"Smart Irrigation System"

A Report Submitted
as Requirements for the Community Engagement Project 2
Semester IV, AY 2025-2026

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Certificate

This is to certify that Community Engagement Project 2 is entitled **"Smart Irrigation System"** is a work of

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Community Engagement Project 2 Report Approval

This Community Engagement Project report entitled **" Smart Irrigation System"** by **Yash Khanvilkar, Rohit Kumar , Harshit Patil, Tirth Shetty** is approved for the completion of Community Engagement Project 2 course of Semester IV of AY 2025-2026 in the Department of Electronics & Telecommunication Engineering.

Examiners

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Date: / /

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Abstract

Water scarcity is one of the major challenges faced by the agricultural sector in India. Traditional irrigation practices depend on manual operation or fixed scheduling, which leads to excessive water usage and inefficient crop management. This project proposes a Smart Irrigation System that uses soil moisture and environmental sensors to automate irrigation based on real-time field conditions. The system uses a microcontroller (ESP32) to monitor soil moisture, temperature, and humidity. Based on predefined threshold values, a relay-controlled pump supplies water only when required. The proposed system reduces water wastage, minimizes labor effort, and promotes sustainable agriculture practices. The design is low-cost and suitable for small and medium-scale farmers. Furthermore, the system can be enhanced with IoT capabilities to enable remote monitoring and control through mobile or web applications. This allows farmers to access real-time data, receive alerts, and manage irrigation from anywhere, improving decision-making and operational efficiency. By integrating modern technology with traditional farming practices, the system contributes to precision agriculture and supports long-term environmental sustainability.

Chapter 1

Introduction

Agriculture is one of the most important sectors contributing to the economy and food production of many countries, especially India[1]. Farmers largely depend on irrigation systems for crop cultivation. However, traditional irrigation methods often result in excessive water consumption, uneven distribution of water, and high dependency on manual labor[2]. These challenges create the need for an efficient and automated irrigation solution.

With the advancement of Internet of Things (IoT) technology, smart agricultural systems are becoming increasingly popular[3]. IoT enables real-time monitoring, automation, and remote access to agricultural processes. Smart irrigation systems use sensors and microcontrollers to monitor soil and environmental conditions and automatically control irrigation based on the collected data.

The proposed project, **Smart Irrigation System Using IoT**, is designed to automate irrigation using an ESP32 microcontroller[4], soil moisture sensors, humidity and temperature sensors, IR sensors, and relay modules. The system continuously monitors soil moisture levels and environmental conditions. When the moisture level in the soil falls below a predefined threshold, the ESP32 automatically activates the water pump through the relay module. Once sufficient moisture is achieved, the pump is turned OFF automatically.

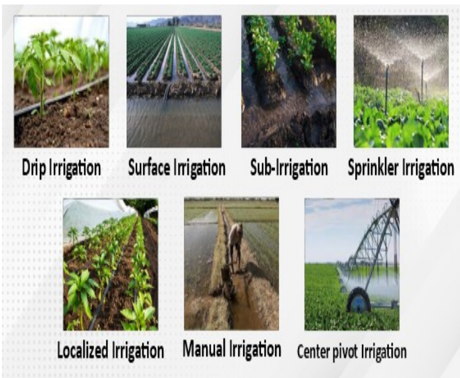
In this project, two soil moisture sensors are placed at different positions in the field. One sensor is positioned at the beginning of the field while the second sensor is placed at the end of the field. This arrangement helps in monitoring moisture distribution across the entire irrigation area and improves irrigation accuracy.

The ESP32 microcontroller sends the collected sensor data to the Blynk IoT cloud platform through Wi-Fi connectivity. Farmers can monitor soil moisture, temperature, humidity, and pump status remotely using the Blynk mobile application. In addition to cloud monitoring, a local web dashboard has also been developed to display the real-time readings within the local network.

The project aims to reduce water wastage, minimize manual intervention, improve irrigation efficiency, and support modern smart farming techniques. The system is cost-effective, energy-efficient, and suitable for small-scale as well as medium-scale agricultural applications.

1.1 Problem Statement

Agriculture is one of the largest consumers of water in India. Traditional irrigation methods such as flood irrigation often lead to excessive water wastage, uneven water distribution, and poor crop management. Many regions in India including Maharashtra, Karnataka, Rajasthan, and Tamil Nadu frequently face water scarcity due to inefficient irrigation practices and irregular rainfall patterns. Farmers still depend on manual irrigation systems, which require continuous human effort and do not provide real-time monitoring of soil conditions. These issues increase operational costs and reduce irrigation efficiency.



(a) Traditional Irrigation


(b) Water Wastage in India

Figure 1.1: Problems in Traditional Irrigation Systems

The major problems associated with traditional irrigation systems are:

- Excessive water wastage due to over-irrigation
- Lack of real-time monitoring of soil conditions
- High dependency on manual labor
- Uneven distribution of water across the field
- Difficulty in remotely monitoring agricultural fields

These limitations create the need for an intelligent irrigation system that can automatically monitor soil conditions and supply water only when required.These issues can negatively affect crop growth, increase operational costs, and lead to inefficient water utilization. Therefore, there is a need for an automated irrigation system that can monitor field conditions and control irrigation intelligently.

1.2 Need for the Project

Water scarcity is becoming a major issue in modern agriculture due to increasing population, irregular rainfall, and inefficient irrigation practices. According to agricultural studies and reports published by the Food and Agriculture Organization (FAO), a significant amount of irrigation water is wasted because of traditional flood irrigation methods [5]. Smart irrigation systems help conserve water by supplying water only when required based on real-time soil conditions.

Different crops require different amounts of water at different stages of growth. For example, crops such as rice require a higher water supply, while crops like wheat, cotton, and pulses require controlled irrigation. Excess watering can damage crops, reduce soil fertility, and increase water wastage. Therefore, an automated irrigation system is necessary to maintain proper soil moisture levels and improve agricultural productivity.

Studies have shown that IoT-based smart irrigation systems can improve water-use efficiency by nearly 40%–60% and increase crop yield through accurate irrigation scheduling [3]. Real-time monitoring using soil moisture sensors and ESP32 controllers helps farmers make better irrigation decisions and reduce manual effort.

(a) Smart Irrigation in Agricultural Field

(b) Soil Moisture Monitoring

Figure 1.2: Need for Smart Irrigation Systems

The major needs for this project include:

- Efficient utilization of water resources
- Reduction in manual labor and human effort
- Real-time monitoring of field conditions
- Improvement in crop productivity
- Support for modern precision agriculture techniques
- Remote accessibility through IoT platforms

1.3 Objectives of the Project

The main objective of the proposed Smart Irrigation System is to develop an automated and intelligent irrigation solution that can monitor soil conditions and control water supply efficiently. The system is designed to reduce water wastage, improve irrigation efficiency, and support modern precision agriculture techniques using IoT technology. By integrating sensors, ESP32 microcontroller, relay modules, and cloud monitoring platforms, the system provides real-time monitoring and automatic irrigation control for agricultural applications.

The important objectives of the project are as follows:

- To automate irrigation using soil moisture sensing technology

  This objective focuses on reducing manual irrigation practices by automatically supplying water whenever the soil moisture level falls below the predefined threshold value.

- To reduce water wastage through intelligent irrigation control

  The system supplies water only when required, thereby preventing over-irrigation and conserving water resources effectively.

- To monitor soil moisture, temperature, and humidity in real time

  Environmental parameters are continuously monitored using sensors to maintain proper field conditions for healthy crop growth.

- To control the water pump automatically using ESP32 and relay modules

  The ESP32 microcontroller processes sensor data and activates the relay module to switch the water pump ON or OFF automatically.

- To display sensor readings on Blynk IoT platform and local web dashboard

  The system provides real-time monitoring through the Blynk mobile application and a local web dashboard for easy accessibility and observation.

- To improve irrigation efficiency and crop health

  Maintaining proper soil moisture helps improve crop productivity and reduces damage caused by insufficient or excess watering.

- To implement a low-cost and energy-efficient smart farming solution

  The project is designed using affordable components such as ESP32 and soil moisture sensors, making it suitable for small-scale and medium-scale farmers.

1.4 Scope of the Project

The scope of the Smart Irrigation System is focused on improving water management and automation in agricultural fields using IoT technology. The system can be used in different agricultural and domestic environments where efficient irrigation is required. By using real-time soil moisture monitoring and automatic pump control, the system helps reduce water wastage and human effort while improving irrigation accuracy.

The project can be implemented in the following areas:

- Agricultural farms

  The system can be used in small-scale and medium-scale farms to automate irrigation and improve crop productivity.

- Greenhouses

  The system helps maintain proper environmental conditions inside greenhouses through controlled irrigation.

- Home gardens

  Smart irrigation can be applied in home gardening systems to reduce unnecessary water usage and support healthy plant growth.

- Nurseries

  Plant nurseries require regular moisture monitoring, and the proposed system helps maintain proper soil conditions automatically.

- Smart farming applications

  The project supports modern smart farming techniques through IoT-based monitoring and automation.

- Water conservation systems

  The system contributes to water conservation by reducing excessive irrigation and optimizing water utilization.

The proposed system can also be expanded in the future by integrating artificial intelligence, weather forecasting systems, GSM communication modules, and solar-powered irrigation technologies for advanced smart agriculture applications. The system can also be expanded in the future by integrating artificial intelligence, weather forecasting systems, and solar-powered irrigation techniques.

1.5 Applications

The Smart Irrigation System has several practical applications in modern agriculture and water management systems. The system helps automate irrigation processes, monitor environmental conditions in real time, and improve efficient utilization of water resources. Due to its low-cost design and IoT-based monitoring capability, the system can be implemented in different agricultural and domestic environments.

The major applications of the proposed system are as follows:

- Automated agricultural irrigation

  The system can automatically control irrigation in agricultural fields based on soil moisture conditions, reducing manual effort and water wastage.

- Smart farming and precision agriculture

  The project supports precision agriculture by continuously monitoring soil and environmental parameters and supplying water accurately according to crop requirements.

- Greenhouse monitoring systems

  The system can be used inside greenhouses to maintain proper soil moisture and environmental conditions for healthy plant growth.

- Home gardening automation

  Smart irrigation technology can also be applied in home gardens and small plantations to automate watering operations.

- Water conservation projects

  The system helps conserve water by reducing unnecessary irrigation and improving efficient water utilization.

- Remote irrigation management

  Using Blynk IoT platform and web dashboard monitoring, farmers can monitor and manage irrigation systems remotely from any location.

The proposed Smart Irrigation System is suitable for both small-scale and medium-scale agricultural applications and supports the development of sustainable farming techniques.

1.6 Advantages of the System

The proposed Smart Irrigation System provides several advantages over traditional irrigation methods. By using soil moisture sensors, ESP32 microcontroller, and IoT-based monitoring, the system improves irrigation efficiency, reduces water wastage, and minimizes human intervention. The automation capability of the system helps farmers monitor field conditions continuously and control irrigation intelligently.

The major advantages of the proposed system are as follows:

- Reduces water wastage

  The system supplies water only when the soil moisture level falls below the threshold value, preventing excessive irrigation and conserving water resources.

- Minimizes human intervention

  Automatic pump control reduces the need for continuous manual monitoring and irrigation operations.

- Provides automatic irrigation control

  The ESP32 controller automatically activates or deactivates the water pump based on real-time soil moisture readings.

- Enables remote monitoring through IoT

  Farmers can monitor sensor readings and pump status remotely using the Blynk IoT application and local web dashboard.

- Improves irrigation efficiency

  Accurate soil moisture monitoring ensures efficient irrigation and proper water distribution across the agricultural field.

- Enhances crop productivity

  Maintaining proper soil moisture conditions helps improve crop growth and overall agricultural productivity.

- Cost-effective and energy-efficient

  The system uses affordable hardware components and consumes less power, making it suitable for practical agricultural applications.

The implementation of smart irrigation technology helps modernize agricultural practices and supports sustainable water management techniques.

Chapter 2

Literature Survey

2.1 Introduction

Smart irrigation systems have become an important research area in modern agriculture due to increasing water scarcity[3] and the growing demand for efficient farming techniques. Researchers and engineers have developed various IoT-based irrigation systems to automate water management and improve agricultural productivity.

Traditional irrigation methods mainly depend on manual operation and fixed watering schedules. These methods often result in over-irrigation, under-irrigation, and unnecessary water wastage. To overcome these limitations, automated irrigation systems using sensors, wireless communication, and microcontrollers have been developed.

The proposed Smart Irrigation System combines IoT technology, sensor-based monitoring, and automation to provide efficient irrigation management with real-time monitoring and remote accessibility.

2.2 Traditional Irrigation Systems

Traditional irrigation systems are widely used in agriculture for supplying water to crops. These methods mainly depend on manual operation and fixed watering schedules. Although traditional irrigation techniques are simple and commonly used, they often result in excessive water wastage and inefficient irrigation management. In many agricultural regions, farmers still rely on conventional irrigation methods that do not provide proper control over water distribution and soil moisture monitoring.

The commonly used traditional irrigation systems are:

- Manual irrigation

Water is supplied manually by farmers using pipes, buckets, or channels. This method requires continuous human effort and proper supervision.

- Flood irrigation

  Large quantities of water are released directly into the agricultural field. Although simple, this method leads to significant water wastage due to over-irrigation and evaporation losses.

- Sprinkler irrigation

  Water is sprayed over crops using sprinkler systems. This method provides better water distribution compared to flood irrigation but still consumes considerable water and electrical power.

- Drip irrigation

  Water is supplied drop by drop near plant roots. Drip irrigation improves water efficiency but requires proper installation and maintenance.

(a) Flood Irrigation Method

(b) Drip Irrigation Method

Figure 2.1: Traditional Irrigation Techniques

Although these irrigation methods are widely used, they suffer from several disadvantages such as:

- Excessive water consumption
- Uneven water distribution
- High labor requirements
- Lack of automation
- Difficulty in monitoring soil conditions

These drawbacks increase operational costs and reduce overall irrigation efficiency. Therefore, modern smart irrigation systems are required for efficient water management and precision agriculture.

2.3 IoT-Based Smart Irrigation Systems

IoT-based smart irrigation systems use sensors, microcontrollers, and internet connectivity to automate irrigation processes and improve water management efficiency [3]. Soil moisture sensors continuously monitor soil conditions and send the collected data to controllers such as ESP32 or Arduino. Based on predefined threshold values, the controller automatically activates or deactivates the irrigation pump.

The collected sensor data can also be uploaded to cloud platforms for remote monitoring and analysis. Farmers can monitor real-time field conditions using mobile applications or web dashboards, which helps improve irrigation accuracy and reduce water wastage.

The major features of IoT-based smart irrigation systems include:

- Automatic irrigation control
- Real-time monitoring
- Remote access through mobile applications
- Efficient water utilization
- Reduced human intervention
- Data logging and analysis

(a) IoT-Based Smart Irrigation

(b) Soil Moisture Sensor Monitoring

Figure 2.2: IoT-Based Smart Irrigation Technologies

IoT-enabled irrigation systems help farmers improve crop productivity, conserve water resources, and automate irrigation management efficiently. These systems support precision agriculture and play an important role in sustainable farming techniques.

2.4 Review of Existing Research Papers

Recent research in smart agriculture focuses on reducing water wastage, improving crop productivity, and automating irrigation systems using IoT technology. Researchers have proposed various systems using soil moisture sensors, wireless sensor networks, ESP32 microcontrollers, and cloud-based monitoring platforms. These studies show that smart irrigation systems improve irrigation efficiency, reduce manual labor, and support precision farming techniques.

2.4.1 IoT Based Smart Irrigation System

Researchers developed an automated irrigation system using soil moisture sensors and microcontrollers to reduce water wastage. The system automatically controls the water pump based on soil moisture conditions and improves irrigation efficiency.

Key Features:

- Automatic pump control
- Soil moisture monitoring

- Reduced water wastage
- Improved crop productivity

2.4.2 Smart Agriculture Monitoring using ESP32

This research focused on using ESP32 for smart agriculture applications [4]. The ESP32 microcontroller was selected because it provides built-in Wi-Fi and Bluetooth connectivity, low power consumption, fast processing capability, and support for real-time sensor monitoring. These features make ESP32 suitable for IoT-based irrigation systems where remote monitoring and automatic control are required. The system used Wi-Fi connectivity for cloud communication and remote monitoring through mobile applications.

Key Features:

- ESP32-based control system
- Wireless monitoring
- Cloud data storage
- Real-time environmental monitoring

2.4.3 Wireless Sensor Network for Smart Farming

Wireless sensor networks are widely used in precision agriculture[6] for monitoring temperature, humidity, soil moisture, and environmental conditions. These systems help farmers make accurate irrigation decisions.

Key Features:

- Sensor-based field monitoring
- Wireless communication
- Energy-efficient operation
- Improved farm management

Figure 2.3: Wireless Sensor Network used in Smart Farming [6]

2.5 Comparison Between Traditional and Smart Irrigation

Traditional irrigation systems mainly depend on manual operation and fixed watering schedules, which often lead to water wastage and inefficient resource utilization. In contrast, smart irrigation systems use sensors, IoT communication, and automated control techniques to optimize water usage based on real-time field conditions. Table 2.1 presents a comparison between traditional irrigation methods and IoT-based smart irrigation systems based on findings reported in previous smart irrigation research studies [3, 6].

Parameter	**Traditional Irrigation**	**Smart Irrigation**
Water Usage	High	Optimized
Human Effort	High	Low
Automation	Not Available	Fully Automated
Remote Monitoring	Not Possible	Possible using IoT
Water Wastage	High	Reduced
Efficiency	Moderate	High
Operational Cost	Higher in long term	Lower in long term

Table 2.1: Comparison of Traditional and Smart Irrigation Systems

Source: Adapted from previous smart irrigation research studies [3, 6].

2.6 Research Statistics

Several agricultural studies have reported that IoT-based smart irrigation systems significantly improve water conservation, reduce manual labor, and increase crop productivity [3, 6].

Parameter	Improvement
Water Conservation	45% – 60%
Increase in Crop Productivity	20% – 30%
Reduction in Manual Labor	50%
Energy Savings	35%
Reduction in Water Wastage	55%

Table 2.2: Benefits of Smart Irrigation Systems

Source: Data compiled from previous smart irrigation research studies [3, 6]

2.7 Advantages of Existing IoT Irrigation Systems

Existing IoT-based irrigation systems provide several advantages in modern agriculture. These systems help farmers monitor field conditions in real time and automate irrigation processes based on soil moisture levels and environmental conditions. By using sensors, wireless communication, and cloud platforms, smart irrigation systems improve water management and reduce unnecessary irrigation. They also reduce human effort and operational costs while improving crop productivity and irrigation efficiency.

The major advantages of existing IoT irrigation systems are:

- Efficient water management
- Automatic irrigation scheduling
- Remote monitoring capability
- Reduced manpower requirement
- Increased agricultural productivity
- Better resource management
- Real-time environmental monitoring

2.8 Limitations of Existing Systems

Although existing smart irrigation systems provide many benefits, certain limitations still exist in practical implementation. Most IoT-based irrigation systems depend heavily on internet connectivity for cloud communication and remote monitoring. This issue can be reduced by providing local monitoring options such as local web dashboards that can operate within the local network even without internet access. Sensor maintenance and calibration are also necessary to ensure accurate readings; however, this problem can be minimized by using durable sensors and performing periodic maintenance.

Another major limitation is the high initial installation cost of smart irrigation systems. This can be overcome by using low-cost microcontrollers such as ESP32 and affordable soil moisture sensors. Power supply dependency is another challenge in remote agricultural fields, which can be addressed using rechargeable batteries or solar-powered backup systems. Some irrigation systems also face scalability issues in large farms, but modular system design and wireless sensor networks can improve scalability and system expansion.

The major limitations of existing systems are:

- Dependence on internet connectivity
- Sensor maintenance requirements
- Initial installation cost
- Power supply dependency
- Limited scalability in some systems

2.9 Proposed System Advantages

The proposed Smart Irrigation System is designed to overcome many drawbacks of existing irrigation solutions by combining IoT technology, automation, and real-time monitoring features. The system uses ESP32 microcontroller technology for reliable wireless communication and efficient data processing. Soil moisture sensors continuously monitor soil conditions and automatically control irrigation whenever required. In addition to cloud-based monitoring through the Blynk platform, the system also provides a local web dashboard for monitoring within the local network. The proposed solution is cost-effective, scalable, and suitable for both small-scale and medium-scale agricultural applications.

The main advantages of the proposed system are:

- Using ESP32 for efficient wireless communication
- Providing both cloud monitoring and local dashboard monitoring
- Using multiple soil moisture sensors for better accuracy

- Offering automatic pump control
- Reducing water and energy wastage
- Providing a low-cost and scalable solution

2.10 Summary

The literature survey shows that IoT-based smart irrigation systems are highly effective in improving irrigation efficiency, reducing water wastage, and supporting precision agriculture techniques [3, 6]. Modern smart farming systems use sensors, wireless communication, cloud platforms, and automation technologies to monitor agricultural fields and control irrigation processes intelligently. These systems help farmers optimize water usage, reduce manual labor, and improve crop productivity.

The proposed Smart Irrigation System combines automation, IoT connectivity, and sensor-based monitoring to provide an efficient, reliable, and cost-effective irrigation solution suitable for modern agriculture. The system supports both cloud-based and local monitoring methods and can be further expanded in the future using artificial intelligence, weather prediction systems, and renewable energy technologies [4].

Chapter 3

System Design and Methodology

3.1 Introduction

The Smart Irrigation System is designed to automate the irrigation process using IoT technology and sensor-based monitoring[3]. The system continuously monitors soil moisture, temperature, and humidity conditions in the agricultural field and automatically controls the water pump whenever irrigation is required.

The entire system is controlled using the ESP32 microcontroller, which processes the sensor data and communicates with cloud and local monitoring platforms through Wi-Fi connectivity[4].

3.2 System Overview

The proposed system consists of both hardware and software components integrated together to achieve automatic irrigation control and real-time monitoring.

The major components of the system are:

- ESP32 Microcontroller
- Soil Moisture Sensors
- DHT Sensor (Temperature and Humidity)
- IR Sensors
- Relay Module
- Water Pump

- Blynk IoT Platform
- Local Web Dashboard
- Wi-Fi Communication

The system monitors the moisture content of the soil continuously[6]. If the moisture level becomes lower than the predefined threshold value, the ESP32 activates the relay module which turns ON the water pump. Once the soil moisture level reaches the required value, the pump is turned OFF automatically.

3.3 Block Diagram

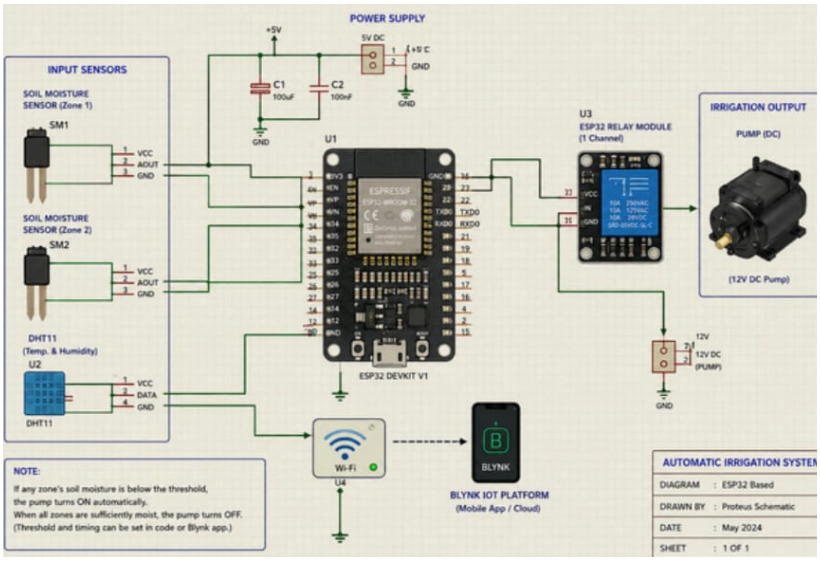


Figure 3.1: Block Diagram of Smart Irrigation System

3.4 System Architecture

The architecture of the Smart Irrigation System is divided into three major sections:

1. Sensor Unit
2. Control Unit
3. Monitoring and Communication Unit

3.4.1 Sensor Unit

The sensor unit consists of:

- Soil Moisture Sensors
- DHT Sensor
- IR Sensors

The sensors continuously collect environmental data from the agricultural field.

3.4.2 Control Unit

The ESP32 microcontroller acts as the main control unit of the system[7]. It receives sensor data, processes the readings, and controls the relay module based on predefined conditions.

3.4.3 Monitoring and Communication Unit

The monitoring unit includes:

- Blynk IoT Cloud Platform
- Local Web Dashboard

The ESP32 sends real-time sensor data through Wi-Fi for remote monitoring and data visualization[4].

3.5 Working Principle

The working of the Smart Irrigation System is explained below:

1. The soil moisture sensors continuously monitor the moisture content in the soil[6].
2. The DHT sensor measures the temperature and humidity of the environment.
3. The IR sensor is used for water flow or object detection purposes.
4. All sensor data is sent to the ESP32 microcontroller.
5. The ESP32 compares the soil moisture readings with predefined threshold values.
6. If the soil is dry, the ESP32 activates the relay module.

7. The relay module turns ON the water pump automatically.
8. Water is supplied to the field through irrigation pipes.
9. Once sufficient moisture is detected, the ESP32 turns OFF the pump.
10. The collected data is displayed on the Blynk IoT platform and local web dashboard.

3.6 Hardware Components

3.6.1 ESP32 Microcontroller

ESP32 is a powerful Wi-Fi and Bluetooth-enabled microcontroller used as the main controller of the system.

Features of ESP32:

- Built-in Wi-Fi and Bluetooth
- Dual-core processor
- Low power consumption
- Multiple GPIO pins
- High processing capability

3.6.2 Soil Moisture Sensor

The soil moisture sensor measures the water content present in the soil. It helps determine whether irrigation is required or not.

Functions:

- Detect soil dryness
- Monitor moisture levels
- Provide analog/digital output

Two soil moisture sensors are used in the project:

- One at the beginning of the field
- One at the end of the field

This arrangement improves irrigation monitoring accuracy[6].

3.6.3 DHT Sensor

The DHT sensor measures:

- Temperature
- Humidity

Environmental monitoring helps improve irrigation management.

3.6.4 Relay Module

The relay module acts as an electronic switch used to control the water pump.

Functions:

- Turns ON/OFF the water pump
- Provides isolation between ESP32 and pump
- Enables automatic switching

3.6.5 IR Sensor

The IR sensor is used for:

- Water flow detection
- Object sensing
- Additional monitoring purposes

3.6.6 Water Pump

The water pump supplies water to the agricultural field whenever irrigation is required.

3.7 Software Requirements

The software tools used in the project are:

Software	**Purpose**
Arduino IDE	Programming ESP32
Blynk IoT Platform	Cloud Monitoring
Embedded C/C++	Programming Language
Web Dashboard	Local Monitoring

Table 3.1: Software Requirements

3.8 Circuit Connections

The major circuit connections are:

- Soil moisture sensors connected to ESP32 analog pins
- DHT sensor connected to digital GPIO pin
- Relay module connected to output GPIO pin
- Water pump connected through relay module
- ESP32 connected to Wi-Fi network

3.9 Flowchart of the System

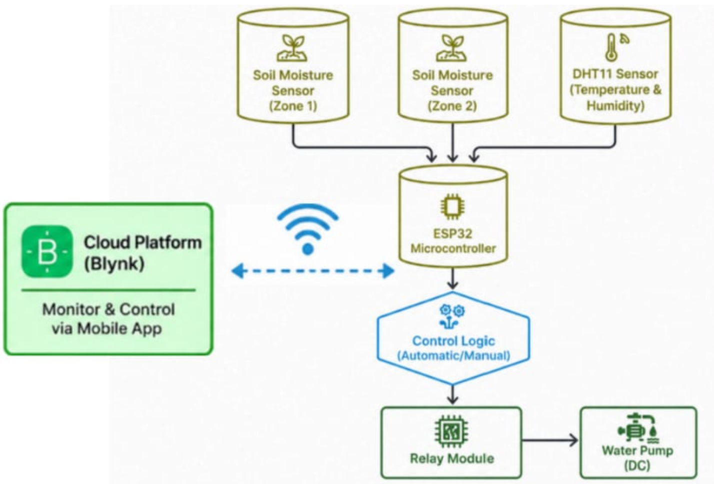


Figure 3.2: Flowchart of Smart Irrigation System

3.10 Methodology

The methodology followed in the project is:

1. Collection of sensor data from the field
2. Processing data using ESP32
3. Comparing moisture values with threshold values
4. Automatic activation/deactivation of water pump

5. Uploading sensor data to Blynk cloud[3]
6. Displaying readings on local web dashboard
7. Continuous monitoring and control

3.11 Advantages of the Proposed Methodology

- Fully automated irrigation
- Real-time monitoring
- Efficient water utilization[8]
- Remote accessibility
- Reduced manual effort
- Low-cost implementation
- Scalable for larger farms

3.12 Summary

This chapter explained the methodology and working process of the proposed Smart Irrigation System using IoT technology. The system integrates ESP32, soil moisture sensors, relay modules, Blynk cloud platform, and a local web dashboard to automate irrigation and monitor field conditions in real time. Sensor data is continuously collected and processed to control the water pump automatically based on soil moisture levels.

The proposed methodology helps reduce water wastage, minimize manual effort, and improve irrigation efficiency. Cloud monitoring and local dashboard support enable remote accessibility and real-time monitoring, making the system suitable for modern smart agriculture applications. The overall design is low-cost, scalable, and energy-efficient for practical agricultural use[3, 4].

Chapter 4

Implementation and Results

4.1 Introduction

This chapter explains the implementation process of the Smart Irrigation System and the results obtained after testing the system. The hardware components were assembled and programmed to automate irrigation based on soil moisture conditions.

The system was tested under different soil moisture levels to analyze its performance, water management capability, and automation efficiency.

4.2 Hardware Implementation

The Smart Irrigation System was implemented using the following hardware components:

- ESP32 Microcontroller
- Soil Moisture Sensors
- DHT Temperature and Humidity Sensor
- IR Sensors
- Relay Module
- Water Pump
- Power Supply
- Connecting Wires

The components were connected according to the circuit design. The ESP32 microcontroller was used as the central controller for collecting sensor data and controlling the irrigation process[7].

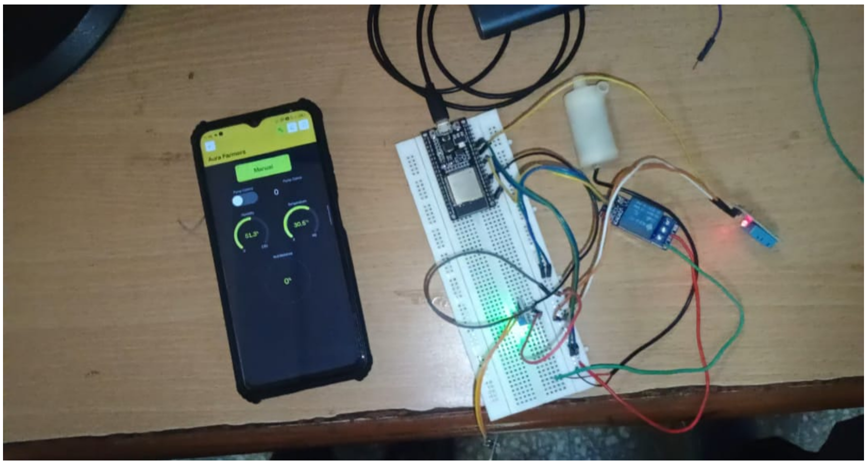


Figure 4.1: Hardware circuit

4.3 Software Implementation

The software implementation was carried out using Arduino IDE[9]. The ESP32 was programmed using Embedded C/C++ language[4].

The program performs the following tasks:

- Reads soil moisture sensor values
- Reads temperature and humidity data
- Compares moisture values with threshold values
- Controls the relay module automatically
- Sends sensor data to Blynk IoT platform
- Hosts a local web dashboard for monitoring

4.4 Wi-Fi and IoT Connectivity

The ESP32 was connected to a Wi-Fi network for cloud communication. The sensor readings and pump status were uploaded to the Blynk IoT cloud platform[3].

The Blynk platform provided:

- Real-time sensor monitoring
- Remote accessibility
- Mobile-based monitoring
- Pump status indication
- Environmental data visualization

A local web dashboard was also created to display the readings within the local network.

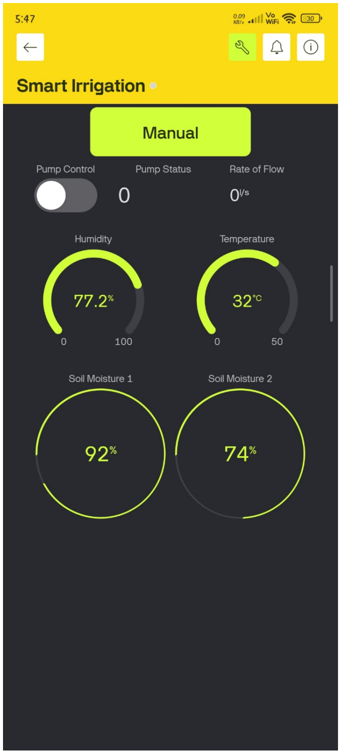


Figure 4.2: Blynk IOT Output

4.5 System Operation

The working operation of the system is explained below:

1. Soil moisture sensors continuously monitor soil conditions.
2. The DHT sensor measures environmental temperature and humidity.

3. Sensor data is sent to the ESP32.
4. The ESP32 compares the moisture level with predefined threshold values.
5. If the soil becomes dry, the relay module is activated.
6. The relay module turns ON the water pump.
7. Water is supplied to the field automatically.
8. Once the required moisture level is reached, the pump turns OFF.
9. The readings are updated on Blynk IoT and the local dashboard.

4.6 Experimental Setup

The experimental setup was designed to test the performance of the Smart Irrigation System under different soil moisture conditions. For efficient irrigation, soil moisture levels between 40% and 60% are generally considered suitable for most agricultural crops, while moisture levels below 30% indicate dry soil conditions requiring irrigation. Moisture levels above 70% indicate excessive water content, where irrigation should be stopped to avoid overwatering.

The experimental setup included:

- A small agricultural soil testing area
- Two soil moisture sensors placed at different positions
- Water pump connected through relay module
- ESP32 controller with Wi-Fi connectivity
- Monitoring through Blynk mobile application and local website

One soil moisture sensor was placed at the beginning of the field while the second sensor was placed at the end of the field to monitor moisture distribution accurately [6].

4.7 Observation Table

The system was tested under different soil moisture conditions and the following observations were recorded.

Soil Moisture (%)	**Pump Status**	**Condition**
20%	ON	Dry Soil
35%	ON	Moderate Moisture
60%	OFF	Sufficient Moisture
80%	OFF	Wet Soil

Table 4.1: Observation Table of Smart Irrigation System

4.8 Sensor Readings

The following environmental readings were observed during system testing.

Time	**Temperature (°C)**	**Humidity (%)**	**Pump Status**
09:00 AM	29	65	OFF
11:00 AM	33	55	ON
01:00 PM	36	48	ON
04:00 PM	31	60	OFF

Table 4.2: Environmental Sensor Readings

4.9 Results Obtained

The Smart Irrigation System produced the following results:

- Accurate soil moisture detection
- Automatic control of water pump
- Reduction in unnecessary water usage
- Real-time environmental monitoring
- Successful cloud data transmission using Blynk
- Successful display of readings on local web dashboard
- Reduced manual intervention
- Improved irrigation efficiency

4.10 Performance Analysis

The performance of the system was analyzed based on:

- Water conservation
- Automation efficiency
- Sensor response accuracy
- Real-time monitoring capability
- Reliability of pump control

The system responded effectively to changing soil moisture conditions and successfully automated the irrigation process.

4.11 Advantages Achieved

The implemented system provided several advantages:

- Reduced water wastage
- Efficient irrigation management
- Low power consumption
- Remote field monitoring
- Cost-effective automation
- Improved crop management
- Reduced human effort[8]

4.12 Challenges Faced During Implementation

Some challenges faced during implementation were:

- Sensor calibration issues
- Wi-Fi connectivity fluctuations
- Moisture sensor sensitivity variations
- Power supply stability
- Environmental disturbances during testing

These challenges were minimized through proper calibration and stable circuit connections.

4.13 Project Output

The final system successfully:

- Automated irrigation using IoT
- Controlled the water pump automatically
- Monitored environmental conditions
- Sent real-time data to cloud platform
- Displayed readings on local dashboard
- Improved irrigation efficiency

The developed hardware prototype of the Smart Irrigation System was successfully implemented and tested. The system integrated soil moisture sensing, automatic pump control, and IoT-based monitoring using ESP32 and Blynk platform.

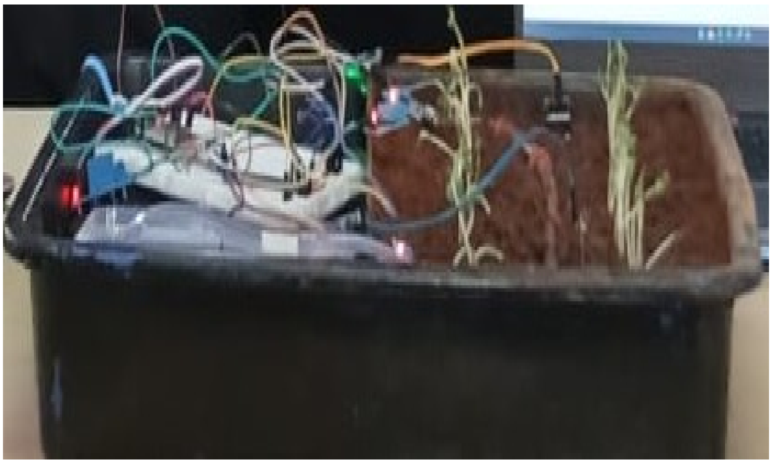


Figure 4.3: Final Working Model of Smart Irrigation System

4.14 Local Web Dashboard Output

A local web dashboard was developed using the ESP32 web server feature to display real-time sensor readings and irrigation status within the local network. The dashboard provides an easy-to-use graphical interface for monitoring important agricultural parameters.

The dashboard displays:

- Soil Moisture Sensor 1 Reading
- Soil Moisture Sensor 2 Reading
- Temperature Reading
- Humidity Reading
- Water Flow Rate
- Pump Status

The ESP32 hosts the webpage locally and updates the sensor readings in real time[4]. The dashboard can be accessed through the IP address assigned to the ESP32 in the local Wi-Fi network.

Figure below shows the developed Smart Irrigation Dashboard displaying live sensor data and pump status.

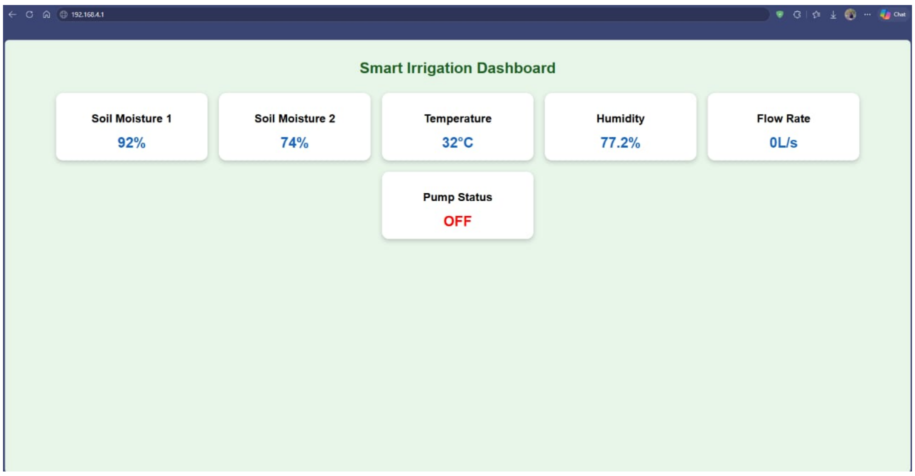


Figure 4.4: Smart Irrigation Local Web Dashboard

The dashboard successfully displayed:

- Soil Moisture 1 = 92%
- Soil Moisture 2 = 74%
- Temperature = 32°C
- Humidity = 77.2%
- Flow Rate = 0 L/s
- Pump Status = OFF

The local dashboard improved system usability by providing a real-time monitoring interface without requiring external cloud access.

4.15 Summary

This chapter discussed the implementation process and experimental results of the Smart Irrigation System. The system successfully automated irrigation using soil moisture sensing and IoT-based monitoring[3]. The obtained results demonstrate that the proposed system is efficient, reliable, and suitable for smart agriculture applications.

Chapter 5

Conclusion

This project successfully demonstrates the design and implementation of a Smart Irrigation System using sensors and microcontroller-based automation. By integrating soil moisture sensing with environmental monitoring, the system is capable of making real-time decisions to control irrigation effectively. Unlike traditional irrigation methods that rely on manual operation or fixed schedules, this system ensures that water is supplied only when required, thereby significantly reducing water wastage and improving overall efficiency.

The developed system proves to be reliable, responsive, and cost-effective, making it highly suitable for small and medium-scale agricultural applications. The use of components such as soil moisture sensors, DHT sensors, microcontrollers (ESP32), and relay modules ensures accurate monitoring and precise control of irrigation. The automated operation minimizes human intervention, reduces labor effort, and prevents issues such as over-irrigation and soil nutrient loss, which are common in conventional methods.

Furthermore, this project highlights the practical application of embedded systems and sensor technology in solving real-world agricultural problems. It demonstrates how simple electronic components can be combined to create an intelligent system that supports sustainable farming practices. The system also provides flexibility for future enhancements such as IoT integration, remote monitoring, data logging, and AI-based irrigation scheduling, which can further improve performance and usability.

In conclusion, the Smart Irrigation System meets its objectives of efficient water management, automation, and cost-effectiveness. It contributes to precision agriculture by optimizing resource utilization and improving crop productivity. This project not only serves as a valuable learning experience in electronics and system design but also presents a meaningful solution with significant social and environmental impact.

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Appendix A

Datasheets

ESP32

The ESP32 is a powerful microcontroller with built-in Wi-Fi and Bluetooth capabilities. It is used to process sensor data and control the irrigation system. Compared to Arduino, it provides higher processing power and supports IoT-based applications.

Key Features:

- Operating Voltage: 3.3V
- Input Voltage: 5V (via USB)
- CPU: Dual-core processor
- Clock Speed: Up to 240 MHz
- Wi-Fi: 802.11 b/g/n
- Bluetooth: v4.2 (BLE)
- GPIO Pins: 30+
- ADC Channels: 12-bit resolution

Datasheet: `https://cdn.sparkfun.com/datasheets/IoT/esp32_datasheet_en.pdf`

DHT11 Temperature and Humidity Sensor

The DHT11 is a digital sensor used for measuring temperature and humidity. It provides calibrated output and communicates with the ESP32 using a single-wire protocol.

Key Features:

- Operating Voltage: 3.3V – 5V
- Temperature Range: 0°C to 50°C
- Humidity Range: 20% to 90% RH
- Accuracy: ±2°C, ±5% RH
- Output: Digital

Datasheet: `https://www.mouser.com/datasheet/2/758/DHT11-Technical-Data-Shee` `pdf?srsltid=AfmBOopRIo9OkqbEOseZxXaZxmdwJLnsp-3Ku-mDii5W4KmiTwtLk9My`

Soil Moisture Sensor

This sensor measures soil moisture by detecting conductivity between probes. It provides analog output to ESP32 for real-time monitoring.

Key Features:

- Operating Voltage: 3.3V – 5V
- Output: Analog and Digital
- Adjustable sensitivity
- Application: Soil moisture detection

Datasheet: `https://handsontec.com/dataspecs/sensor/Soil%20Moisture%20Sensor.pdf`

Relay Module (5V)

The relay module allows ESP32 to control high-power devices like water pumps. It acts as a switch and provides electrical isolation.

Key Features:

- Operating Voltage: 5V
- Control Signal: Digital input
- Switching Capacity: 250V AC / 10A
- Isolation: Optocoupler-based

Datasheet: `https://mm.digikey.com/Volume0/opasdata/d220001/medias/docus/5773/TS0010D%20DATASHEET.pdf`

Water Pump (DC Pump)

The water pump is used to deliver water to the field. It is controlled automatically through the relay module.

Key Features:

- Operating Voltage: 5V / 9V / 12V
- Type: DC submersible pump
- Application: Irrigation and water supply

Datasheet: `https://www.scribd.com/document/420329697/pump-data-sheet`