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Smart Domestic Water Tank Filling System using Free Weather API, ESP8266 and Pump Controller

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Abstract
In rural areas, domestic water tank systems typically operate using automated controllers that activate water pumps when the tank is empty. However, during extreme climatic events such as cyclones or storms, prolonged power outages can disrupt the pumping process, leading to severe water crises for households. To address this issue, we propose a Smart Domestic Water Tank Filling System that integrates an ESP8266 microcontroller with internet connectivity and Free Weather API-based weather forecasting. The system periodically retrieves real-time weather data and analyzes forecasts for impending storms or cyclones. Upon detecting adverse weather conditions, the system proactively triggers the water pump at predefined intervals to ensure the tank remains filled before a power failure occurs. This intelligent approach enhances water availability and resilience against unforeseen climatic disruptions. The proposed system improves household water security and optimizes water resource management by making informed pumping decisions based on weather predictions. Through this innovation, rural communities can mitigate the challenges posed by erratic power supply and extreme weather conditions, ensuring a continuous and reliable water supply during emergencies.

Keywords: Smart Water Tank, Free Weather API, Water Management, Weather Forecasting, IoT, Rural Water Security, Climate Resilience.

Introduction
Access to a reliable water supply is fundamental for households, particularly in rural areas where domestic water tank systems are widely used. These systems are typically automated to activate a pump when the tank water level falls below a predefined threshold. However, frequent power outages can prevent the pump from operating during extreme climatic conditions such as cyclones and storms, leading to critical water shortages. The unpredictable weather events exacerbate the problem, making it difficult for families to store an adequate water supply in advance.

We propose a Smart Domestic Water Tank Filling System that integrates an ESP8266 microcontroller with internet connectivity and weather forecasting capabilities using the OpenWeather API to address this challenge. The system continuously monitors weather conditions and identifies potential storms or cyclones in advance. If an adverse weather event is forecasted, the system initiates proactive water pumping regularly, ensuring the tank is filled before a power outage occurs. This predictive approach enhances water security and resilience, enabling rural households to mitigate the impact of unexpected disruptions in their water supply.

This paper explores the design and implementation of this smart water tank system, highlighting its benefits regarding water resource management, IoT integration, and climate resilience. By leveraging real-time weather data, the proposed system optimizes water availability. It minimizes the risks associated with sudden weather changes, ensuring a more reliable and sustainable solution for rural communities.

Literature Review
The growing concern of water security in rural areas has led researchers to explore smart solutions for water management. Ahmed and Patel (2023) provided an extensive review on smart water management systems, emphasizing the role of IoT in automating water

conservation practices. Similarly, Baker and Thomas (2021) highlighted the importance of IoT-driven solutions in achieving sustainable water resource management, advocating for real-time data collection to optimize efficiency. Machine learning has been integrated into smart agricultural practices, with Chen and Rodriguez (2020) demonstrating its effectiveness in weather prediction for optimizing water usage. Further, Davies and Kumar (2019) examined the impacts of climate change on rural water security and underscored the necessity of predictive analytics in mitigating disruptions.

Recent studies, such as those by Gomez et al. (2021) and Hernandez et al. (2023), have leveraged IoT-based weather forecasting to enhance water resource planning and optimize water distribution in remote areas. These approaches align with real-time monitoring systems discussed by Hoffman and Singh (2022), which aim to enhance climate-resilient infrastructure. Moreover, Jackson and Wei (2021) explored the role of IoT in improving water conservation techniques through cloud-based applications, while Johnson (2021) emphasized the significance of IoT in strengthening climate resilience for rural water security. Several studies have focused on integrating automation in water management. Jones and White (2020) analyzed the impact of extreme weather events on rural water supply systems, providing a foundation for smart intervention strategies. Kumar, Desai, and Mishra (2022) highlighted challenges and opportunities in microcontroller-based water automation, while Lee, Yang, and Wu (2019) demonstrated how IoT could facilitate rural water tank automation. Similarly, Martinez and Singh (2022) detailed IoT-enabled water conservation strategies tailored for developing countries.

Advanced weather prediction technologies have further strengthened smart water management. Nakamura (2019) explored the application of weather forecasting in smart agriculture, while Smith and Brown (2020) discussed the implications of extreme weather events on rural water storage solutions. Thompson and Evans (2023) examined weather-based automation in smart homes, emphasizing its potential for integration into water management systems.

Emerging research by Wang and Chen (2021) has demonstrated the feasibility of cloud-based weather monitoring for irrigation, while Xiao and Zhang (2020) identified IoT's role in sustainable water conservation. Finally, Zhao, Green, and Kwon (2020) investigated the intersection of IoT and predictive analytics in smart water management, underscoring the transformative potential of data-driven decision-making in water conservation.

Methodology

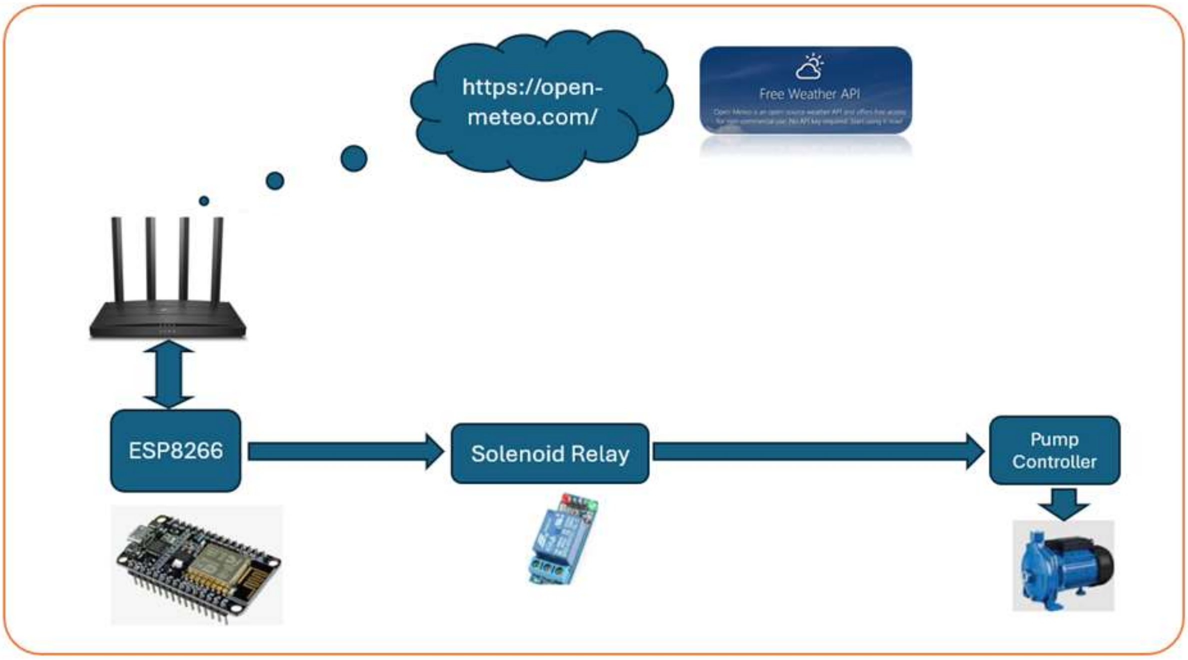

Fig. 1: Project Block Diagram

The image 1 illustrates a smart water pump control system that utilizes ESP8266, Open-Meteo API, and a solenoid relay to automate water pumping based on weather conditions.

Components and Workflow:

1. Internet Connection (Wi-Fi Router)
   - The ESP8266 is connected to the internet via a Wi-Fi router.
   - It fetches weather data from Open-Meteo (a free weather API).
2. ESP8266 Microcontroller
   - The ESP8266 acts as the core controller.
   - It retrieves real-time weather updates from Open-Meteo.
   - Based on the weather forecast (e.g., storms or heavy rain), it decides whether to activate the water pump.
3. Solenoid Relay
   - The ESP8266 controls a solenoid relay, which acts as an electrical switch.
   - The relay is responsible for switching the pump controller ON or OFF.
4. Pump Controller & Water Pump
   - The pump controller receives commands from the relay.
   - If adverse weather conditions (like a storm or cyclone) are predicted, the pump is triggered every 2 hours to ensure the water tank is filled

in advance.
  - The pump then stops once the tank is full.

Working Principle:

- The ESP8266 continuously monitors the weather forecast.
- If extreme weather (storms, cyclones, or heavy rain) is detected, the system automatically triggers the water pump at 2-hour intervals to ensure the tank remains filled before power failures occur.
- The system prepares for water scarcity proactively based on weather predictions.

Advantages

✓ Automated Water Management – Reduces manual intervention.

✓ Weather-Based Smart Control – Prepares in advance for power failures.

✓ IoT-Enabled – Real-time monitoring and decision-making.

✓ Energy-Efficient – Runs the pump only when necessary.

This system is ideal for rural areas where water shortages often occur due to power outages during extreme weather events.

The project code is available from: https://github.com/sudipchakraborty/Smart-Domestic-Water-Tank-Filling-System.git

Conclusion

This study presents an innovative approach to rural water management by integrating IoT and weather forecasting into a bright domestic water tank filling system. By leveraging the ESP8266 microcontroller and OpenWeather API, the system ensures that households maintain an adequate water supply despite extreme climatic events. The proposed system enhances resilience by proactively filling the water tank at predefined intervals when adverse weather conditions are predicted, mitigating the risk of water shortages due to prolonged power outages.

The literature review highlights the significance of IoT, machine learning, and real-time weather monitoring in improving water management systems. Studies have shown that predictive analytics and automation can optimize resource utilization and enhance sustainability in water conservation. The findings reinforce the necessity of integrating smart technology into rural water systems to enhance reliability and resilience against environmental uncertainties.

Future work can further explore enhancements such as integrating solar-powered backup systems to mitigate power outage concerns, incorporating machine learning algorithms for more accurate weather predictions, and expanding the system to support large-scale water distribution networks. Overall, the proposed system represents a significant step toward sustainable and intelligent water management in rural communities.

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