Design and Implementation of an IoT Based Water Level And Soil Moisture Monitoring System

A Project

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SONARGAON UNIVERSITY (SU)

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Abstract

The Water Level and Soil Moisture Monitoring System is an IoT-based solution designed to automate the management of water resources, including water tank levels and soil moisture content. This system uses an Ultrasonic Sensor for measuring water levels in tanks, a Soil Moisture Sensor to monitor the moisture content in the soil, and a Node MCU for processing the data and controlling the pumps. The water tank is managed automatically based on the readings from the ultrasonic sensor, while the field irrigation pump is controlled remotely through the Blynk app based on real-time soil moisture data. The system employs a 2-Channel Relay Module to control the activation of two mini water pumps, one for the field and one for the water tank. The water tank pump is automatically activated when the water level falls below a certain threshold, while the irrigation pump is triggered when soil moisture levels drop, ensuring optimal water usage. Additionally, an LCD with I2C provides users with real-time feedback on the system's status, while the Blynk app offers remote monitoring and control from a smartphone. This project aims to optimize water consumption, reduce waste, and enhance the efficiency of irrigation and water tank management in agricultural, residential, and industrial settings. The system is easy to implement, energy-efficient, and scalable, with potential applications in farming, smart homes, parks, and other public spaces. Through this system, water conservation can be significantly improved, contributing to more sustainable resource management.

Chapter -1
Introduction

1.1 Introduction

In recent years, the need for efficient water management has become increasingly important due to rising water scarcity and the growing demands of agriculture, industry, and household consumption. Traditional methods of water usage are often wasteful and inefficient, leading to water shortages, especially in areas where water is a limited resource. This project aims to address this issue by developing a Water Level and Soil Moisture Monitoring System that can automate water management and facilitate remote control and monitoring.

This system utilizes a combination of sensors, actuators, and cloud-based technologies to monitor the water level in a tank and the soil moisture in fields, providing an integrated solution for better resource management. The project leverages modern technologies such as Node MCU, a popular microcontroller board, to control two mini water pumps — one for filling a water tank and the other for irrigating a field. The system incorporates an Ultrasonic sensor to measure the water level and a Soil Moisture sensor to assess the moisture content in the soil. Additionally, a 2-Channel Relay module is used to control the pumps, and an LCD with I2C is employed to provide real-time data locally.

One of the key components of the project is the Blynk app, which enables remote monitoring and control of the system via a smartphone. The app allows users to interact with the system, providing them with data such as soil moisture levels and water tank levels in real-time. Furthermore, the water tank pump is designed to operate automatically when the water level falls below a certain threshold, ensuring that the tank is always filled without manual intervention.

The 5V SMPS (Switched-Mode Power Supply) is used to power the Node MCU and sensors, while a 9V Adapter powers the water pumps, ensuring they receive the necessary power for operation. This integrated system helps reduce water wastage by automating irrigation processes based on soil moisture content, while also ensuring that the water tank is maintained at an optimal level, eliminating the risk of running out of water during critical moments.

The goal of this project is to create an efficient, low-cost, and automated water management solution that can be used in agricultural fields, homes, and other water-dependent applications. By integrating IoT (Internet of Things) and cloud technologies, this system can provide a convenient and sustainable approach to managing water resources, ultimately leading to improved water conservation, reduced human intervention, and more effective agricultural practices.

In summary, this thesis presents the design and implementation of a water level and soil moisture monitoring system that is powered by the Node MCU, controlled remotely via the Blynk app, and uses sensors for real-time monitoring. The system aims to automate the management of water resources, offering an efficient solution to the growing need for smart water management in today's world.

1.2Objectives

Aims of a proposed system is:

- To design a smart irrigation system based on soil moisture and water level data.
- To construct a functional prototype using NodeMCU, sensors, and IoT technologies.
- To test the performance of the system under real-time environmental conditions.
- To automate the irrigation process using real-time soil moisture sensor readings.
- To monitor and manage the water tank level using an ultrasonic sensor to prevent overflow and shortages.
- To enable remote monitoring and control of the system through the Blynk mobile application.
- To optimize water usage and minimize wastage in agricultural, residential, and industrial settings.
- To promote water conservation and support sustainable resource management practices.
- To display real-time system feedback using an LCD with I2C communication

1.3 Project Methodology:

The Project Methodology for the Water Level and Soil Moisture Monitoring System:

1. **System Design and Planning**
    - Defining the objectives and requirements for the system, including the selection of sensors, pumps, and microcontroller.
    - Planing the integration of the components (Ultrasonic Sensor, Soil Moisture Sensor, Node MCU, Relay Modules, Water Pumps, etc.) and the communication protocols for remote monitoring.
2. **Hardware Selection**
    - Selecting appropriate sensors: **Ultrasonic Sensor (HC-SR04)** for water level measurement and **Soil Moisture Sensor** for detecting soil moisture.
    - Choosing a **Node MCU (ESP8266)** to handle the sensor data processing and communication with the Blynk app.
    - Using a **2-Channel Relay Module** to control the water pumps based on sensor readings.
    - Selecting an **LCD with I2C** for local display of water level and soil moisture status.
3. **Circuit Design and Assembly**
    - Connecting the sensors, Node MCU, and relay module to the breadboard, ensuring proper wiring for power and signal transmission.
    - Setting up the **Ultrasonic Sensor** and **Soil Moisture Sensor** to feed data to the Node MCU.
    - Wiring the relay module to the Node MCU to control the pumps for irrigation and water tank management.
    - Using jumper wires to connect all components, ensuring secure and stable connections.

4. **Software Development**
    - Programing the **Node MCU** using the **Arduino IDE** to handle sensor data collection and processing.
    - Developing algorithms to control the pumps: activate the **field pump** based on soil moisture readings and the **water tank pump** based on ultrasonic water level data.
    - Integrating the system with the **Blynk app** for remote monitoring and control. Programing the app to receive and display real-time data on water levels and soil moisture, and allow control over the pumps.
5. **Testing and Calibration**
    - Testing each component individually (sensor calibration, pump control via relay) to ensure proper functioning.
    - Testing the **Blynk app** connectivity for remote control and monitoring.
    - Calibrating the **Soil Moisture Sensor** and **Ultrasonic Sensor** to ensure accurate readings in different environmental conditions.
    - Simulating different water level and soil moisture conditions to verify that the system responds appropriately (activating/deactivating pumps).
6. **Integration and Final Testing**
    - Integrating all components (hardware and software) into a fully functioning system.
    - Testing the system under various conditions, such as low water levels, dry soil, and normal conditions, ensuring the pumps function correctly based on real-time sensor data.
    - Ensuring the **LCD display** is showing accurate, real-time information about soil moisture and water levels.
7. **System Deployment and Monitoring**
    - Deploying the system in a real-world environment (such as a garden or farm) for continuous monitoring and management.

- Regularly monitoring system performance, adjust sensor thresholds if needed, and perform maintenance as required.

8. **Documentation and Final Reporting**
    - Documenting the design process, components, wiring diagrams, and code.
    - Preparing a detailed report on the methodology, results, system performance, and potential improvements.

By following these steps, the project aims to provide a fully functional and reliable water level and soil moisture monitoring system that can optimize water usage, conserve resources, and be managed remotely through the Blynk app.

Chapter-2
System components

2.1 Experimental Equipment

The proposed system is made of several components and they are:

- Ultrasonic Sensor (HC-SR04)
- Soil Moisture Sensor
- Node MCU (ESP8266)
- 2-Channel Relay Module
- Mini Water Pumps (2)
- 5V SMPS (Switched-Mode Power Supply)
- 9V Adapter
- LCD Display with I2C Module
- Jumper Wires and Breadboard

2.2 Hardware:

A Water Level Monitoring system designed with Node MCU, Ultrasonic Sensor, Soil Moisture sensor, Water Pump, Relay module, LCD, Adapter and several essential hardware components, each playing a critical role in its operation. Below is an outline of these components:

2.2.1 SMPS

A switched-mode power supply (SMPS) is an electronic circuit that converts power using switching devices that are turned on and off at high frequencies, and storage components such as inductors or capacitors to supply power when the switching device is in its non-conduction state. Switching power supplies have high efficiency and are widely used in a variety of electronic equipment, including computers and other sensitive equipment requiring stable and efficient power supply. A switched-mode power supply is also known as a switch-mode power supply or switching-mode power supply.



Figure 2.1: SMPS

2.2.2 Node MCU

we use a NodeMCU or ESP8266 development Board which is transformation of ESP12E wifi module and containing the ESP8266 chip which capacity is 32-bit LX106 RISE. It supports RTOS and it can operate 80MHz to 160MHz with adjustable clock frequency. It contain 1280 KB RAM and also 4 MB of flash memory to store data and programs. In this module we find wi-fi and Bluetooth and deep sleep operating features that make it ideal for IoT Projects. This ESP8266 is a family of Wi-Fi modules developed by the Chinese company Espressif.



Figure 2.2: Node MCU

2.2.3 Relay

The relay permits a small amount of electrical current to control high current loads. When voltage is supplied to the coil, small current passes through the coil, resulting in a larger amount of current passing through the contacts to control the electrical load. Relays are electrically operated switches that open and close the circuits by receiving electrical signals from outside sources. Some people

may associate “relay” with a racing competition where members of the team take turns passing batons to complete the race. The “relays” embedded in electrical products work in a similar way; they receive an electrical signal and send the signal to other equipment by turning the switch on and off. For example, when you push the button on a TV remote to watch TV, it sends an electrical signal to the “relay” inside the TV, turning the main power ON. There are various types of relays used in many applications to control different amounts of currents and number of circuits.

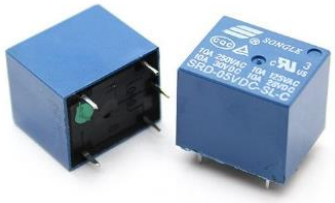


Figure 2.3: Relay

2.2.4 Adapter 9V

A 9V adapter is a power supply unit designed to convert alternating current (AC) from a standard wall outlet into a stable 9V direct current (DC) output. This DC output is used to power electronic devices that require 9V for operation, such as small motors, water pumps, or sensors. The adapter typically comes with a barrel jack connector, which fits into the power input of the device being powered. In your water level and soil moisture monitoring system, the 9V adapter would be responsible for powering the water pumps, which require higher voltage than components like the Node MCU or sensors. By providing a consistent 9V DC, the adapter ensures reliable operation of these high-power components in your system.



Figure 2.4: Adapter

2.2.5 LCD

The I2C LCD component is used in applications that require a visual or textual display. This component is also used where a character display is needed but seven consecutive GPIOs on a single GPIO port are not possible. In cases where the project already includes an I2C master, no additional GPIO pins are required.



Figure 2.5: LCD

2.2.6 Soil Moisture Sensor

Soil moisture sensors are used in numerous research applications, e.g. in agricultural science and horticulture including irrigation planning, climate research, or environmental science including solute transport studies and as auxiliary sensors for soil respiration measurements.

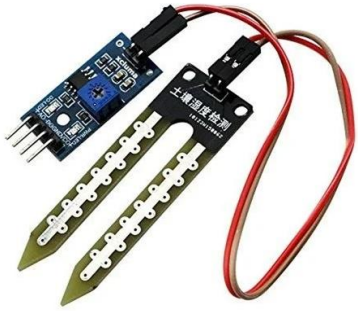


Figure 2.6: Soil Sensor

2.2.7 Ultrasonic Sensor

Ultrasonic sensors can detect the movement of targets and measure the distance to them in many automated factories and process plants. Sensors can have an on or off digital output for detecting the movement of objects, or an analog output proportional to distance.



Figure 2.7: Ultrasonic Sensor

2.2.8 Mini Water Pump

A 5V DC mini water pump is a small water pump designed to operate on a 5-volt direct current (DC) power supply. These pumps are commonly used in various applications where a compact and low-power water pumping solution is required.



Figure 2.8: Water Pump

Chapter-3
Design and Implementation

3.1 Circuit Diagram

Here we included the Circuit diagram of our proposed system. Here we try to show different components of this system with proper connection in bellow. You See here that we make sure 220V AC supply to our SMPS to get 5V DC output that will be use here to power on all of our sensors and Microcontroller.

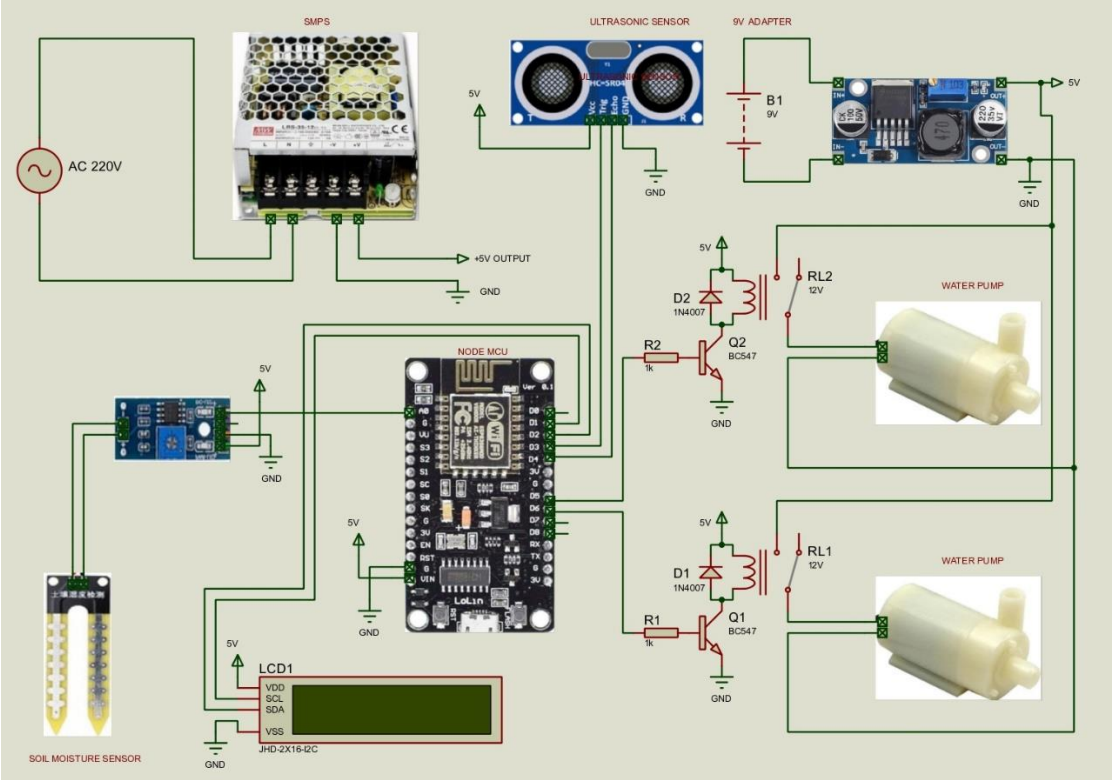


Figure 3.1: Circuit diagram of Proposed System.

Here we use Node MCU to control our system as per our program. It will read all sensors value and will take necessary steps. One LCD Display is use here to show full operational output manually. Soil Moisture sensor will read amount of the water in soil and that will show in our LCD display and Blynk app also. When we need to Turn on water pump at that time we need to switch on from our blynk app then water pump will be running and we will switch off from our blynk app then it will be turn off again. Ultrasonic Sensor will measure water level of Water Tank. If water level is showing high, Node MCU will send command to relay to turn OFF water Pump. on the other hand, if water level is showing low, then Node MCU will send command to relay to turn ON

water Pump. This full operational output will be showing on LCD and will be sent all sensors data to Blynk IoT Platform to monitoring from remote area.

3.2 Block Diagram

Here we included the block diagram of our proposed system. In this system we try to show different part of working as different blocks in bellow. You See here that we make sure 220V AC supply to our SMPS to get 5V DC output that will be use here to power on all of our sensors and Microcontroller.

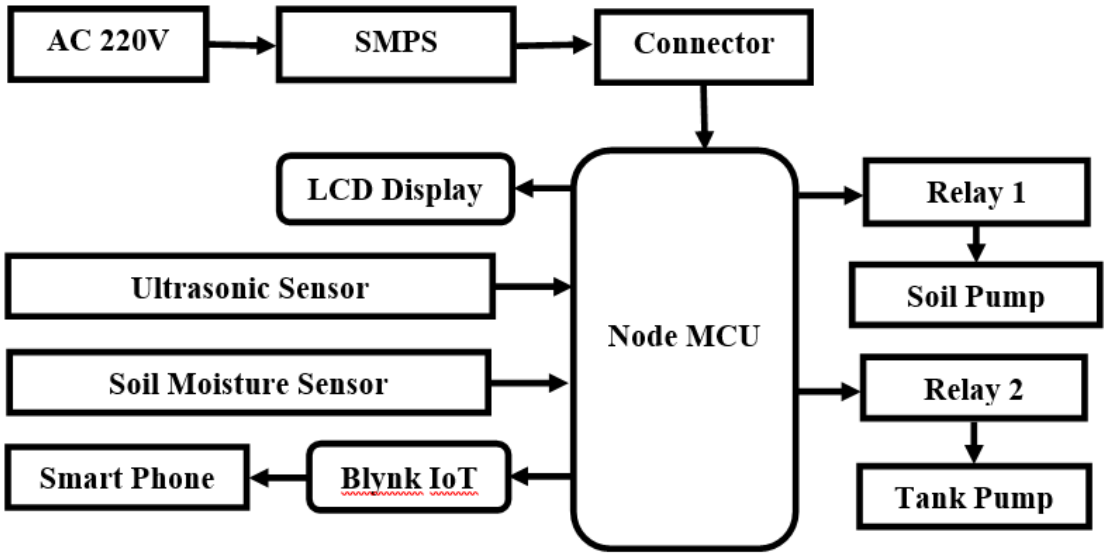


Figure 3.2: Block Diagram of Proposed System.

Here we use Node MCU to control our system as per our program. It will read all sensors value and will take necessary steps. One LCD Display is use here to show full operational output manually. Soil Moisture sensor will read amount of the water in soil and that will show in our LCD display and Blynk app also. When we need to Turn on water pump at that time we need to switch on from our blynk app then water pump will be running and we will switch off from our blynk app then it will be turn off again. Ultrasonic Sensor will measure water level of Water Tank. If water level is showing high, Node MCU will send command to relay to turn OFF water Pump. on the other hand, if water level is showing low, then Node MCU will send command to relay to turn ON water Pump. This full operational output will be showing on LCD and will be sent all sensors data to Blynk IoT Platform to monitoring from remote area.

3.3 Full overview

This is the Full overview of our IoT Based Water Level Monitoring system.



Figure 3.3: Full overview of Proposed System.

3.4 Applications

Applications of the Water Level and Soil Moisture Monitoring System:

Agriculture and Smart Farming

- Automated irrigation for optimal crop growth.
- Water conservation and efficient irrigation management.

Home Gardens and Landscaping

- Automated watering of gardens and lawns.
- Water tank monitoring to prevent overflow.

Greenhouses and Horticulture

- Optimized watering and humidity control in greenhouses.
- Suitable for hydroponics and vertical farming setups.

Industrial Applications

- Monitoring water levels in industrial water tanks.
- Use in water treatment plants for efficient water management.

Irrigation Systems in Parks and Public Spaces

- Automated irrigation in public parks and recreational areas.
- Efficient water usage in municipal landscapes.

Environmental Monitoring and Water Conservation

- Contributes to water conservation efforts.
- Can be used in smart cities for optimized water usage.

Rural and Remote Areas

- Water management in rural and remote locations.
- Integration with rainwater harvesting systems.

Educational and Research Purposes

- Used in academic research related to water management and agriculture.
- Hands-on learning tool for STEM education.

Pumping Stations and Water Distribution Systems

- Monitoring and controlling water levels in pumping stations.
- Enhances efficiency in water distribution networks.

Chapter - 4
Analysis of Results

4.1 Result

Here we will show the operational output of our proposed system.



Figure 4.1: Showing Water Level and Soil Moisture Value in LCD



Figure 4.2: Showing Water Level and Soil Moisture Value in Blynk app LCD.



Figure 4.3: Showing Water Level and Soil Moisture Value in Blynk app Dashboard.



Figure 4.4: Water Pump is on to filling Water Tank.



Figure 4.5: Soil Moisture Value Low Detecting.



Figure 4.6: Water Pump is ON after get command from Blynk App.

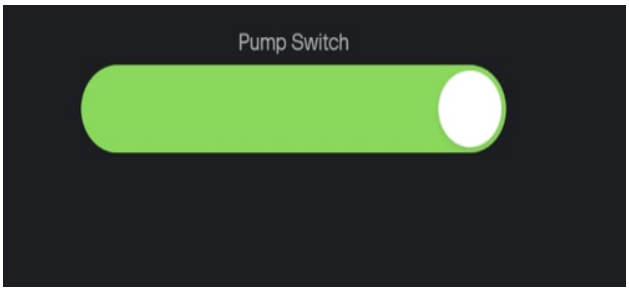


Figure 4.7: Pump Switch ON in Blynk app.



Figure 4.8: Pump Switch OFF in Blynk app.

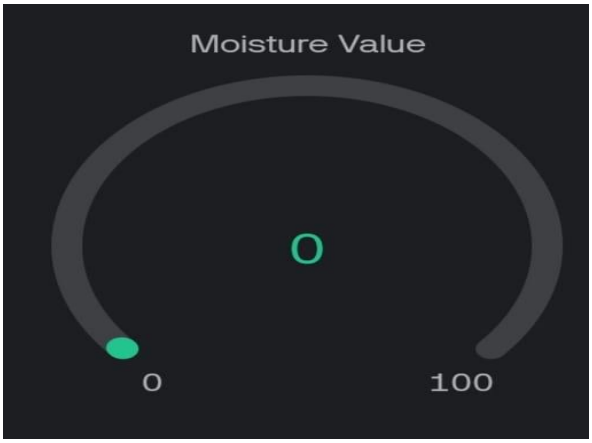


Figure 4.9: Moisture Value Low

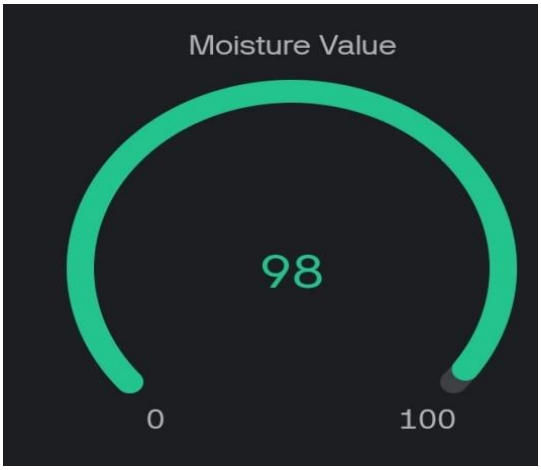


Figure 4.10: Moisture Value High

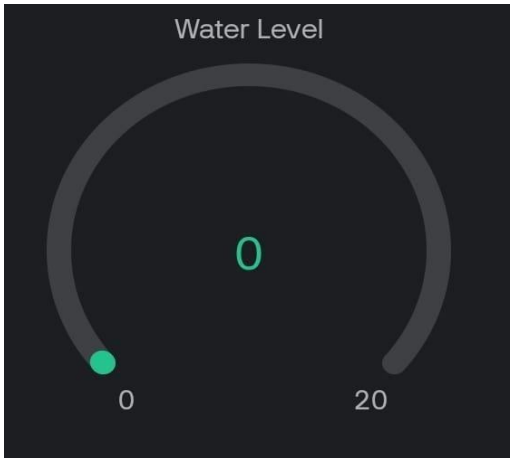


Figure 4.11: Water Level Low



Figure 4.12: Water Level High

Chapter - 5
Benefits and limitation

5.1 Advantages:

Advantages of the Water Level and Soil Moisture Monitoring System:

Efficient Water Usage: Reduces water wastage by activating irrigation only when soil moisture is low, ensuring optimal use of water resources.

Automation: Automates water level control in tanks and irrigation processes, minimizing human intervention and reducing labor costs.

Remote Monitoring and Control: Enables real-time monitoring and control via the Blynk app, allowing users to manage the system remotely from any location.

Cost Savings: Helps reduce water consumption, leading to potential savings in water bills, especially in areas with high water costs.

Sustainability: Promotes water conservation by ensuring that irrigation and water tank refills only occur when necessary, contributing to sustainable water management.

Prevention of Overflow and Shortage: The ultrasonic sensor ensures that water tanks are filled to optimal levels, preventing overflow or water shortages.

Easy Integration with Existing Systems: The system can be easily integrated into existing irrigation and water tank setups, making it adaptable to different environments.

Real-Time Data: Provides up-to-date data on water levels and soil moisture, allowing for better decision-making and timely interventions.

Scalable and Customizable: Can be expanded to control multiple irrigation zones or integrated into larger water management systems as needed.

Energy Efficiency: Utilizes energy-efficient components, reducing overall power consumption and operational costs.

User-Friendly: The LCD display and Blynk app interface provide easy-to-understand, accessible data for users, making the system simple to operate and monitor.

Improved Crop Yields: By ensuring optimal watering schedules based on real-time soil moisture data, the system can help improve crop health and yield.

Flexibility for Various Applications: Suitable for agriculture, home gardens, industrial applications, and environmental monitoring, making it a versatile solution for water management.

5.2 Disadvantages

Disadvantages of the Water Level and Soil Moisture Monitoring System:

Initial Setup Cost: The cost of purchasing sensors, microcontrollers, water pumps, and other components may be high for small-scale users or low-budget applications.

Dependency on Internet Connectivity: The remote monitoring and control features rely on internet access, making the system less effective in areas with unreliable or no internet connectivity.

Maintenance and Calibration: Regular maintenance and calibration of sensors (soil moisture and ultrasonic sensors) are required to ensure accurate readings and prevent system malfunctions.

Limited Power Supply Options: The system may require external power sources, such as 9V adapters or 5V SMPS, which could be a limitation in areas with unstable power supply or no access to mains electricity.

System Complexity: The integration of multiple components, including sensors, microcontrollers, pumps, and mobile apps, can make the system complex to set up, especially for non-technical users.

Sensor Sensitivity and Accuracy: Soil moisture sensors may not always provide accurate readings, especially in heterogeneous soils, leading to possible over-irrigation or under-irrigation.

Dependency on External Power for Pumps: The water pumps in the system rely on external power (like the 9V adapter), which can be a limitation if power outages occur or if there are issues with the power supply.

Limited Pumping Capacity: The mini water pumps used in the system might have limited capacity for larger irrigation needs, making them unsuitable for large-scale agricultural applications without modification.

Environmental Factors Affecting Sensors: Soil moisture and ultrasonic sensors can be influenced by environmental factors such as temperature, humidity, or physical obstructions, leading to potential inaccuracies in readings.

App Dependency: The system's remote control relies heavily on the Blynk app or similar platforms, which may require updates or internet access to work properly, potentially creating dependency on third-party applications.

Possible Software/Hardware Compatibility Issues: Compatibility between different components, such as the microcontroller, sensors, and mobile app, may pose challenges during setup or troubleshooting.

Limited Scalability for Larger Systems: For large agricultural fields or extensive water management systems, scaling the system might require additional modifications and the integration of more powerful hardware or components.

Future Scope

The future scope of IoT-based water level and soil moisture monitoring systems includes:

- Enabling smart and automated irrigation to save water.
- Providing real-time alerts for floods and droughts.
- Integrating with AI for better farming decisions.
- Supporting environmental and climate monitoring.
- Improving water management in agriculture and cities.
- These systems help increase crop yield and promote sustainable water use.

Chapter - 6
Conclusion

6.1 Conclusion

In conclusion, The Water Level and Soil Moisture Monitoring System presents an innovative and efficient solution for automating water management, ensuring optimal water usage, and promoting sustainability across various applications. By utilizing key technologies like ultrasonic sensors, soil moisture sensors, relay modules, and microcontrollers, the system can automate irrigation processes, prevent water tank overflows, and provide real-time data through the Blynk app for remote monitoring and control.

This system has the potential to significantly improve water conservation efforts in agriculture, residential areas, public spaces, and industrial applications. It offers multiple advantages, including reduced water wastage, cost savings, ease of use, and enhanced resource management. Moreover, it provides scalability, enabling adaptation to different environments, from small-scale gardens to large agricultural fields.

However, like any technology, the system has some limitations, such as initial setup costs, dependency on internet connectivity, and the need for regular maintenance and calibration. These factors should be considered when implementing the system, especially in areas with unreliable power or internet access.

Overall, the Water Level and Soil Moisture Monitoring System offers a practical and effective approach to modern water management, contributing to environmental sustainability and improving resource efficiency. With continued advancements in sensor technology and microcontroller integration, this system can be further enhanced to meet the growing demands of water conservation and smart farming.