IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, February 2026
Impact Factor: 8.2

# IoT-Based Smart Irrigation System

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**Abstract:** *Efficient irrigation management is essential for improving agricultural productivity and conserving water resources. In many agricultural areas, irrigation is still performed manually without checking the real-time condition of the soil. This often results in excessive water usage, uneven crop growth, and increased labor effort. The proposed IoT-Based Smart Irrigation System automates irrigation by continuously monitoring soil moisture levels using sensors connected to a NodeMCU ESP8266 microcontroller. The system also monitors temperature and humidity to estimate possible rainfall conditions and avoid unnecessary watering. A separate fertilizer pump is integrated to provide nutrient control when required. All system parameters are monitored and controlled remotely through the Blynk IoT cloud platform. The developed system helps in conserving water, reducing manual intervention, and improving overall crop health through intelligent automation.*

**Keywords*:*** IoT, Smart Irrigation, NodeMCU ESP8266, Soil Moisture Sensor, Rain Prediction, Fertilizer Control, Automation

## I. INTRODUCTION

Agriculture is highly dependent on water availability and proper irrigation management. Traditional irrigation practices often rely on manual operation or fixed time schedules, which may not reflect the actual needs of the crops. Over-irrigation leads to water wastage and root damage, while under- irrigation reduces crop productivity.

With the advancement of IoT technology, agricultural systems can now be automated using real-time data collection and cloud connectivity. Sensors can monitor soil and environmental conditions continuously, while microcontrollers process the data and make intelligent decisions.

This project presents a smart irrigation system that automatically controls water supply based on soil moisture levels. It also includes rain prediction logic and fertilizer control, making it a more complete and practical solution for modern farming needs.

## II. LITERATURE SURVEY

Previous research has explored various automated irrigation techniques. Early irrigation automation systems used GSM modules to control pumps remotely via SMS. Although these systems provided remote access, they lacked environmental sensing capabilities.

Wireless sensor network-based systems improved monitoring accuracy but required complex infrastructure and higher installation costs. Later IoT-based irrigation systems introduced cloud monitoring platforms that enabled real-time data visualization.

However, many existing systems do not integrate rain prediction logic or fertilizer management in the same framework. Some systems also lack a proper manual override feature, which is necessary in practical farming conditions. The proposed system addresses these limitations by integrating automatic irrigation, environmental monitoring, rain alerts, fertilizer control, and cloud-based supervision into a single, cost-effective setup.

## III. PLATFORM TECHNOLOGY USED

The system is developed using NodeMCU ESP8266 as the main microcontroller. It is selected due to its built-in Wi-Fi capability, compact size, and suitability for IoT applications.

The Arduino IDE is used for programming the microcontroller. Sensor libraries are used to read soil moisture and DHT11 temperature-humidity values. The Blynk IoT platform serves as the cloud interface for data monitoring and remote control.

Communication between the hardware system and cloud dashboard is established through Wi-Fi connectivity. Virtual pins are used in the Blynk application to display temperature, humidity, soil moisture values, pump status, and fertilizer control.

## IV. PROBLEM STATEMENT

In conventional irrigation systems, water is supplied based on fixed time intervals or manual observation rather than actual soil moisture conditions. This leads to inefficient water utilization and increased operational costs. Additionally, traditional systems do not account for environmental conditions such as humidity and temperature, which may indicate the possibility of rainfall. As a result, irrigation may continue even when natural rainfall is sufficient, causing unnecessary water wastage.

Another major limitation is the absence of nutrient management integration. Farmers often apply fertilizers manually without synchronization with irrigation cycles.

There is a need for a smart irrigation system that monitors soil moisture in real time, predicts possible rainfall conditions, integrates fertilizer control, and allows remote monitoring to enhance efficiency and sustainability in agriculture.

## V. AIM AND OBJECTIVES

**Aim**

To design and implement an IoT-based smart irrigation system that automates water and fertilizer management using real-time environmental monitoring.

**Objectives**

- To continuously monitor soil moisture levels.
- To control irrigation automatically using threshold-based logic.
- To measure temperature and humidity for environmental analysis.
- To implement a basic rain prediction alert system.
- To provide manual control with automatic return to auto mode.
- To enable real-time cloud monitoring and data visualization.
- To reduce water wastage and improve crop yield.

## VI. CIRCUIT DESIGN AND SYSTEM ARCHITECTURE

The system consists of sensing, processing, control, communication, and user interface layers.

The soil moisture sensor is connected to the analog input pin of NodeMCU to measure soil water content. The DHT11 sensor is connected to a digital pin to measure temperature and humidity.

Two relay modules are used:

- One relay controls the water pump.
- The second relay controls the fertilizer pump.

The NodeMCU processes sensor values and compares them with predefined threshold values. If the soil is dry, the water pump is activated automatically. When the soil becomes sufficiently moist, the pump is turned off.

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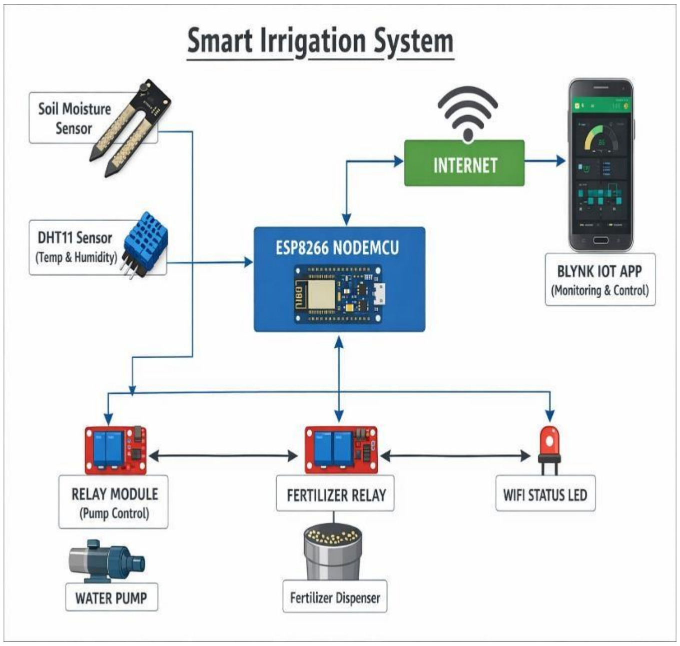
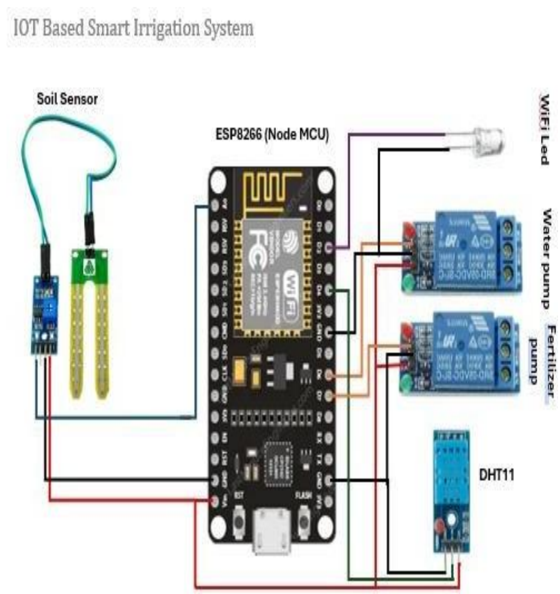
All data is transmitted via Wi-Fi to the Blynk cloud platform, where users can monitor and control the system through a mobile dashboard.

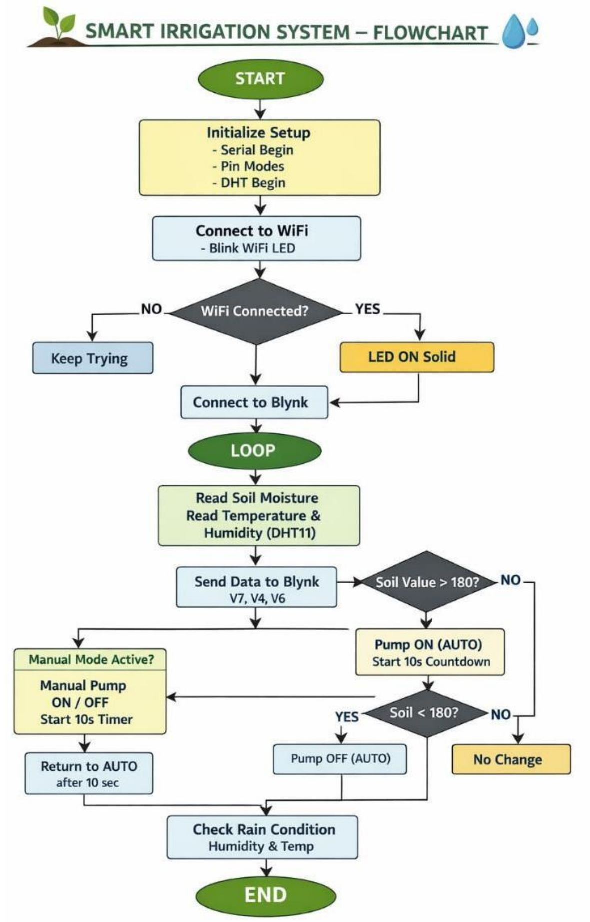
### 6.1 Block Diagram




### 6.2 Circuit Diagram



**6.3 Flow Chart**




## VII. COMPONENTS / MATERIALS USED

**• NodeMCU ESP8266:**
Acts as the central controller of the system. It reads sensor data, processes decision logic, and manages Wi-Fi communication with the cloud server.

**• Soil Moisture Sensor:**
Measures the volumetric water content in soil. It helps determine whether irrigation is required.

**• DHT11 Temperature and Humidity Sensor:**
Provides environmental data used for monitoring and rain prediction logic.

**• Relay Module (2-Channel):**
Works as an electronic switching device to control high- power devices like pumps using low-voltage signals from the microcontroller.

**• Water Pump:**
Supplies water to crops when activated by the system.

**• Fertilizer Pump:**
Dispenses liquid fertilizer manually through cloud-based control.

**• LED Indicator:**
Indicates Wi-Fi connection status to ensure proper connectivity.
**• Power Supply:**
Provides stable voltage for safe and efficient operation of the system.

## VIII. WORKING OF THE SYSTEM

The system reads soil moisture values at regular intervals. If the soil moisture reading exceeds the predefined threshold, indicating dry soil, the water pump is turned ON automatically. Once the soil moisture falls below the threshold value, the pump is turned OFF.

The DHT11 sensor measures temperature and humidity. If humidity is high and temperature is comparatively low, the system predicts a possible rainfall condition and sends a notification through the Blynk application.

The system also includes manual override functionality. Users can switch the pump ON or OFF through the mobile dashboard. After a specific duration, the system automatically returns to automatic mode to prevent continuous manual operation.

A countdown timer feature displays pump operation time for better monitoring. Fertilizer control is managed separately through a second relay, allowing users to activate it manually when required.

## IX. RESULTS

The system was tested under varying soil moisture conditions to evaluate its performance. When the soil was dry, the pump activated automatically without delay. Once adequate moisture was achieved, the pump turned off accurately according to the threshold value.

Environmental monitoring through the DHT11 sensor successfully triggered rain prediction notifications when humidity levels were high. This feature helped avoid unnecessary irrigation during potential rainfall conditions.

Real-time monitoring through the Blynk platform showed minimal latency, typically within a few seconds. The system maintained stable operation during continuous testing. Compared to manual irrigation methods, water usage was significantly reduced, and irrigation became more consistent and controlled.

## X. ADVANTAGES AND APPLICATIONS

**Advantages**

- Efficient Water Management: Water is supplied only when required, reducing wastage and conserving resources.
- Reduced Manual Effort: Automation minimizes human supervision and saves time.
- Real-Time Monitoring: Users can monitor soil and environmental conditions remotely.
- Rain Prediction Alert: Prevents unnecessary watering during high humidity conditions.
- Integrated Fertilizer Control: Allows better nutrient management along with irrigation.

**Applications**

- Agricultural Fields: Suitable for small and medium-scale farms to improve irrigation efficiency.
- Greenhouses: Provides controlled irrigation in enclosed environments.
- Home Gardens: Can automate watering systems for residential gardening.
- Smart Farming Systems: Can be integrated into precision agriculture setups.

## XI. FUTURE SCOPE

**• Solar-Powered Operation:**
The system can be powered using solar panels and battery storage to make it energy-efficient and suitable for remote agricultural areas.

**• Weather Forecast Integration:**
Real-time weather APIs can be integrated to automatically adjust irrigation schedules based on predicted rainfall and temperature conditions.

**• AI-Based Irrigation Scheduling:**
Machine learning algorithms can analyze historical sensor data to intelligently determine optimal irrigation timing and water quantity.

**• Multi-Field Monitoring:**
Multiple sensor nodes can be deployed across large farms to enable zone-wise monitoring and precise irrigation control.

**• Mobile Notifications and Alerts:**
Advanced alert systems like SMS or push notifications can inform farmers about soil conditions, pump status, and weather changes in real time.

**• Data Analytics for Crop Plans:**
Stored sensor data can be analyzed to generate irrigation trends and support better crop planning and yield optimization.

## XII. CONCLUSION

The developed IoT-Based Smart Irrigation System demonstrates how modern technology can significantly improve traditional agricultural practices. By continuously monitoring soil moisture and environmental conditions, the system ensures that water is supplied only when necessary.

The integration of rain prediction logic and fertilizer control enhances the overall efficiency of irrigation management.

The system not only reduces water wastage but also minimizes manual intervention and operational costs. Real- time cloud monitoring increases transparency and user convenience. Overall, the proposed system provides a practical, scalable, and cost-effective solution for sustainable and smart agriculture.

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