LoRa Based Water Management & Motor Control System

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Abstract—This system aims to design and develop a Lo-Ra-based Smart Water Management and Motor Control System that monitors essential water parameters such as water level and pH value. The primary objective is to ensure efficient utilization of water resources in agriculture, industries, and residential setups through real-time monitoring and automated motor control. The proposed system consists of sensor nodes integrated with a micro-controller and Lo-Ra transceiver for long-range, low-power communication. Data collected from the sensors is transmitted to a central gateway, where it is processed to make irrigation or water supply decisions. A relay-based motor driver controls the water pump automatically when sensor thresholds are reached, while a mobile/web dashboard allows for remote monitoring and manual override. The methodology includes sensor calibration, Lo-Ra communication setup, system integration, and prototype testing. Expected outcomes include accurate sensing of water parameters, reliable long-distance data transmission, and automated motor operation that reduces manual effort and water wastage. The significance of this project lies in its low-cost, scalable, and sustainable solution for water management. It directly addresses the challenges of water scarcity, improves crop productivity, and supports smart city and agricultural applications by promoting efficient and intelligent resource management.

I. INTRODUCTION

Water is one of the most valuable natural resources and plays a vital role in agriculture, industry, and domestic usage. With increasing population, urbanization, and climate change, water scarcity has become a pressing global issue. Inefficient irrigation practices, lack of real-time monitoring, and excessive water wastage are major challenges that directly impact crop productivity, industrial processes, and household water supply systems. Currently, most irrigation and water management systems are either manually operated or rely on conventional wireless technologies such as GSM or Wi- Fi. While these systems provide some level of automation, they are often expensive, consume high power, and suffer from limited coverage, especially in rural or remote areas. Traditional water monitoring solutions also tend to focus on a single parameter such as soil moisture or water level, without integrating multiple water-quality and soil-related factors together. This limits their effectiveness in sustainable water resource management. Recent advancements in the Internet of Things (IoT) and low-power wide-area networks (LPWANs), particularly

LoRa(Long Range Radio) technology, provide a promising solution to these limitations. LoRa enables low-power, long-range, and cost-effective communication, making it highly suitable for agriculture, smart cities, and environmental monitoring applications. By integrating multiple sensors such as soil moisture, pH, and water level with LoRa communication and automated motor control, it is possible to achieve efficient, real-time, and intelligent water management.

II. MOTIVATION

The motivation behind choosing this system is to develop a sustainable, scalable, and affordable solution that addresses the shortcomings of current systems. By providing farmers, industries, and households with a reliable tool for water monitoring and automated control, this system aims to reduce water wastage, improve crop productivity, and contribute to long-term water conservation. Moreover, the system aligns with global initiatives such as the United Nations Sustainable Development Goals (SDG 6: Clean Water and Sanitation, SDG 12: Responsible Consumption and Production), making it both technologically relevant and socially impactful.

III. PROBLEM STATEMENT

Water management in agricultural fields, residential water tanks, and industrial water systems is still largely performed manually, leading to excessive water wastage, inefficient motor operation, and delayed monitoring of important water quality parameters. Traditional systems also face limitations in long-distance communication, especially in remote areas where internet connectivity is weak or unavailable. Continuous manual checking of water level, soil moisture, and water quality increases human effort and may result in motor dry running, overflow conditions, and poor water resource utilization.

To overcome these problems, there is a need for an intelligent, low-power, and long-range monitoring system that can remotely monitor water parameters and automatically control water pumps and motors. The proposed LoRa-Based Smart Water Management and Motor Control System uses LoRa wireless communication technology along with sensors such as water level, soil moisture, and pH sensors to provide real-time monitoring and automatic motor control. The system aims to reduce water wastage, improve irrigation efficiency, minimize human intervention, and provide reliable long-distance communication with low power consumption.

IV. LITERATURE REVIEW

1. Patel et al. (2025) - "LoRa-Based Smart Agriculture Monitoring and Automatic Irrigation System". Objective: Propose and validate a LoRa-based monitoring and automatic irrigation prototype for rural agriculture.
2. Liopa-Tsakalidi et al. (2024) - "A LoRaWAN-based IoT platform for smart irrigation in olive groves". Objective: Deploy and evaluate a LoRaWAN irrigation platform over a 22-hectare olive grove to study operational scalability.
3. Forhad et al. (2024) - "IoT based real-time water quality monitoringsystem in water treatment plants". Objective: Design an IoT system for continuous water quality monitoring (pH, turbidity) in a water treatment context.
4. Research Gate - "IoT-Based Real-Time Water Quality Monitoring & Sensor Calibration" (2024/2025) Objective: Improve accuracy and reliability of IoT water quality systems via calibration workflows.
5. Xu et al. (2025) - " Experimental Study on Propagation Characteristics of 433 MHz LoRa in Maize Fields".
6. Zeta et al. (2025, PMC article) - "A Low-Cost pH Sensor for Real-Time Monitoring (with temp compensation)". Objective: Develop an affordable pH sensor module with temperature compensation and ML based correction for field use.

V. OBJECTIVE

The objectives of the proposed system is as follows:

- To monitor water levels in tanks and reservoirs
- remotely
- To control water pumps (motors) from a distance
- To prevent water overflow and wastage
- To automate motor operation based on water levels
- To provide real-time status updates of the system
- To enable long-range communication using LoRa
- To reduce manual effort in water management
- To ensure low power consumption for remote deployment

VI. PROPOSED SYSTEM

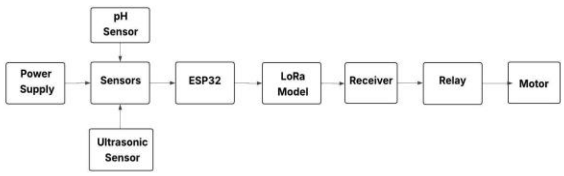


Fig.1 System overview of the proposed system

1.Power Supply

The power supply unit provides the necessary electrical energy to all system components such as sensors, ESP32 microcontroller, LoRa module, and relay. It ensures a stable DC voltage (typically 3.3V to 5V) for proper operation of the circuit.

2.Sensors Unit

This unit consists of two main sensors:

i)Ultrasonic Sensor:

Measures the water level in the tank by calculating the distance between the sensor and the water Surface using ultrasonic waves. This helps determine whether the tank is full, half, or empty.

ii)pH Sensor:

Monitors the quality of water by measuring its pH value. This ensures the water is suitable for use Both sensors send their data to the ESP32 microcontroller for processing.

3.ESP32 Microcontroller

The ESP32 acts as the central processing unit of the system. It receives analog or digital data from the sensors, processes the readings, and prepares the data to be transmitted wirelessly. It also makes control decisions based on programmed conditions such as when to start or stop the motor.

4.LoRa Module (Transmitter)

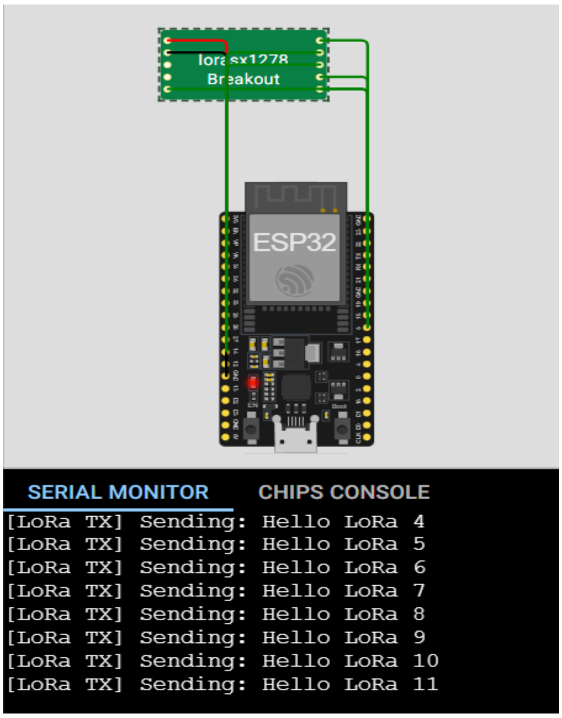
The LoRa (Long Range) module connected to the ESP32 transmits the processed sensor data over long distances using low-power wireless communication. LoRa technology enables the system to work efficiently in remote or rural areas where Wi-Fi or GSM connectivity may be limited.

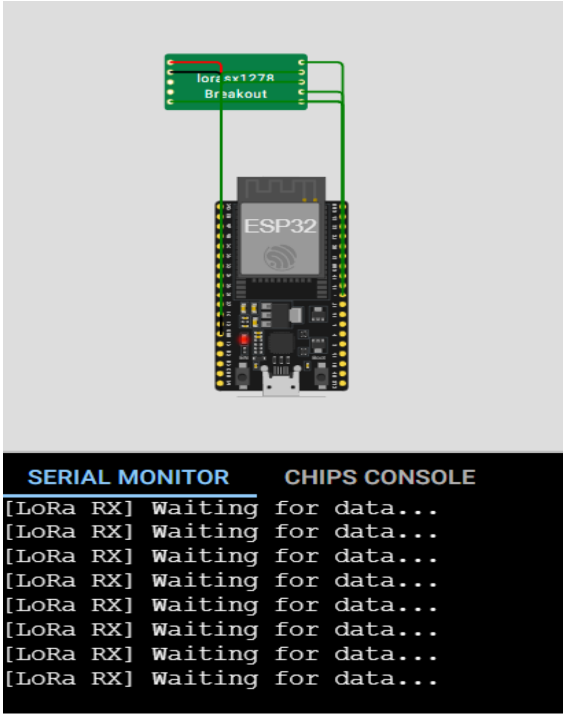
5.LoRa Receiver

The receiver module is placed at the control station or monitoring end. It receives the data sent by the LoRa transmitter and provides the information to the control system (for example, a display, dashboard, or microcontroller). This allows users to monitor water level and pH remotely.

6.Relay

The relay acts as an electronic switch that controls the motor operation based on commands from the receiver or ESP32. When the water level drops below a set limit, the relay activates the motor; when the tank is full, it automatically turns off the motor.





7.Motor

The motor (typically a water pump) is responsible for pumping water to the tank or irrigation area. It is controlled automatically through the relay circuit to maintain optimal water levels without human intervention.

VII. RESULTs AND DISCUSSION

The developed LoRa communication system using the ESP32 microcontroller and SX1278 LoRa module was successfully implemented and tested. The transmitter node continuously transmitted text data packets in the format “Hello LoRa” with incrementing numbers through LoRa wireless communication. The serial monitor of the transmitter displayed successful packet transmission messages such as:

- “Sending: Hello LoRa 4”
- “Sending: Hello LoRa 5”
- “Sending: Hello LoRa 6”

This confirms that the ESP32 transmitter node correctly initialized the SX1262 module and transmitted data packets at regular intervals.

At the receiver side, the ESP32 with SX1262 module continuously monitored incoming packets. The serial monitor displayed the status message “Waiting for data…”, indicating that the receiver node was successfully initialized and operating in listening mode for LoRa communication.

The experimental setup verified successful hardware interfacing between the ESP32 and SX1262 LoRa module using SPI communication protocol. The modules operated with low power consumption and demonstrated stable wireless transmission capability suitable for long-range monitoring applications

The obtained results demonstrate that the proposed LoRa-based wireless communication system can be effectively used for smart water management and motor control applications. The transmitter node was able to send sensor or control data wirelessly over LoRa communication, while the receiver node continuously remained in receive mode for monitoring incoming packets.

The use of the SX1262 LoRa module provides several advantages compared to conventional wireless technologies such as Wi-Fi and Bluetooth:

- Long communication range
- Low power consumption
- Better signal penetration in rural and remote environments
- Reliable data transmission for IoT applications

The successful transmission of sequential "Hello LoRa" packets confirms proper SPI interfacing between ESP32 and SX1262 modules. The receiver continuously waiting for packets indicates that the receiver initialization and synchronization process worked correctly.

During testing, it was observed that:

- Proper pin configuration is essential for successful communication.
- Matching frequency settings on transmitter and receiver are required.
- Stable power supply improves LoRa module performance.
- Communication can occur at short distance even without antenna during testing, but antenna is necessary for long-range practical deployment.

Thus, the proposed system provides a reliable and cost-effective solution for smart irrigation, water tank monitoring, and remote motor control applications using LoRa technology.

VIII. SCOPE

The scope of a LoRa-based water management and motor control system includes the remote monitoring and control of water resources over long distances using low-power communication technology. The system is designed to measure water levels in tanks, wells, or reservoirs and automatically or manually control water pumps based on real-time data. It helps prevent water overflow and dry running of motors, thereby improving efficiency and reducing wastage. The solution is particularly suitable for rural, and large-scale areas where conventional communication networks are limited. It also supports real-time alerts, data logging, and integration with IoT platforms for better monitoring and analysis. Additionally, the system is scalable and can be expanded to manage multiple tanks and pumps, making it applicable for residential and industrial water management systems.

IX. CONCLUSION

The proposed Lo-Ra-based Smart Water Management and Motor Control System presents a sustainableand innovative solution to the challenges of water scarcity, inefficient irrigation, and resource mismanagement. By integrating water level sensors with Lo- Ra-based longrange, low-power communication, the system enables reliable real-time monitoring and automated pump control. This ensures optimum water utilization, reduces wastage, and enhances productivity in agricultural, residential, and industrial applications.

Compared to conventional GSM- or Wi-Fi-based systems, the use of Lo-Ra technology offers clear advantages in terms of coverage and cost-effectiveness, making it particularly suitable for rural and remote areas. The prototype also incorporates a user-friendly IoT dashboard, allowing both automated operation and manual override, thereby enhancing flexibility and usability.

In conclusion, this system is expected to contribute significantly toward smart cities, and sustainable water resource management. It not only provides a technical solution but also aligns with global sustainability goals, making it both technologically relevant and socially impactful.

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