The rapid population growth has increased food demand, exposing the inefficiencies of traditional farming methods. Conventional farming methods inefficiently utilize resources such as land, water, herbicides, and fertilizers. The growing requirement for food, both in terms of quantity and quality, has led to a demand for the expansion and industrialization of the agricultural industry. There is a growing interest in automation within agriculture to maximize resource utilization effectively and sustainably increase production. AGRISENSE, a smart IoT-based prototype, addresses this by utilizing precision agriculture techniques for optimal resource use. By collecting and analyzing real-time data on soil moisture, temperature, and humidity through ThingSpeak and Blynk Cloud, it ensures optimal crop growth conditions. This system improves water utilization, reduces manual labor, enhances soil fertility, and increases productivity, highlighting the critical role of technological advancements in modern agriculture.

Key Words:

Internet of Things (IoT), Smart irrigation system, Precision agriculture, Blynk, Farm automation, water pump.

I. INTRODUCTION

Due to the rapid expansion of the global population, there is a projected substantial increase in the demand for food over the next decade. Traditional farming techniques are inadequate to meet this demand for food crops, inefficiently utilizing resources such as land, water, herbicides, and fertilizers. The growing requirement for food, both in terms of quantity and quality, has led to a demand for the expansion and industrialization of the agricultural industry, with a growing interest in automation within agriculture to maximize resource utilization effectively and sustainably increase production.

The "Internet of Things" represents a highly promising set of technologies that can provide numerous solutions for modernizing agriculture, transforming both human and machine operations on farms. One of the key areas where IoT is making a significant impact is in the development of precision agriculture techniques. This paper presents a smart IoT-based prototype system that supports precise crop irrigation and utilizes real-time data analysis to minimize errors and provide forecasting. Smart agricultural technology and Internet of Things (IoT) technology provided farmers with advanced management tools to enhance both the quantity and quality of their crops. AGRISENSE uses ThingSpeak, a powerful cloud platform for collecting, analyzing, and visualizing data obtained from IoT sensors deployed in agricultural fields. ThingSpeak provides an easy-to-use interface for farmers to access real-time and historical data about various environmental parameters affecting crop growth, offering advanced management tools to enhance both the quantity and quality of their crops.

This system extracts crucial parameters such as soil moisture, temperature, and humidity, displaying the data through a web interface for remote monitoring using Blynk Cloud. It operates based on the extracted data, ensuring optimal conditions for specific crop growth. Additionally, the incorporation of IoT principles has enabled instantaneous supervision and regulation of the pump, thereby improving water utilization efficiency and facilitating seamless agricultural practices. This innovative approach underscores the importance of scientific and technological advancements in agriculture to alleviate manual labor, enhance soil fertility, and increase overall productivity, securing a prosperous future for generations to come.

II. LITERATURE REVIEW

In the realm of modern agricultural advancements, several studies highlight the integration of technology to enhance farming efficiency. Alsamhi, S.H., Ma, O., and Shi, Q. (2020) in their paper "A Survey of Indoor Greenhouse Farming Technology and Automation Systems" presented in IEEE Access, discuss various techniques, systems, and advancements in indoor farming methods. This work outlines the evolving landscape of greenhouse farming, emphasizing the role of automation and technology in optimizing indoor farming processes.

Wan, Z., Song, Y., and Cao, Z. (2019) presented their study "Environment Dynamic Monitoring and Remote Control of Greenhouse with ESP8266 NodeMCU" at the IEEE 3rd Information Technology, Networking, Electronics, and Automation Control Conference (ITNEC). This research delves into methods for remotely monitoring and controlling greenhouse conditions using ESP8266 NodeMCU, incorporating sensors to track environmental variables and utilizing the NodeMCU for data processing and communication.

Furthering the discussion on smart irrigation systems, the study "Wireless Sensor and Actuator System for Smart Irrigation on the Cloud" presented at the IEEE 2nd World Forum on Internet of Things (2015), explores a system that employs wireless sensors and actuators to facilitate smart irrigation. This system potentially leverages cloud computing for data storage, analysis, and remote access.

In another notable study, Londhe, G., and Galande, S.G. (2014) in their paper "Automated Irrigation System by Using ARM Processor," published in the International Journal of Scientific Research in Engineering and Technology (IJSRET), discuss the development of an automated irrigation system controlled by an ARM processor. This study highlights the integration of ARM processors to enhance the precision and efficiency of irrigation systems.

Lastly, Jha, S.K. (2023) in "Need for an Orchestration Platform to Unlock the Potential of Remote Sensing Data for Agriculture," featured in the book "Digital Ecosystem for Innovation in Agriculture" published by Springer, argues for an orchestration platform designed to integrate and manage various data sources, such as remote sensing data. This framework aims to coordinate the use of these data sources to improve agricultural practices and optimize resource utilization.

These studies collectively underscore the significance of integrating advanced technologies such as IoT, cloud computing, and automation in modern agriculture to enhance efficiency, productivity, and sustainability.

III. PROPOSED SYSTEM

In this paper, we propose a system designed to automate irrigation using various sensors and an ESP8266 microcontroller. The proposed system integrates a DHT11 temperature and humidity sensor, a soil moisture sensor, and a flame sensor to monitor environmental conditions and manage the irrigation process. The data extracted from sensors is displayed through a web interface for remote monitoring using Blynk Cloud. This setup ensures optimal conditions for specific crop growth by operating based on the extracted data.

The setup involves connecting these sensors to the ESP8266 microcontroller, which is programmed to collect data from the sensors and transmit it wirelessly. The ESP8266 is an excellent choice for this application due to its built-in Wi-Fi capabilities, low power consumption, and ease of programming. The data collected includes temperature, humidity, soil moisture levels, and flame detection, providing a comprehensive overview of the environmental conditions affecting crop growth.

To control the irrigation process, the system includes a relay and a motor pump. The soil moisture sensor continuously monitors the moisture level of the soil. When the moisture level drops below a predetermined threshold, the ESP8266 activates the relay, which in turn switches on the motor pump to irrigate the crops. Once the soil moisture level reaches the desired threshold, the ESP8266 deactivates the relay, turning off the motor pump and conserving water.

The incorporation of the DHT11 sensor allows for the monitoring of temperature and humidity, providing additional data to optimize the irrigation process. The flame sensor serves as a safety feature, detecting the presence of fire and potentially preventing damage to the crops and equipment. This system not only automates the irrigation process but also enhances water utilization efficiency by ensuring that irrigation occurs only when necessary, based on real-time soil moisture levels. The use of wireless data transmission enables remote monitoring and control, allowing farmers to manage their irrigation systems more effectively and with minimal manual intervention. Overall, the proposed system leverages IoT technology to create a more efficient, sustainable, and scalable solution for modern agriculture.

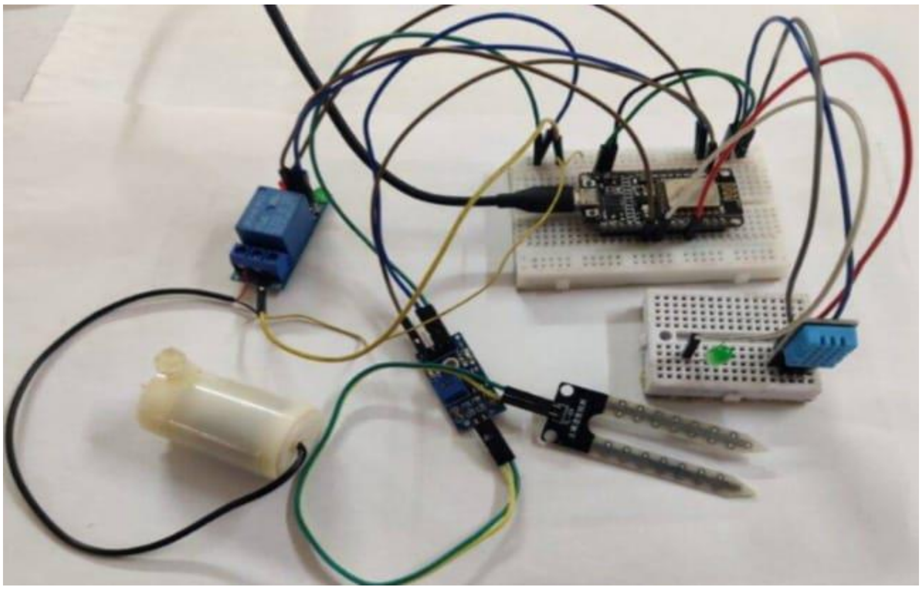

Fig.1. Proposed smart agricultural system - Agrisense

The system's operation illustrated through a simple flow chart is shown in the following figure.

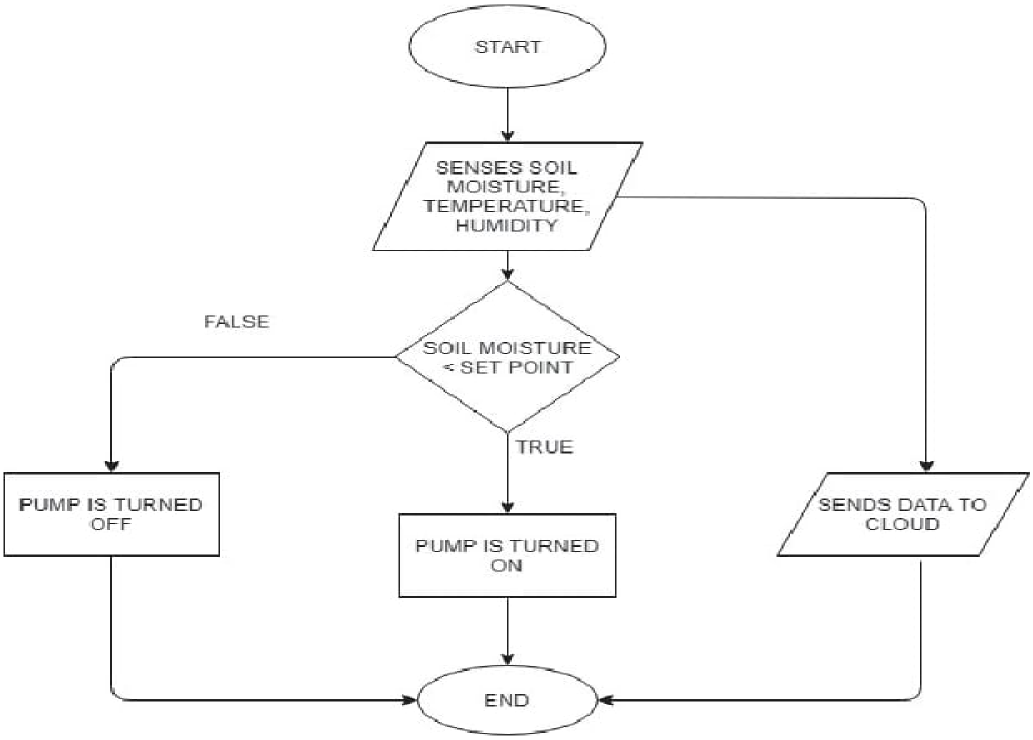

Fig.2. Flow Chart

By combining these components and leveraging the ESP8266's capabilities, our project provides an efficient solution to automate irrigation and ensures optimal plant growth.

IV. RESULT ANALYSIS

The IoT-enabled smart irrigation system demonstrated robust performance in monitoring key environmental parameters, including temperature, humidity, soil moisture, and flame levels. The data collected from these sensors was meticulously visualized using the ThingSpeak platform, providing a comprehensive view of the system's operational metrics.

The following figures illustrate the sensor data, offering a clear representation of the environmental conditions over time.

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a) b)

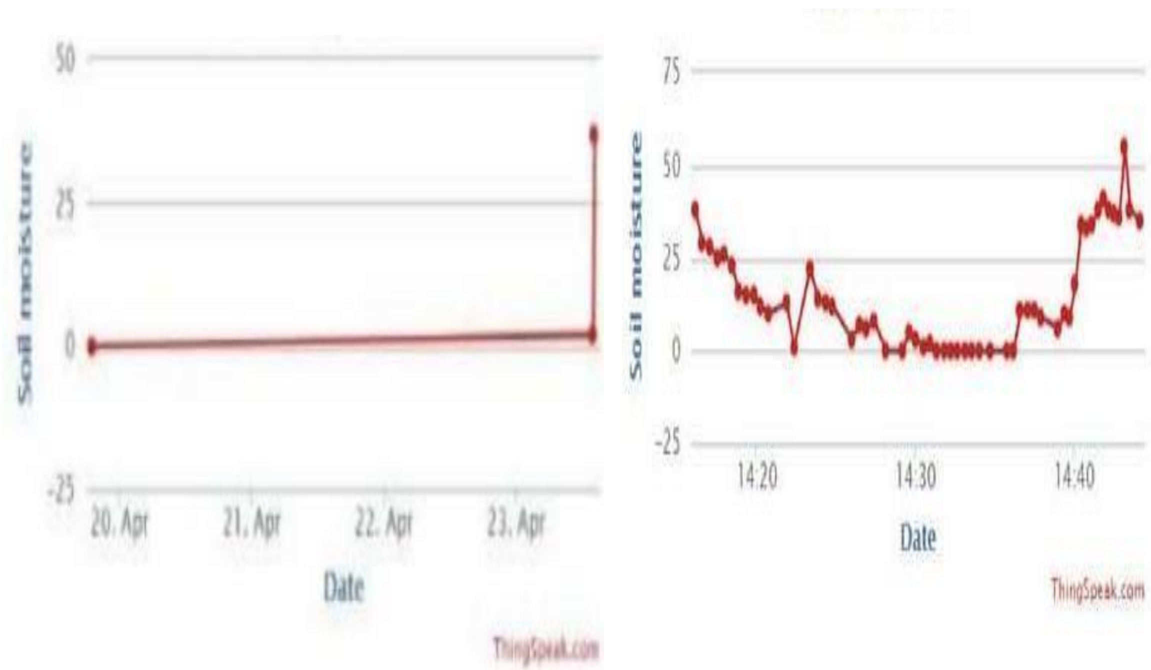

Fig.3. Representation of Soil Moisture Sensor data in ThingSpeak extracted during day time from a) Dry soil b) Wet soil.

a) b)

Fig.4. Representation of Soil Moisture Sensor data in ThingSpeak extracted during night time from a) Dry soil b) Wet soil.

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a) b)

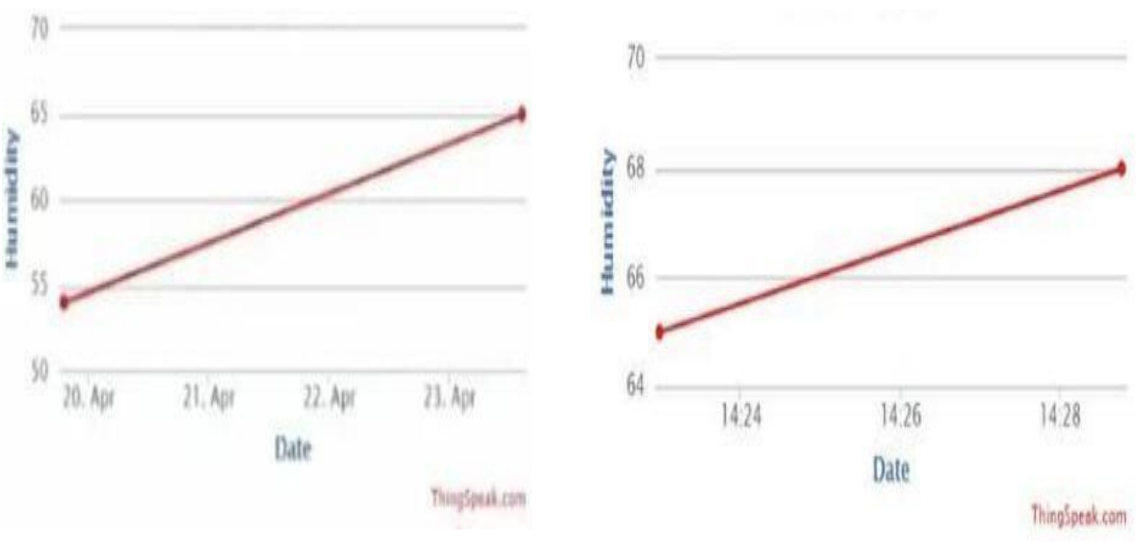

Fig.5. Representation of Humidity Sensor data in ThingSpeak extracted during day time from a) Dry soil b) Wet soil.

a) b)

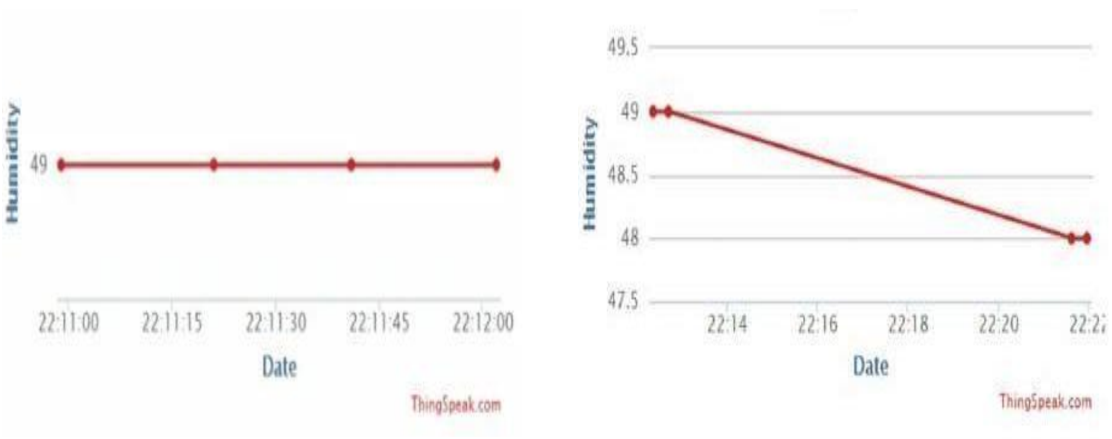

Fig.6. Representation of Humidity data in ThingSpeak extracted during night time from a) Dry soil b) Wet soil.

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a) b)

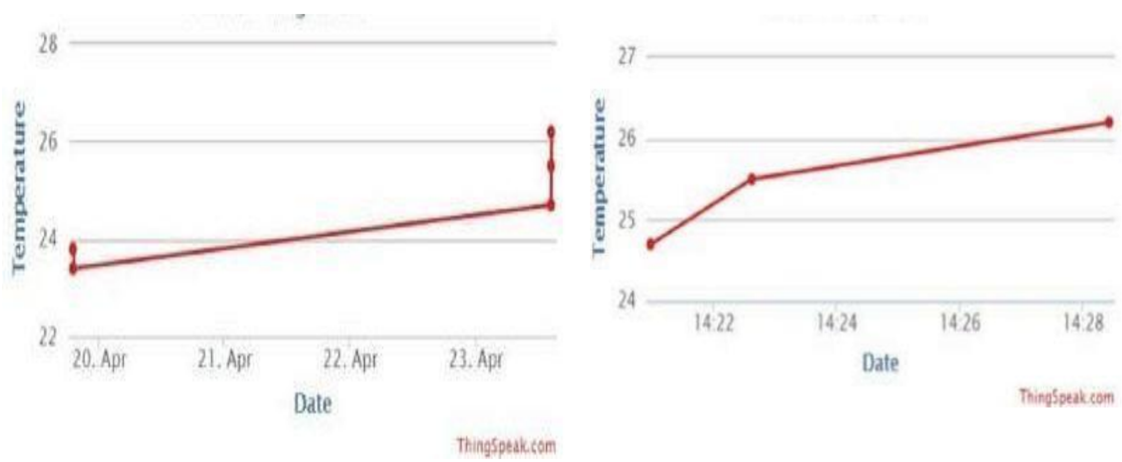

Fig.7. Representation of Temperature data in ThingSpeak extracted during day time from a) Dry soil b) Wet soil.

a) b)

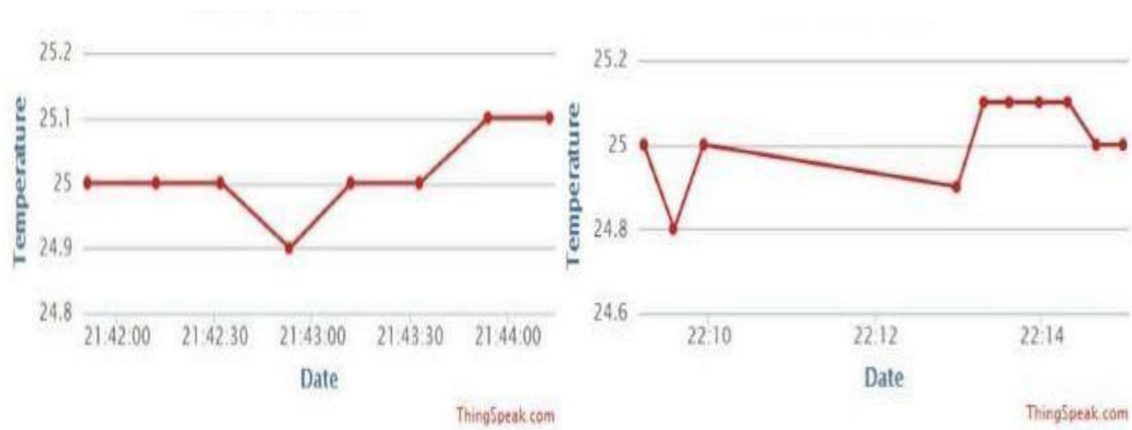

Fig.8. Representation of Temperature data in ThingSpeak extracted during day time from a) Dry soil b) Wet soil.

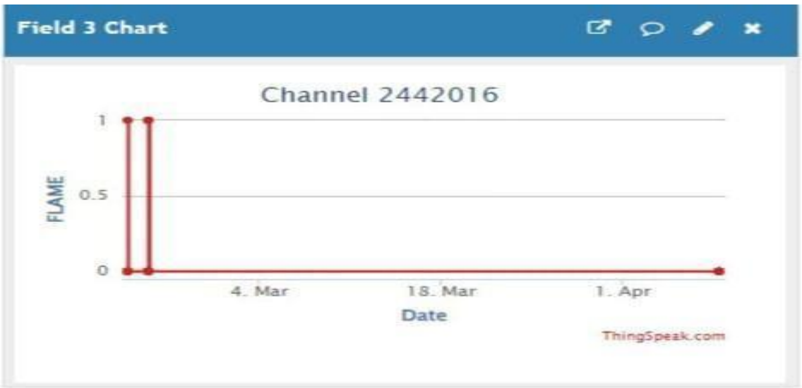

Fig.9. Representation of Flame sensor data.

The analysis of the sensor data reveals significant insights into the relationship between soil moisture levels and temperature variations. The data indicates a clear pattern where soil moisture levels tend to be lower during the daytime when temperatures are elevated. This trend suggests increased evaporation rates and reduced moisture retention during warmer periods. Conversely, at night, when temperatures drop, soil moisture levels rise, likely due to decreased evaporation and cooler temperatures allowing for better moisture retention.

These observations underscore the system's effectiveness in capturing and displaying critical environmental data. The ability to correlate soil moisture levels with temperature fluctuations demonstrates the system's capability to provide actionable insights for optimizing irrigation practices. By leveraging real-time data, the system enables more precise and responsive irrigation management, ultimately contributing to improved resource utilization and enhanced agricultural productivity.

The IoT-enabled smart irrigation system successfully monitored temperature, humidity, soil moisture and flame levels over time, presenting data-rich plots for analysis.

V. CONCLUSION

In this paper, we presented an IoT-enabled smart irrigation system designed to enhance water management through real-time monitoring and automation. By integrating sensors for temperature, humidity, soil moisture, and flame detection with the ESP8266 microcontroller and utilizing cloud platforms like ThingSpeak and Blynk Cloud, the system effectively provides a comprehensive solution for modern agricultural irrigation needs.

The analysis of the collected data demonstrated that the system is capable of accurately monitoring and responding to environmental changes. Specifically, it was observed that soil moisture levels decrease during the day when temperatures are higher and increase at night when temperatures drop. This ability to dynamically adjust irrigation based on real-time data ensures optimal soil conditions for crop growth while conserving water resources.

The successful implementation and performance of this system highlight its potential to significantly improve irrigation efficiency and sustainability. By leveraging IoT technology, the proposed system not only automates irrigation processes but also facilitates remote monitoring and control, reducing manual intervention and enhancing overall farm management. This work contributes to the advancement of smart agriculture technologies, offering a scalable and effective approach to meet the growing demands for efficient and sustainable farming practices.

VI. FUTURE SCOPE

The IoT-enabled smart irrigation system demonstrates significant potential for agricultural efficiency, with several opportunities for future enhancement. Future improvements could include integrating additional sensors to monitor more environmental factors, such as soil pH and light intensity, and incorporating machine learning for predictive analytics to optimize irrigation schedules. Expanding the system's scalability for various crops and agricultural settings, improving energy efficiency, and developing advanced user interfaces could further enhance its functionality. Additionally, integrating with other agricultural technologies, like drones, and conducting extensive field trials to refine the system would ensure its effectiveness and adaptability in diverse real-world scenarios.

REFERENCES

[1] S. H. Alsamhi, O. Ma, and Q. Shi, "A Survey of Indoor Greenhouse Farming Technology and Automation Systems," IEEE Access, vol. 8, pp. 126398-126421, 2020.

[2] Z. Li, J. Wang, R. Higgs, L. Zhou, and W. Yuan, "Design of an Intelligent Management System for Agricultural Greenhouses Based on the Internet of Things," Proc. IEEE Int. Conf. Computational Science and Engineering (CSE) and IEEE Int. Conf. Embedded and Ubiquitous Computing (EUC), Guangzhou, China, 2017, pp. 154-160.

[3] F. K. Shaikh, S. Karim, S. Zeadally, and J. Nebhen, "Recent Trends in Internet-of-Things-Enabled Sensor Technologies for Smart Agriculture," IEEE Internet Things J., vol. 9, no. 23, pp. 23583-23598, Dec. 2022.

[4] Z. Wan, Y. Song, and Z. Cao, "Environment Dynamic Monitoring and Remote Control of Greenhouse with ESP8266 NodeMCU," Proc. IEEE 3rd Inf. Technol., Netw., Electron. Autom. Control Conf. (ITNEC), Mar. 2019, pp. 377-382.

[5] N. Sales, O. Remdios, and A. Arsenio, "Wireless Sensor and Actuator System for Smart Irrigation on the Cloud," IEEE 2nd World Forum Internet Things, 2015.

[6] I. Mat, M. R. M. Kassim, and A. N. Harun, "Precision Agriculture Applications Using Wireless Moisture Sensor Network," Proc. IEEE 12th Malaysia Int. Conf. Communications (MICC), 2015.

[7] M. S. Mekala and P. Viswanathan, "A Survey: Smart Agriculture IoT with Cloud Computing," Proc. Int. Conf. Microelectronic Devices, Circuits and Systems (ICMDCS), 2017.

[8] G. Londhe and S. G. Galande, "Automated Irrigation System by Using ARM Processor," Int. J. Sci. Res. Eng. Technol. (IJSRET), vol. 3, no. 2, May 2014.

[9] D. Selvath, S. Salivahanan, G. Indumathi, K. R. Vijay Kumar, and S. Thamaraiselvi, "Fuzzy Logic Based Intelligent Control for Irrigation System," IETE Tech. Rev., vol. 20, pp. 199-203, 2003.

[10] S. K. Jha, "Need for an Orchestration Platform to Unlock the Potential of Remote Sensing Data for Agriculture," in Digital Ecosystem for Innovation in Agriculture, Cham, Switzerland: Springer, 2023, pp. 61-73.

[11] M. Mahbub, "A Smart Farming Concept Based on Smart Embedded Electronics, Internet of Things, and Wireless Sensor Network," Internet Things, vol. 9, p. 100161, 2020.

[12] J. L. Avinash, K. N. S. Kumar, G. B. A. Kumar, G. R. Poornima, R. Gatti, and S. S. Kumar, "A Wireless Sensor Network-Based Precision Agriculture," Proc. Int. Conf. Recent Trends Electron., Inf., Commun. Technol. (RTEICT), Nov. 2020, pp. 413-417.

[13] N. A. M. Leh, M. S. A. M. Kamaldin, Z. Muhammad, and N. A. Kamarzaman, "Smart Irrigation System Using Internet of Things," Proc. 2019 Int. Conf. Software Engineering and Technology (ICSET), Shah Alam, Malaysia, 2019, pp. 96-101.

[14] H. Sundmaeker, et al., "Vision and Challenges for Realizing the Internet of Things," Cluster of European Research Projects on the Internet of Things (CERPIoT), 2010.