IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.414 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 12, December 2025

DOI: 10.17148/IJIREEICE.2025.131205

"Design and Implementation of a Smart Irrigation System Using Soil Moisture Sensor and IoT"

G. Shri Lakshmi

Pre-Final year UG student, Department of Electronics and Communication Engineering,

Saranathan College of Engineering, Trichy-12, India

Abstract: This paper presents an soil moisture sensor to detect the moisture content in the soil and an NodeMCU (ESP32) Microcontroller Board to control a water pump. The system uses a IoT-based smart irrigation system designed to automatically control water flow according to soil moisture levels. When the soil is dry, the motor is switched ON to provide water, and it automatically switches OFF when the required moisture level is reached. The project is further enhanced using IoT, allowing users to monitor and control the irrigation process remotely via the internet. This approach ensures efficient water usage, reduces manual effort, and is especially beneficial for agricultural and home gardening applications.

Keywords: IoT, NodeMCU (ESP32) Microcontroller, Soil Moisture Sensor, Smart Irrigation, Automated Watering System

I. INTRODUCTION

Water scarcity and inefficient irrigation practices are major challenges in agriculture. Traditional irrigation systems rely on manual monitoring, leading to over-watering or under-watering of plants. To address this issue, automation through microcontrollers and IoT has emerged as an effective solution. This project focuses on developing an automatic irrigation system using IoT technology. The soil moisture sensor continuously monitors the soil's humidity level and sends data to the microcontroller. Based on this reading, the motor pump is automatically controlled. Integration with IoT platforms such as Blynk allows users to monitor and operate the system remotely, ensuring efficient use of water resources.

II. OBJECTIVE

1. To develop a system that automatically waters plants based on soil moisture levels.
2. To enable remote monitoring and control of the irrigation system via IoT.
3. To conserve water and improve plant health by avoiding overwatering.

III. METHODOLOGY

The system consists of a soil moisture sensor, relay module, water pump, and IoT connectivity through the ESP32 or Node MCU module. When the soil is dry, the sensor sends a low output signal to the Arduino, which in turn activates the motor via the relay. When the soil is sufficiently moist, the signal changes, and the motor is turned off. IoT integration enables users to check soil status and control the motor manually from anywhere through a smartphone application such as Blynk. The flow of operation is simple, efficient, and reliable for small-scale and smart farming applications.

Method:

1. The soil moisture sensor measures soil water content.
2. The sensor sends readings to the microcontroller.
3. If the soil is dry, the microcontroller triggers the relay to turn on the water pump.
4. When the soil is sufficiently moist, the pump is turned off.
5. Users can monitor soil moisture and control the pump remotely through the Blynk app.

IV. NEED OF THE PROJECT

Smart irrigation systems are essential to ensure efficient use of water in agriculture, which is one of the most water-consuming sectors. Traditional irrigation methods often lead to unnecessary wastage of water due to continuous or manually scheduled watering. In many cases, farmers may not know the exact moisture condition of the soil, resulting in over-watering or under-watering that affects plant health and crop yield. With increasing water scarcity and the need for sustainable farming, automation in irrigation has become highly important. A smart irrigation system using Arduino

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.414 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 12, December 2025

DOI: 10.17148/IJIREEICE.2025.131205

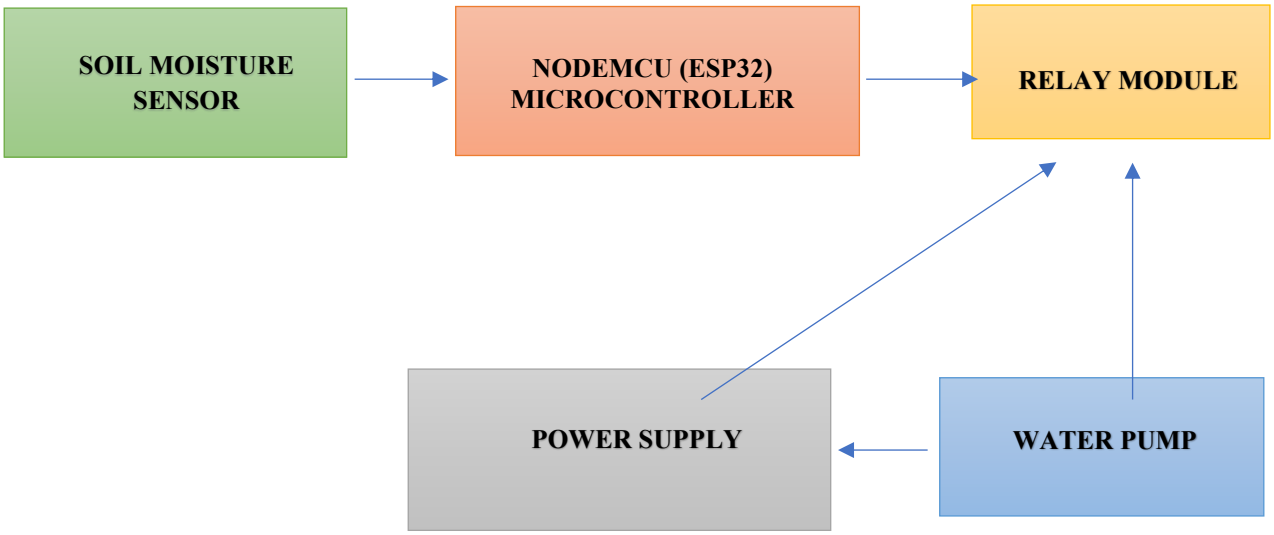
continuously monitors the soil moisture and supplies water only when it is really needed. This helps in conserving water resources and reducing human labour and supervision. It also improves crop productivity by maintaining the correct soil moisture level at all times. Such systems are cost-effective and can be easily implemented in farms, gardens, and nurseries. Therefore, the development of this project supports modern precision agriculture and promotes environmentally responsible farming practices.

V. PROPOSED SYSTEM

The proposed smart irrigation system is designed to automatically control the watering process based on real-time soil moisture levels. A soil moisture sensor is placed in the plant pot to continuously measure the water content in the soil. This sensor sends an analog signal to the microcontroller board (NodeMCU/Arduino compatible board shown in the image), which processes the moisture readings. When the soil becomes dry and falls below a set threshold, the controller activates a relay module. The relay then powers the water pump connected to the water tube, allowing water to flow to the plant. Once the soil moisture reaches a sufficient level, the controller turns OFF the pump to prevent unnecessary water wastage. An external battery is used as the power supply for the motor and controller, ensuring safe voltage distribution. Using IoT capability of the NodeMCU board, the system can also send moisture data and irrigation status to the cloud or a mobile app, enabling remote monitoring and control. This automation increases irrigation efficiency, reduces manual labour, and ensures healthier plant growth by providing the right amount of water at the right time.

VI. SYSTEM OVERVIEW

The smart irrigation system shown in the prototype automatically waters the plant based on soil moisture level. A soil moisture sensor is inserted into the plant pot to measure the water content in the soil. The sensor continuously sends moisture data to the NodeMCU/Arduino microcontroller. When the soil dries beyond the set threshold, the controller activates a relay module. The relay functions as an electronic switch that turns ON the water pump connected through a separate power supply. The pump pushes water through the tube directly into the plant pot, ensuring irrigation only when required. Once sufficient moisture is sensed again, the controller turns OFF the relay, stopping water flow and preventing over-watering. The portable power sources make the setup easy to install anywhere. This smart system reduces manual irrigation effort and ensures efficient water usage for plant growth.



VII. COMPONENTS FUNCTION

[1] Soil probe and sensor circuit board:

The soil probe is inserted into the soil to detect the moisture level. It works by measuring the electrical conductivity between its metal electrodes—wet soil conducts electricity better than dry soil. The sensor circuit board is connected to the probe and converts the raw moisture readings into usable analog or digital signals. It includes components like comparators, resistors, and sometimes a potentiometer for calibration.

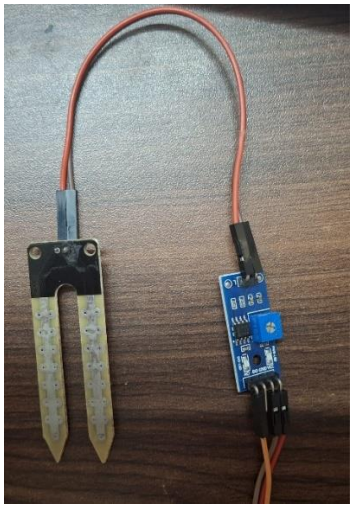
IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.414 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 12, December 2025

DOI: 10.17148/IJIREEICE.2025.131205

In this system, the board processes the probe's data and sends an accurate moisture value to the NodeMCU. Its role is to ensure consistent and reliable detection of soil water condition so the irrigation motor can be controlled properly.



[2] Double Relay Module:

A relay module is an electrically operated switch used to control high-power devices like motors using a low-power signal. The double relay module contains two relays, so it can operate two loads if required in automation systems. It isolates the control side (NodeMCU) from the power side (pump) for safety. In this system, it receives control signals from the NodeMCU and switches ON/OFF the water motor accordingly. It provides protection against back EMF and ensures safe load switching. It plays a crucial role in executing the decision taken by the controller.

[3] NodeMCU (ESP8266):

NodeMCU is a Wi-Fi-enabled microcontroller board based on the ESP8266 chip. It can connect to IoT platforms, cloud servers, or mobile devices for data monitoring and automation. In this project, NodeMCU receives input from the soil moisture sensor and processes the data. Based on programmed logic, it sends control commands to the relay module to run the motor only when required. It allows remote monitoring and Smart Farming automation. Hence, NodeMCU acts as the "brain" of the irrigation system.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

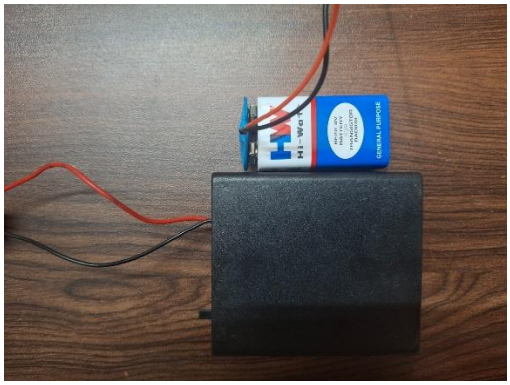
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.414 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 12, December 2025

DOI: 10.17148/IJIREEICE.2025.131205

[4] Power Supply (Adapter/Regulated Supply):

The power supply is used to provide the required stable voltage and current to the components in the system. It converts AC household mains to DC low-voltage power suitable for NodeMCU, relay module, and sensors. Without a reliable supply, the components may malfunction or get damaged. In this system, it ensures continuous powering of the control circuit so automation works 24/7. It may independently power the water pump depending on voltage rating. Thus, it is essential for safe and efficient system operation.



[5] Water Pump / Motor:

The water pump or motor is used to push and supply water from the tank or source to the crop field. It is a high-power device controlled automatically through the relay. In this system, the pump runs only when moisture goes below the set threshold and stops when soil becomes adequately wet. It helps in preventing water wastage and reduces manual effort in irrigation. Its role is to deliver water efficiently and maintain healthy crop growth in an automated manner.

[6] Wires (Connecting Cables):

Wires are used to interconnect all components in the smart irrigation system, enabling the flow of electrical power and signals. They ensure proper communication between the soil sensor, relay module, NodeMCU, and water pump. Different types of wires like jumper wires, power cables, and insulated copper wires are used based on current and voltage requirements. They help create a stable and secure circuit that supports accurate data transmission. In this project, wires play a crucial support role by linking each part so the system functions as a unified whole.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.414 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 12, December 2025

DOI: 10.17148/IJIREEICE.2025.131205

[7] Power Switch:

The power switch is a manual control device placed in the power supply line of the system. It allows the user to turn the entire irrigation unit ON or OFF when needed. The switch helps in safe operation and maintenance by disconnecting power during adjustments or emergency conditions. It also protects the components from accidental short circuits by allowing controlled startup. In this system, the power switch ensures that water pump and electronics operate only when intended, improving safety and energy efficiency.

[8] Blynk App

Blynk is an IoT mobile application used to monitor and control hardware devices remotely through the internet. It provides a user-friendly interface with widgets like buttons, displays, and notifications that interact with microcontrollers such as NodeMCU. In this smart irrigation system, Blynk displays the real-time soil moisture level sent from the NodeMCU and allows the user to turn the water pump ON or OFF from anywhere. It also helps in receiving alerts when the soil becomes too dry.

Thus, Blynk enables wireless communication, smart decision making, and remote management of the irrigation system, making it more efficient and automated.

VIII. WORKING

The system continuously monitors the moisture level of the soil using the soil probe placed in the plant root zone. The moisture sensor detects the conductivity of soil and sends a proportional analog signal to the NodeMCU microcontroller. The NodeMCU processes this value and compares it with a preset moisture threshold value, which determines whether the soil is dry or sufficiently wet. If the soil becomes too dry, the NodeMCU activates the relay module, which switches ON the water pump to supply water to the plants. Once the soil moisture level increases to the required range, the NodeMCU turns OFF the relay, stopping the pump automatically to prevent over-irrigation.

Meanwhile, the sensed moisture values are sent to the Blynk IoT app through Wi-Fi, allowing real-time monitoring on the mobile phone. The user can also manually control the pump from Blynk using a virtual ON/OFF button. A power supply provides the required voltage to run the entire setup safely. Thus, the system ensures efficient water usage, reduces manual effort, and enables remote control and automation of irrigation.

In this Smart Irrigation System, all components are interconnected to form a complete monitoring and control circuit. The soil moisture probe is inserted into the soil and connected to the soil sensor circuit board, which contains the signal

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

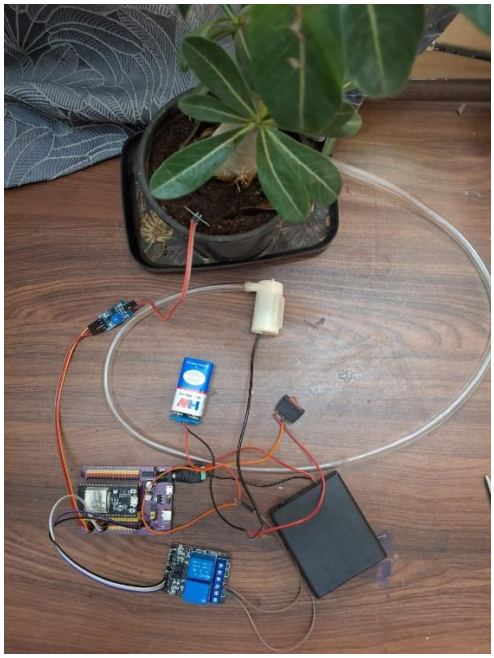
Impact Factor 8.414 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 12, December 2025

DOI: 10.17148/IJIREEICE.2025.131205

conditioning electronics. The output from this board is given to the A0 pin of the NodeMCU, so that the microcontroller can read the changing moisture values. The VCC and GND pins of the sensor are connected to the 3.3V and GND pins of the NodeMCU to provide power to the sensing module.

The NodeMCU is linked to a 2-channel relay module which controls the switching of the water pump. The IN1 pin of the relay module is connected to D1 (GPIO5) of NodeMCU to receive the control signal. The VCC and GND pins of the relay are connected to the NodeMCU power and ground respectively, sharing a common ground for proper operation. The water pump is powered by an external power supply since pumps require higher voltage than NodeMCU can provide. The positive terminal of the pump is connected directly to the external supply, while the negative terminal is routed through the relay's COM and NO terminals, allowing the relay to act as a switch.

A power switch is placed between the external power supply and the pump to allow safe manual isolation when required. All connections between boards and modules are made using insulated jumper wires ensuring correct polarity and secure contact. Once powered ON, the NodeMCU uses Wi-Fi to communicate with the Blynk App, sending sensor data and receiving pump control commands. Thus, the electrical connections enable the sensor to provide input, the controller to make decisions, and the relay-pump circuit to execute irrigation action.



IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.414 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 12, December 2025

DOI: 10.17148/IJIREEICE.2025.131205

Pin Connections of Smart Irrigation System
(NodeMCU + Soil Moisture Sensor + Relay + Pump + Power supply + Switch)
1.Soil Moisture Sensor → NodeMCU

Soil Sensor Pin	NodeMCU Pin	Purpose
VCC	3.3V	To power the sensor module
GND	GND	Common ground
A0	A0	Sends analog soil moisture data

Soil Probe is inserted into the soil and connected to the sensor board.

2. Relay Module → NodeMCU

Relay Pin	NodeMCU Pin	Function
IN1	D1 (GPIO5)	Controls relay switching for pump
VCC	5V / VIN	Relay power supply
GND	GND	Shared ground

Only **IN1** used (single pump).
Relay acts as a switch controlled by NodeMCU.

3. Water Pump → Relay + Power Supply

Component	Connected To	Function
Pump + (Positive)	+ of External Power Supply (e.g., 12V)	Main power for motor
Pump – (Negative)	COM terminal of Relay	Relay switching path
NO terminal of Relay	– of External Power Supply	Pump runs only when relay ON

NO = Normally Open → Pump is normally OFF → turns ON only when required.

4.Power switch

Switch	Connected To	Function
One terminal	+ line of external power supply	Manual control
Other terminal	Pump + wire	ON/OFF safety switch

5.NodeMUC

NodeMCU Pin	Connected Component	Purpose / Signal Role
3.3V	Soil Moisture Sensor VCC	Powers the sensor
GND (any one)	Soil Sensor GND + Relay GND + Power Supply – (Common Ground)	Reference ground connection
A0	Soil Moisture Sensor A0 Output	Reads soil moisture analog data
D1 (GPIO5)	Relay Module IN1	Controls water pump switching
VIN (5V input)	Relay Module VCC	Provides power for relay driving
USB Port	(Optional) External powering of NodeMCU	5V supply from adapter/laptop
Wi-Fi Module (Internal)	Blynk Cloud	Sends data / receives pump control

Blynk setup and configuration:

Blynk is a powerful IoT platform that allows users to remotely monitor and control hardware devices using a smartphone or web dashboard. In this Smart Irrigation System, Blynk is used to display the live soil moisture value sensed by the ESP32 and to manually control the water pump from anywhere using the internet. The setup involves creating a project in the Blynk console, generating an authentication token, and configuring datastreams such as V0 for the pump and V1 for moisture reading. This token is uploaded into the ESP32 code, enabling secure communication between the device

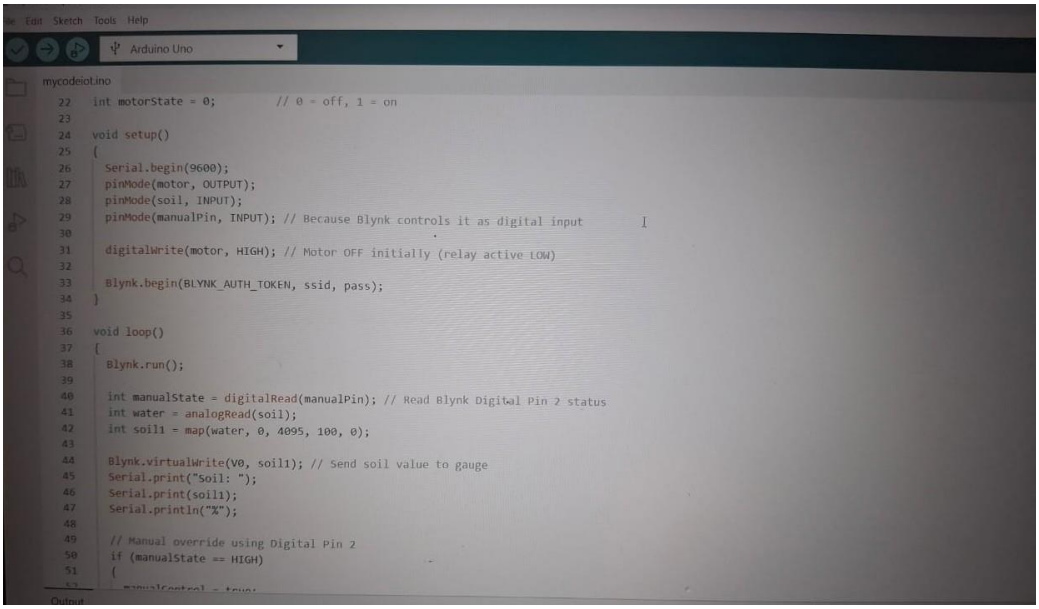
IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

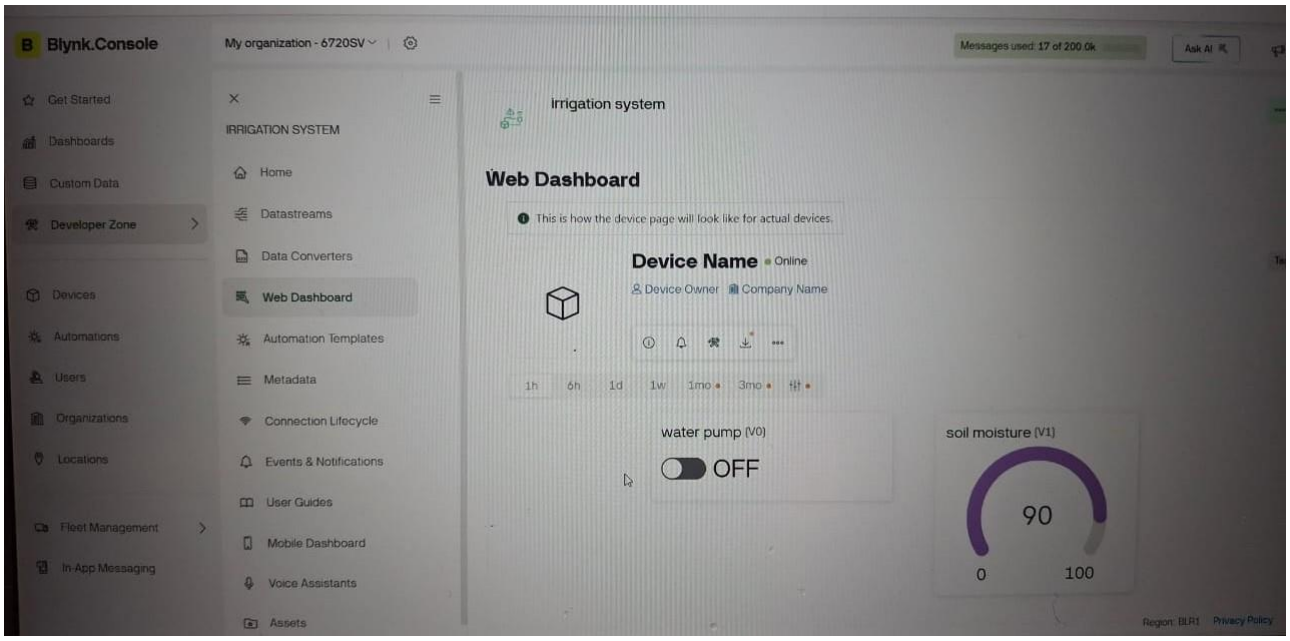
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.414 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 12, December 2025

DOI: 10.17148/IJIREEICE.2025.131205

and cloud. The soil moisture values are continuously sent to Blynk, where they are visualized through gauges or displays, while a button widget allows users to operate the pump manually when needed. Thus, Blynk ensures real-time monitoring, remote automation, and better user control, making the irrigation system smarter and more convenient.





1. Blynk Dashboard Setup Steps:
    1. Create an account on Blynk IoT platform and start a new project named *Smart Irrigation System*.
    2. Select ESP32 as the hardware and note the Blynk Authentication Token generated automatically.
    3. Go to Developer Zone → Datastreams, and create datastreams for soil moisture and pump control (V0, V1, V2 etc.).
    4. Open Web Dashboard and drag widgets:
        - Button for Water Pump Control
        - Gauge or Display for Soil Moisture Level
    5. Link each widget to the corresponding Virtual Pin and configure their properties such as labels, range, and data type.
    6. Add your Wi-Fi SSID, password, and Blynk Auth Token to the ESP32 code and upload it.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.414 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 12, December 2025

DOI: 10.17148/IJIREEICE.2025.131205

7. Once ESP32 connects to Wi-Fi, real-time data starts appearing in the Blynk Dashboard for remote control and monitoring.

2.Datastreams & Widget Mapping Table:

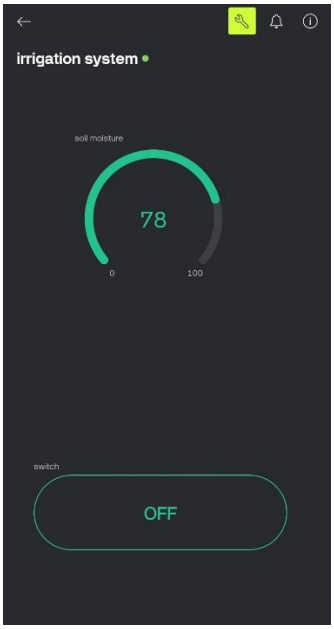
Datastream	Virtual Pin	Data Type	Widget Used	Purpose
Soil Moisture	V0	Integer	Gauge / Display Widget	Show real-time moisture values
Water Pump Control	V1	Boolean	Button Switch	Turn pump ON/OFF manually
Pump Status Message	V2	String	Label/Text Display	Display pump ON/OFF status

3. Blynk Working Flow – IoT Communication Process:

The soil moisture sensor sends continuous readings to the ESP32 microcontroller. The ESP32 processes the data and transmits the moisture value to the Blynk Cloud over Wi-Fi. The Blynk Dashboard then displays this information live for the user to monitor from anywhere. If the soil becomes too dry or the user presses the pump control button in the app, Blynk sends a command back to the ESP32. The ESP32 activates the relay module accordingly to switch the water pump ON or OFF. This two-way IoT communication provides both automation and remote manual control, ensuring intelligent and efficient irrigation.

Testing & Validation of Smart Irrigation System

The system was tested under different soil conditions to validate sensor accuracy and proper relay control. Initially, when the soil was dry, the sensor output dropped below the predefined threshold, which triggered the relay and successfully turned ON the water pump. When the soil moisture increased to a sufficient level, the system automatically turned OFF the motor, confirming effective automation. The manual switch in the Blynk app was also tested to override the automatic mode, and the pump responded correctly to user commands. All results showed that the soil sensing, IoT communication, relay switching, and pump functionality were reliable and stable. This confirms that the designed Smart Irrigation System meets the operational requirements and provides efficient remote irrigation management.



The displayed output from the Blynk mobile app confirms that the Smart Irrigation System is successfully connected to the internet and operating in real time. The gauge widget is showing the current soil moisture level (78%), indicating that the sensor data is accurately being transmitted from the ESP32 to the Blynk Cloud. The switch widget below allows the user to manually control the water pump remotely, and the “OFF” state confirms that the pump is currently inactive. The green online indicator at the top ensures that the device is actively communicating with the Blynk server. This output verifies that both monitoring and manual control functions of the smart irrigation system are working as intended.

This screenshot represents the real-time interface of the Smart Irrigation System on the Blynk mobile application. The soil moisture value is continuously displayed through a graphical gauge, allowing the user to monitor the water content in the soil from anywhere using their smartphone. The switch button below functions as a manual control for the water

DOI: 10.17148/IJIREEICE.2025.131205

pump, enabling instant ON/OFF control depending on plant requirements. The green status indicator at the top confirms that the device is actively connected to the Blynk cloud via Wi-Fi. This interface ensures remote accessibility, user-friendly interaction, and seamless IoT-based automation in irrigation.

IX. RESULTS AND DISCUSSION

The Smart Irrigation System using soil moisture sensing and IoT technology was successfully developed and tested. The NodeMCU/ESP32 microcontroller accurately received soil moisture data from the sensor and controlled the water pump through a relay module. The soil moisture values were continuously monitored and displayed both in the Serial Monitor and on the Blynk IoT mobile dashboard. The system operated efficiently in automatic mode by activating the pump when the soil was dry and turning it off once adequate moisture was restored. Additionally, manual control through the Blynk app provided flexibility for the user to override the automatic action whenever required. The real-time updates and online connectivity status ensure reliable IoT communication between the hardware and the cloud platform. Overall, the results confirm that the implemented system provides intelligent water management, accurate monitoring, and remote accessibility, making it highly suitable for modern smart agriculture applications.

X. CONCLUSION

The designed Smart Irrigation System utilizing a soil moisture sensor and IoT technology has proven to be an efficient and intelligent solution for automated irrigation. By integrating the ESP32 microcontroller with the Blynk cloud platform, the system effectively enables real-time monitoring and remote control of the water pump, ensuring optimal plant hydration with minimal human intervention. The automatic irrigation logic successfully conserves water by activating the pump only when the soil moisture drops below the threshold and switching it off when moisture is adequate. The successful testing and output results validate the system's reliability, responsiveness, and suitability for agricultural applications. This project demonstrates how IoT can be effectively adopted to improve water utilization, enhance crop health, and support modern precision farming practices.

REFERENCES

[1]. B. V. Ashwini, "A Study on Smart Irrigation System Using IoT for Surveillance of Crop-Field," *International Journal of Engineering and Technology*, vol. 7, no. 4.5, pp. 370-373, Sep. 2018

[2]. S. Velmurugan, V. Balaji, T. Manoj Bharathi, and K. Saravanan, "An IoT based Smart Irrigation System using Soil Moisture and Weather Prediction," *International Journal of Engineering Research & Technology (IJERT)*, vol. 8, no. 07, May 2020.

[3]. M. T. Huque, J. Jafor Godhuli, S. M. Raziur Rahman Pushon, and E. Haque, "Internet of Things (IoT)-based Smart Irrigation System for Sustainable Agriculture," *Journal of Informatics Electrical and Electronics Engineering (JIEEE)*, vol. 4, no. 3, Nov. 2023.

[4]. L. M. Yu, W. L. Gao, R. R. Shamshiri, S. Tao, Y. Z. Ren & Y. J. Zhang, "Review of research progress on Soil moisture sensor technology," *International Journal of Agricultural & Biological Engineering*, Vol. 14, No. 4,2021."Development of an IoT-Based Precision Irrigation System for Tomato Seedlings," *Applied Sciences (MDPI)*, Vol. 13, No. 9, 2023.

[5]. V Salam, "Internet of things in agricultural innovation and security," in Internet of Things for Sustainable Community Development. Springer, 2020, pp. 71–112.

[6]. M. Mozaffari, W. Saad, M. Bennis, Y.-H. Nam, and M. Debbah, "A tutorial on UAVs for wireless networks: Applications, challenges, and open problems," IEEE Communications Surveys & Tutorials, vol. 21, no. 3, pp. 2334 2360, 2019. A. D.Boursianis, M. S. Papadopoulou, P.Diamantoulakis ,A.LiopaTsakalidi, P.Barouchas, G.Salahas, G. Karagiannidis, S. Wan, and S. K. Goudos, "Internet of things (iot) and agricultural unmanned aerial vehicles (uavs) in smart farming: A comprehensive review," Internet of Things, p. 100187, 2020.