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Smart Irrigation System Using IoT

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Abstract

Agriculture plays a crucial role in global food security and economic stability. However, traditional irrigation methods often result in water wastage, inefficient crop hydration, and high labour costs. As water scarcity continues to rise, it is essential to adopt sustainable solutions that optimize irrigation practices.

This paper presents an IoT-based Smart Irrigation System, designed to automate and enhance water management in agriculture. The system integrates soil moisture sensors, temperature sensors, humidity sensors, and rain sensors, feeding real-time environmental data to an Arduino UNO microcontroller. Based on preset thresholds, the system activates the water pump only when required, reducing excessive water consumption. Additionally, a timer-based scheduling feature ensures irrigation continuity even when sensor data is unavailable.

To protect crops from damage, an ultrasonic animal repellent buzzer is incorporated into the system. This IoT-driven approach successfully minimizes manual intervention, improves agricultural efficiency, and supports sustainable farming practices. The implementation of cloud-based monitoring allows farmers to remotely control irrigation, ensuring transparency and control over water distribution.

Keywords: *Smart Irrigation, IoT, Soil Moisture Sensor, Automated Water Pump, Sustainable Agriculture, Arduino, Real-time Monitoring*

1. Introduction

Efficient water management is a critical factor in modern agriculture, particularly as farmers face growing challenges due to climate change and resource scarcity. Traditional irrigation methods, often reliant on manual operation, can lead to excessive water consumption, inconsistent soil hydration, and unnecessary labour demands. These inefficiencies highlight the need for automated and intelligent irrigation solutions that maximize water use while reducing human intervention. The emergence of IoT-based smart irrigation systems offers an effective way to enhance agricultural productivity through real-time data collection and automated water distribution. This paper presents a sensor-driven irrigation model, integrating soil moisture, temperature, humidity, and rain sensors with an Arduino microcontroller to enable precise, automated watering. By leveraging cloud-based monitoring and automation, this system minimizes water wastage, improves efficiency, and promotes sustainable farming practices.

2. Literature Review

In recent years, numerous studies have highlighted the importance of integrating Internet of Things (IoT) in agriculture to enhance efficiency, reduce resource wastage, and support sustainable farming practices. Various smart irrigation models have been proposed and implemented using different sensors and control techniques.

In [1], a wireless sensor network-based irrigation system was proposed that utilized soil moisture and temperature sensors to optimize water usage. The system was capable of automating irrigation schedules but lacked integration with weather forecasting or rain detection, which limited its adaptability to environmental conditions.

Another approach, as described in [2], introduced a GSM-based control system for irrigation that enabled remote management. While effective in remote triggering, the system's dependency on manual input and GSM network availability made it less efficient in unattended or low-signal environments.

A more recent study [3] implemented an IoT-based irrigation system using cloud services and data analytics to provide real-time monitoring. Although the system improved decision-making through data visualization and history logs, it required stable internet connectivity and cloud service subscriptions, which might not be feasible for small-scale farmers.

In [4], the inclusion of weather forecasting and rain sensors was shown to significantly reduce water usage by preventing irrigation during rainfall. The study emphasized the value of integrating multiple sensors and predictive data to enhance the reliability of the system.

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Most existing systems focus on automating irrigation but often neglect real-world challenges such as animal interference or hardware-level contingencies like sensor failures. This project builds on the strengths of previous systems by integrating a timer-based fallback mechanism and an animal repellent feature, offering a more robust and farmer-friendly solution.
By examining previous works, it is evident that while IoT-based irrigation has made significant strides, there is still room for improvement in terms of reliability, affordability, and ease of implementation in rural settings.

3. Methodology

The proposed Smart Irrigation System is designed to automate the irrigation process based on real-time environmental data, aiming to enhance water efficiency and reduce the dependence on manual intervention. The methodology integrates sensor-based data collection, rule-based decision-making, and a dual-mode control mechanism to ensure reliable operation under varying field conditions.
Environmental data is collected through a network of sensors that measure soil moisture, temperature, humidity, and rainfall. This data is analysed to assess whether irrigation is necessary. The system is programmed with threshold values—particularly for soil moisture—beyond which irrigation is either initiated or suppressed. For instance, when the soil moisture level drops below a defined threshold and no rainfall is detected, the system activates the water pump. Otherwise, irrigation remains off. This ensures that water is only supplied when genuinely needed, reducing waste and promoting sustainable usage.
To ensure continuous operation, the system includes a timer-based backup. In cases where sensor readings are unavailable or unreliable, irrigation is triggered at fixed intervals. This fallback mechanism enhances system reliability in remote or harsh environments.

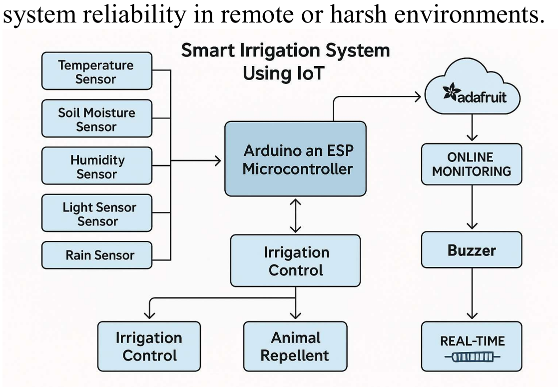

Fig 3.1 System Architecture

The decision logic is governed by simple conditions. If the soil moisture (M_s) is less than a predefined threshold (T_s) and no rain is detected, the irrigation pump is turned ON; otherwise, it remains OFF. This can be summarized as:
If $M_s < T_s$ *and* rain = false, *then* irrigation = ON; *else* irrigation = OFF.
Additionally, an animal repellent buzzer is integrated to deter animals from entering the field. It operates when required, providing protection without requiring complex detection systems.

4. Implementation

The implementation comprises both hardware and software components, working together to enable intelligent irrigation control. The core algorithm evaluates key environmental parameters such as soil moisture and rainfall. When specific threshold conditions are met—such as low moisture levels and absence of rainfall—the system automatically activates the water pump to initiate irrigation. In cases where sensor data is unavailable or invalid, a timer-based fallback mechanism ensures that irrigation continues at scheduled intervals to maintain crop health.

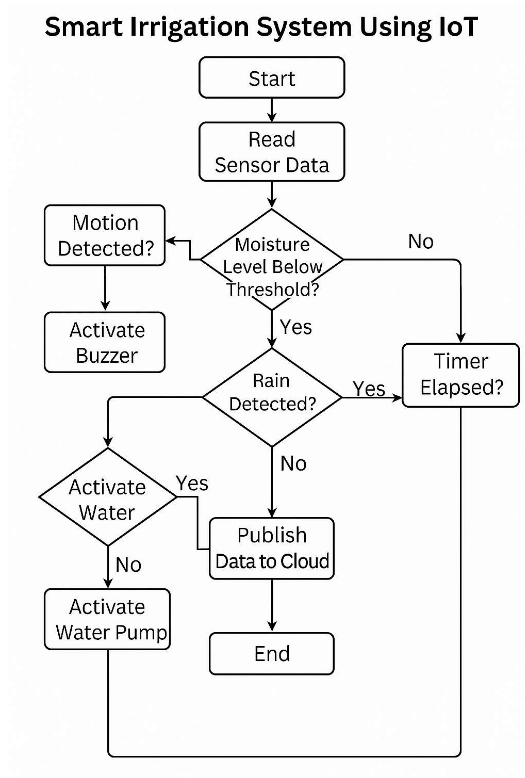

Fig 4.1 System Flow

Real-time sensor data is transmitted and visualized through a web dashboard using the Adafruit IO platform, allowing remote monitoring and insight into field conditions. The software stack includes the

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Arduino IDE for firmware development and programming of microcontrollers, while MQTT (Message Queuing Telemetry Transport) is utilized as the communication protocol for efficient, lightweight data exchange between devices and the cloud.

5. Testing

To assess the reliability, efficiency, and adaptability of the proposed IoT-based smart irrigation system, a comprehensive set of tests was conducted. The evaluation focused on five key aspects: component-level functionality, system integration, performance efficiency, environmental resilience, and user interface usability.

Functional and Component-Level Testing Each hardware element, including soil moisture, temperature, humidity, and rain sensors, was individually verified for accuracy and consistency. The water pump responded correctly to variations in soil moisture, activating only when readings fell below the set threshold. This confirmed the system's ability to deliver precise irrigation based on real-time environmental inputs.

System Integration and Data Flow Integrated testing validated seamless communication among sensors, the Arduino microcontroller, and the cloud platform. Data was successfully transmitted to Adafruit IO in real time via the ESP8266 module, ensuring accurate remote monitoring. The control logic responded consistently to multiple sensor inputs, confirming system stability during simultaneous operations.

Environmental and Reliability Testing The system was tested under diverse simulated environmental conditions, including dry soil, high humidity, artificial rainfall, and fluctuating temperatures. Sensor calibration remained stable across these scenarios, and system functions continued without interruption, indicating strong environmental adaptability and operational resilience.

Usability and Interface Testing The user interface provided through Adafruit IO was evaluated for accessibility and clarity. Users could monitor real-time sensor data and manually override pump control as needed. The interface was found to be intuitive, supporting remote operation without requiring advanced technical knowledge.

6. Results

The Smart Irrigation System successfully demonstrated its intended functionality across all tested scenarios. Sensor-based control allowed precise irrigation based on real-time soil moisture and environmental conditions, reducing unnecessary water usage. The rain sensor prevented irrigation during simulated rainfall, confirming the system's ability to adapt dynamically to weather conditions. The motion-sensing module consistently activated the animal deterrent buzzer when movement was detected, supporting effective crop protection.

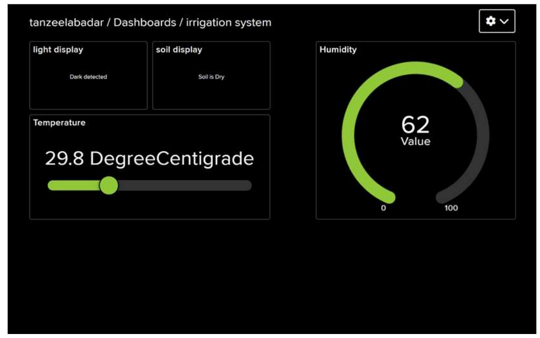

Fig 6.1 Dashboard- Dry Soil

Data logging and remote monitoring were verified through the Adafruit IO dashboard, where live readings from the sensors were updated in real time. The MQTT protocol ensured low-latency, reliable communication between the NodeMCU and the cloud. The fallback timer mechanism activated irrigation as expected when sensor data was unavailable, confirming the robustness of the control logic.

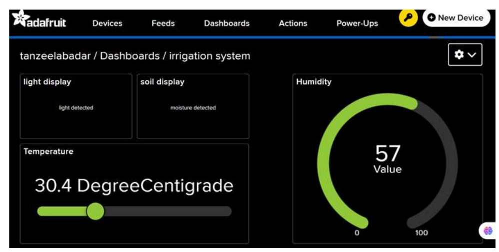

Fig 6.2 Dashboard- Moisture Detected

Parameter	**Traditional Irrigation**	**Smart Irrigation System**
Manual Intervention	Required	Minimal
Scheduling	Fixed (manual)	Dynamic (sensor-based)
Resource Efficiency	Low	High
Real-time Monitoring	Not Available	Enabled via IoT

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Parameter	Traditional Irrigation	Smart Irrigation System
Animal Intrusion Control	Absent	Present (buzzer module)

Table 1: Comparison Between Traditional and Smart Irrigation Methods

7. Conclusion

The adoption of IoT-based smart irrigation systems represents a significant advancement in agricultural technology, addressing the inefficiencies of traditional water management methods. By incorporating sensor-driven automation, these systems enable precise irrigation, ensuring optimal soil hydration while minimizing waste. The integration of real-time monitoring and cloud-based connectivity further enhances efficiency, allowing farmers to make informed decisions and remotely manage irrigation schedules. Additionally, the inclusion of an animal repellent contributes to crop protection without reliance on physical barriers.

This research highlights the effectiveness of automated water regulation in improving agricultural sustainability. As technology continues to evolve, further enhancements—such as AI-driven predictive models, solar-powered irrigation systems, and weather-based adaptive scheduling—will further refine the capabilities of smart irrigation, making water conservation more efficient and accessible.

8. Future Scope

The integration of **IoT-based smart irrigation systems** presents significant opportunities for further technological advancements and expanded applications in agriculture. Future improvements can enhance efficiency, sustainability, and adaptability, ensuring optimal resource management and productivity.

1. AI-Driven Predictive Models: Machine learning algorithms can analyse historical soil moisture levels, climate patterns, and crop health data to predict optimal irrigation schedules. AI-powered analytics can improve water conservation by making precise adjustments based on environmental conditions.
2. Solar-Powered Irrigation: Implementing solar energy solutions for irrigation pumps can reduce dependency on electrical grids and fossil fuels. This eco-friendly approach lowers operational costs and increases accessibility for farmers in remote areas.
3. Weather-Based Adaptive Scheduling: Integrating real-time weather APIs can enable dynamic irrigation control, adjusting water distribution based on rainfall forecasts, humidity levels, and temperature variations, preventing unnecessary irrigation.
4. Mobile and IoT Edge Computing: Deploying edge computing capabilities within the irrigation system can enhance data processing speed, reducing latency and improving system responsiveness. Farmers can receive instant alerts and make timely interventions via mobile applications.
5. Automated Nutrient Monitoring: Future versions of smart irrigation systems could incorporate sensors to analyse soil nutrient composition alongside moisture levels. This feature would allow automated fertilization, ensuring balanced crop nutrition and reducing chemical waste.
6. Large-Scale Integration: Expanding the technology to commercial farms and agricultural sectors can lead to government-supported smart irrigation initiatives, fostering widespread adoption of sustainable irrigation techniques.
7. Advanced Security and Data Encryption: As IoT devices become more interconnected, securing sensor data against cyber threats is crucial. Future smart irrigation systems can integrate secure data transmission protocols to ensure reliability and privacy.

By incorporating these advancements, smart irrigation systems will continue to evolve, supporting precision agriculture, climate resilience, and sustainable farming practices worldwide**.**

9. References

[1] A. Goap, D. Sharma, A. K. Shukla, and C. R. Krishna, "An IoT based smart irrigation management system using machine learning and open-source technologies," *Computers and Electronics in Agriculture*, vol. 155, pp. 41–49, 2018.

[2] S. Barkunan, V. Bhanumathi, and J. Sethuram, "Smart sensor for automatic drip irrigation system for paddy cultivation," *Computers & Electrical Engineering*, vol. 73, pp. 180–193, 2019.

[3] E. A. Abioye et al., "A review on monitoring and advanced control strategies for precision irrigation," *Computers and Electronics in Agriculture*, vol. 173, p. 105441, 2020.

[4] A. K. Pandey and A. Mukherjee, "A review on advances in IoT-based technologies for smart agricultural system," *Internet of Things and Analytics for Agriculture*, vol. 3, pp. 29–44, 2022.

[5] P. K. Singh and A. Sharma, "An intelligent WSN-UAV-based IoT framework for precision agriculture application," *Computers and Electrical Engineering*, vol. 100, p. 107912, 2022.

[6] M. Pramanik et al., "Automation of soil moisture sensor-based basin irrigation system," *Smart Agricultural Technology*, vol. 2, p. 100032, 2022.

DOI: https://doi.org/10.62647/IJITCE2025V13I2sPP86-90

ISSN 2347–3657

Volume 13, Issue 2s, 2025

[7] I. Angelis et al., "Smart agriculture: A low-cost wireless sensor network approach," in *Information and Communication Technologies for Agriculture—Theme I: Sensors*, Springer, 2022, pp. 139–172.

[8] D. Cao et al., "Investigation of the influence of soil moisture on thermal response tests using active distributed temperature sensing (A–DTS) technology," *Energy and Buildings*, vol. 173, pp. 239–251, 2018.

[9] M. Lagos et al., "Challenges in determining soil moisture and evaporation fluxes using distributed temperature sensing methods," *Journal of Environmental Management*, vol. 261, p. 110232, 2020.

[10] J. Vera et al., "Towards irrigation automation based on dielectric soil sensors," *The Journal of Horticultural Science and Biotechnology*, vol. 96, no. 6, pp. 696–707, 2021.

[11] M. Akbari et al., "Surface irrigation simulation-optimization model based on meta-heuristic algorithms," *Agricultural Water Management*, vol. 201, pp. 46–57, 2018.

[12] L. Wang et al., "Effects of different drip irrigation modes on water use efficiency of pear trees in northern China," *Agricultural Water Management*, vol. 245, p. 106660, 2021.

[13] R. Chen et al., "Comparisons of spray characteristics between non-circular and circular nozzles with rotating sprinklers," *Applied Engineering in Agriculture*, p. 0, 2021.

[14] K. Shi et al., "A review of the category, mechanism, and controlling methods of chemical clogging in drip irrigation system," *Agriculture*, vol. 12, no. 2, p. 202, 2022.

[15] M. M. Akalu, "GIS-based land suitability assessment for surface irrigation: A case of Gilgel Gibe watershed, Jimma Zone, Ethiopia," *Arabian Journal of Geosciences*, vol. 15, no. 5, pp. 1–13, 2022.

[16] Mohammed Abdul Bari, Shahanawaj Ahamad, Mohammed Rahmat Ali," Smartphone Security and Protection Practices", International Journal of Engineering and Applied Computer Science (IJEACS) ; ISBN: 9798799755577 Volume: 03, Issue: 01, December 2021 (International Journal,U K) Pages 1-6

[17] M.A.Bari, Sunjay Kalkal, Shahanawaj Ahamad," A Comparative Study and Performance Analysis of Routing Algorithms", in 3rd International Conference ICCIDM, Springer - 978- 981-10-3874-7_3 Dec (2016) ; Impact Factor :4.18

[16] Mohammed Shoeb, Mohammed Akram Ali, Mohammed Shadeel, Dr. Mohammed Abdul Bari, "Self-Driving Car: Using Opencv2 and Machine Learning", The International journal of analytical and experimental modal analysis (IJAEMA), ISSN NO: 0886-9367, Volume XIV, Issue V, May/2022

DOI: https://doi.org/10.62647/IJITCE2025V13I2sPP86-90