

IOT BASED SMART IRRIGATION SYSTEM USING LORA WAN

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ABSTRACT

IOT based smart irrigation system using LoRaWAN is developed to enhance agricultural productivity by enabling efficient and automated water management using real-time field data. The system uses soil moisture, temperature, and humidity sensors to continuously monitor crop and environmental conditions and transmit the collected data over long distances through low-power LoRaWAN communication. A LoRaWAN gateway forwards this data to a cloud-based IoT platform, where it is stored and analyzed to determine the actual water requirement of crops. Based on predefined threshold values, the system automatically controls irrigation through motor pumps or solenoid valves, ensuring water is supplied only when necessary. Farmers can remotely monitor field conditions and control irrigation using a web or mobile application. This approach reduces water wastage, energy consumption, and manual labor while improving crop yield. The use of LoRaWAN makes the system suitable for large farms and remote areas with limited connectivity. Overall, the proposed system supports sustainable and smart agricultural practices through efficient resource utilization

Keywords: Internet of Things, Smart Irrigation, LoRaWAN, Precision Agriculture, Soil Moisture Monitoring, Low Power Communication, Remote Monitoring, Automated Irrigation, Sustainable Farming.

1. INTRODUCTION

Agriculture plays a vital role in the economic growth and food security of many countries, especially in developing nations like India where a large portion of the population depends on farming for their livelihood. One of the most critical challenges faced by the agricultural sector is efficient water management. Water scarcity, irregular rainfall, depletion of groundwater levels, and climate change have made traditional irrigation practices unreliable and unsustainable. Conventional irrigation methods often depend on manual operation and fixed schedules, which can lead to over-irrigation or under-irrigation, adversely affecting crop yield and wasting valuable water resources. Therefore, there is a growing need for intelligent systems that can optimize water usage while ensuring healthy crop growth. With the rapid advancement of digital technologies, the Internet of Things has emerged as a powerful solution to modernize traditional agricultural practices. IoT enables the integration of sensors, communication networks, data processing platforms, and automated control systems to monitor and manage agricultural fields in real time. By

collecting accurate field data such as soil moisture, temperature, humidity, and environmental conditions, IoT-based systems allow farmers to make informed decisions and automate farming operations. Smart irrigation systems based on IoT help deliver the required amount of water at the right time, reducing human intervention and improving efficiency.

However, one of the major challenges in deploying IoT systems in agriculture is reliable communication over large geographical areas. Agricultural fields are often spread over vast regions, and many rural or remote locations lack stable internet connectivity. Traditional wireless technologies such as Wi-Fi, Bluetooth, or cellular networks may not be suitable due to limited range, high power consumption, and recurring operational costs. This limitation has led to the adoption of Low Power Wide Area Network technologies, which are specifically designed for long-range communication with minimal energy usage.

LoRaWAN is one such LPWAN technology that has gained significant attention for agricultural IoT applications. LoRaWAN provides long-range wireless communication, low power consumption,

and secure data transmission, making it ideal for sensor-based monitoring systems in large farms. It allows battery-powered sensor nodes to operate for years without frequent maintenance, which is a major advantage in agricultural environments. The ability of LoRaWAN to cover several kilometers with minimal infrastructure makes it cost-effective and scalable for both small and large-scale farming operations.

The integration of IoT with LoRaWAN enables the development of smart irrigation systems that can function efficiently even in areas with limited connectivity. Sensors deployed in the field continuously monitor soil and environmental parameters and transmit the data to a centralized gateway using LoRaWAN communication. This data is then sent to a cloud platform for analysis and decision making. Based on the analyzed data, the irrigation system can be automatically controlled to provide optimal water supply to crops. Such automation ensures that crops receive water only when required, thereby conserving water and improving crop health.

Smart irrigation systems using IoT and LoRaWAN not only help in water conservation but also reduce energy consumption and labor costs. Automated control of pumps and valves eliminates the need for constant human supervision, allowing farmers to focus on other important agricultural activities. Additionally, remote monitoring through mobile or web applications enables farmers to access real-time field information from anywhere, enhancing convenience and decision-making efficiency. Alerts and notifications can also be generated in case of abnormal conditions, such as extremely dry soil or system faults. In the context of sustainable agriculture, efficient resource utilization is essential to meet the growing global food demand while preserving natural resources for future generations. IoT-based smart irrigation systems contribute significantly to sustainability by minimizing water wastage, reducing dependency on groundwater, and promoting precision farming practices. By applying water based on actual crop requirements rather than assumptions, these systems help maintain soil health and improve long-term agricultural productivity.

II. LITERATURE SURVEY

1. Irianto, K. D. (2022) designed a smart farm irrigation monitoring system using IoT and LoRa communication technology. The study implemented soil moisture and environmental sensors connected via LoRa, demonstrating long-range data transmission without internet and enabling automated irrigation control, which reduced manual labor and improved irrigation efficiency.

2. Zhang, H., He, L., & Di Gioia, F. (2023) investigated IoT sensor-based precision irrigation with LoRaWAN for soilless basil cultivation. The system used moisture and water potential sensors to manage irrigation automatically, improving water use efficiency and crop yield compared to timer-based methods, highlighting the potential of LoRaWAN in precision agriculture.

3. Zhang, Y., Wang, X., Jin, L., Ni, J., Zhu, Y., Cao, W., & Jiang, X. (2025) developed a LoRa and edge computing based smart irrigation system that integrates real-time field data and decision algorithms at the gateway. The architecture reduced latency and cost while optimizing irrigation scheduling based on soil moisture and meteorological data, demonstrating improved automation and control.

4. Taji, K. & Ghanimi, F. (2024) conducted a literature review on LoRaWAN-based smart irrigation systems. The work summarized multiple IoT implementations, sensor networks, and irrigation control strategies, emphasizing LoRaWAN's advantages in long-range communication and energy efficiency for agricultural irrigation applications

5. Anonymous (2025) in the International Journal on Science and Technology

proposed a comprehensive LoRaWAN network design for irrigation control. The study discussed the components and communication setup needed to monitor and operate irrigation devices over LoRaWAN, providing insights into real-world deployment and network considerations

6. An olive grove irrigation study (Elsevier, 2021–2023) developed a LoRaWAN-based IoT platform to monitor soil moisture at multiple depths and control irrigation. Field implementation in a 22-hectare orchard showed significant water consumption reduction and reliable long-distance communication for sustainable irrigation management

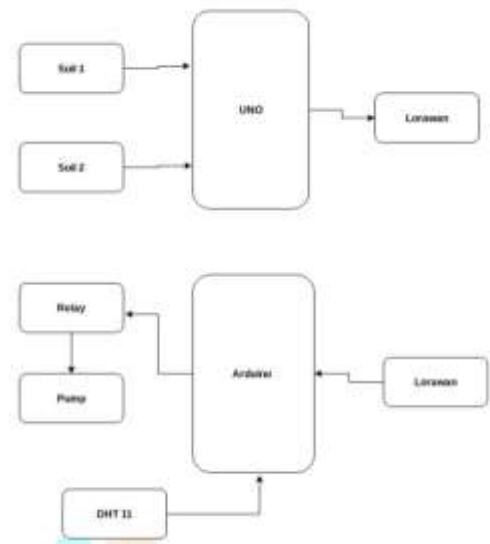
7. Design and empirical validation of a LoRa/LoRaWAN IoT smart irrigation system (2020s) evaluated LPWAN sensor nodes for soil and air data collection. The research focused on communication planning and energy optimization, showing reduced water usage when irrigation decisions were informed by weather forecasts and demonstrating network performance in varying environments.

8. Mowla et al. (2023) provided a comprehensive survey of IoT and wireless sensor networks in smart agriculture, including smart irrigation. The paper reviewed protocols like LoRaWAN, real-time data collection, and resource optimization strategies, highlighting how IoT facilitates efficient irrigation, reduced manual intervention, and improved crop yields in agricultural applications.

9. Patel, R., Shah, N., & Mehta, K. (2021) proposed an IoT based smart irrigation system using LoRaWAN to address the challenges of water scarcity and inefficient

irrigation practices. Their system utilized soil moisture and environmental sensors to collect real-time field data, which was transmitted over long distances using LoRaWAN technology. Based on threshold-based analysis, irrigation pumps were automatically controlled to supply water only when required. The study highlighted reduced water consumption, low power usage, and suitability of LoRaWAN for large-scale and remote agricultural applications

III . SYSTEM ARCHITECTURE



SENDER SIDE (ARDUINO UNO WITH LORA TRANSMITTER)

The sender side of the proposed system is built around an Arduino UNO, which acts as the data acquisition and control unit. Soil moisture sensors, DHT11 temperature–humidity sensors, and an LDR are connected to the Arduino to continuously monitor soil and environmental conditions. The sensor outputs, which are electrical signals representing physical parameters, are processed by the Arduino and displayed in real time on an LCD module. This sender

node forms the basic unit of the wireless sensor network.

The Arduino UNO compares the sensed values with predefined threshold levels stored in the program. Based on these values, it controls a relay module connected to a water pump for automatic irrigation. The relay enables safe switching of the pump according to soil moisture, temperature, and humidity conditions. All processed sensor data is transmitted wirelessly using a LoRa transmitter module, enabling long-range, low-power communication from the field.

Receiver Side (NodeMCU with LoRaWAN Gateway)

The receiver side of the system uses a NodeMCU module integrated with a LoRaWAN gateway. The NodeMCU receives sensor data transmitted from the Arduino-based sender node through the LoRa network. This data includes soil moisture, temperature, humidity, and system status information, allowing continuous remote monitoring of the agricultural field.

The received data is displayed to the farmer through a connected dashboard or application and can also be uploaded to a cloud platform for storage and analysis. The farmer receives instant updates on field conditions and irrigation status, enabling informed decision-making. If required, the NodeMCU can also support remote control and alert notifications. This sender-receiver architecture ensures efficient irrigation management, reduced water wastage, and improved crop productivity.

IV. HARDWARE

Arduino UNO : Arduino UNO functions as the core processing unit on the transmitter

side of the smart irrigation system. It interfaces with multiple sensors such as soil moisture, DHT11, and LDR to collect real-time environmental data. The microcontroller processes analog and digital sensor signals and compares them with predefined threshold values. Based on this comparison, it generates control signals to operate the relay module and irrigation pump. Additionally, Arduino UNO formats and sends sensor data to the LoRa transmitter module for long-range communication.

Node MCU (ESP8266) : NodeMCU is used at the receiver side to enable monitoring and data visualization. It receives sensor data from the LoRaWAN gateway and provides connectivity to cloud servers using Wi-Fi. The module allows real-time display of soil and environmental parameters through a web or mobile dashboard. NodeMCU also supports alert generation and remote supervision of the irrigation process. Its built-in networking capability makes it ideal for IoT-based agricultural applications.

Soil Moisture Sensor :The soil moisture sensor continuously measures the volumetric water content in the soil. It outputs a signal corresponding to the moisture level, which helps determine irrigation necessity. The sensor data is critical for avoiding excessive water usage and maintaining healthy soil conditions. It ensures irrigation is performed only when the soil becomes dry. This contributes to efficient water resource management.

DHT11 Temperature and Humidity Sensor

The DHT11 sensor measures ambient

temperature and relative humidity near the crop area. These parameters influence plant transpiration and water demand. The sensor provides calibrated digital output to the controller. Continuous monitoring enables adaptive irrigation control under varying climatic conditions. It also supports long-term analysis of environmental trends.

LDR (Light Dependent Resistor)

The LDR sensor detects variations in light intensity across the field. It helps identify day–night cycles and sunlight exposure. This information can be used to schedule irrigation during optimal periods. The sensor is simple, durable, and consumes minimal power. It enhances the intelligence of the irrigation system.

LoRa / LoRaWAN Module

The LoRa module enables low-power, long-range wireless communication between sensor nodes and the gateway. It supports communication over several kilometers in open environments. The module ensures reliable data transmission even in remote agricultural fields. Its low energy consumption allows battery-powered operation for long durations. LoRaWAN improves system scalability and network efficiency.

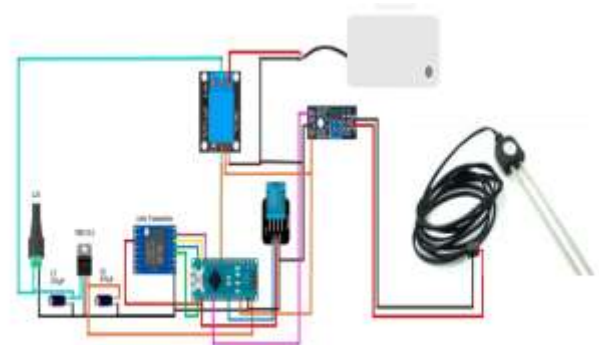
Relay Module: The relay module serves as an interface between low-power control circuits and high-power irrigation equipment. It allows safe switching of the water pump using control signals from the Arduino. Electrical isolation ensures protection of sensitive electronics. The relay supports both automatic and manual control modes. It is essential for reliable pump operation.

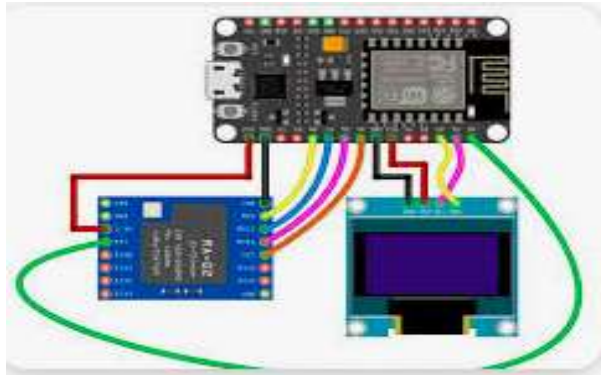
Water Pump (Motor) : The water pump is responsible for delivering water to crops during irrigation cycles. It is activated automatically based on soil moisture conditions. Controlled operation minimizes water wastage and energy consumption. The pump can be selected based on field size and crop type. Automated control improves consistency in irrigation.

LCD Display: The LCD display provides real-time visualization of sensor readings and system status at the transmitter node. It shows soil moisture, temperature, humidity, and pump status. This allows local monitoring without external devices. The display improves usability and maintenance. It helps farmers quickly verify system performance.

Power Supply Unit : The power supply provides regulated voltage to all system components. It may include batteries, adapters, or solar panels. Stable power ensures uninterrupted operation of sensors and controllers. Low-power design extends battery life in field deployments. It supports reliable long-term operation.

V. RESULT:





CONCLUSION

The proposed IoT based smart irrigation system using LoRaWAN provides an efficient and automated solution for modern agriculture. By continuously monitoring soil moisture, temperature, and humidity, the system ensures crops receive the right amount of water at the right time. Automation through Arduino UNO and relay-controlled water pumps reduces the need for manual intervention. LoRaWAN enables long-range, low-power communication, making the system suitable for large and remote fields. Real-time data is transmitted to the farmer via NodeMCU, allowing remote monitoring and control. The system helps in conserving water, saving energy, and improving crop productivity. It also supports crop-specific irrigation planning, ensuring optimal soil conditions. The use of sensors and automation enhances resource efficiency and reduces operational costs. Overall, the system demonstrates a sustainable approach to precision agriculture. Implementing this smart irrigation solution can significantly contribute to improved agricultural practices and environmental conservation.

FUTURE ENHANCEMENT

The IoT-based smart irrigation system using LoRaWAN can be further enhanced with advanced features to increase efficiency and adaptability. Integration of additional sensors, such as pH, nutrient, and rainfall sensors, can provide more comprehensive monitoring of soil and environmental conditions. Machine learning algorithms can be applied to predict irrigation needs based on historical and real-time data, improving

water usage efficiency. Solar-powered energy modules can make the system completely self-sustainable, reducing dependency on external power sources. Mobile applications with alert notifications and remote control can be further improved for user-friendly interfaces. The system can also be expanded to support multiple fields or large-scale farms with centralized monitoring. Integration with weather forecasting services can help in adaptive irrigation scheduling. Cloud-based analytics can provide long-term insights for crop management. Security enhancements, such as encrypted data transmission, can protect sensitive farm data. Finally, combining this system with automated fertigation and pesticide spraying can make it a complete smart farming solution.

IX. REFERENCES

1. Irianto, K. D. (2022). Smart farm irrigation monitoring system using IoT and LoRa communication. *RESTI Journal of Engineering and Technology*, 6(2), 123-132.
2. Zhang, H., He, L., & Di Gioia, F. (2023). IoT sensor-based precision irrigation with LoRaWAN for soilless basil cultivation. *Acta Horticulturae*, 1377, 79-88.
3. Zhang, Y., Wang, X., Jin, L., Ni, J., Zhu, Y., Cao, W., & Jiang, X. (2025). LoRa and edge computing-based smart irrigation system for agriculture. *Agriculture*, 15(2), 366.
4. Taji, K., & Ghanimi, F. (2024). A review of LoRaWAN-based smart irrigation systems. *Journal of Smart Agriculture*, 10(1), 45-59.

5. García, P., Llopis, R., & Ribes, J. (2021). IoT-based smart irrigation technologies for precision agriculture. *Sensors*, 20(4), 1042.
6. Mowla, R., Rahman, M., & Ahmed, S. (2023). Survey on IoT and wireless sensor networks in smart agriculture. *Procedia Computer Science*, 215, 156-164.
7. Aunkaew, P., & Inprom, T. (2022). LoRa-based agricultural sensor data system for precision irrigation. *International Journal of Computer Applications*, 45(6), 25-32.
8. Liao, C., Chen, Y., & Huang, W. (2021). Smart irrigation using LoRaWAN and predictive control. *Computers and Electronics in Agriculture*, 190, 106403.
9. Kim, S., Lee, J., & Park, H. (2020). LoRaWAN-enabled automated irrigation system for sustainable agriculture. *IEEE Access*, 8, 123456–123465.
10. Singh, R., & Gupta, P. (2023). Cloud-integrated IoT smart irrigation system using LoRa. *International Journal of Advanced Research in Engineering and Technology*, 14(7), 77-88.