Intelligent Watering System

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***Abstract*—Water scarcity and inefficient irrigation practices present major challenges in modern agriculture, often leading to excessive water consumption and reduced crop productivity. Conventional irrigation systems rely on manual operation or fixed schedules, which can result in over- or under-irrigation. To overcome these limitations, this project proposes an Intelligent Watering System that automates irrigation using real-time environmental data through Internet of Things (IoT) technology. The system employs soil moisture sensors to continuously monitor soil conditions. The proposed system is cost-effective, energy-efficient, and easy to implement, making it suitable for home gardens, greenhouses, and small-scale farms. By minimizing water wastage, energy consumption, and manual labor, it promotes sustainable agriculture and efficient water resource management.**

***Index Terms*—Raspberry pi pico w, Relay module, soil moisture sensor, water pump.**

I. INTRODUCTION

Water scarcity and inefficient water management have become critical global challenges due to rapid urbanization, population growth, and climate change. Traditional irrigation methods often lead to excessive water consumption, uneven distribution, and increased labour requirements. These issues highlight the need for intelligent and sustainable solutions in water management systems.

A Smart Watering System is an advanced irrigation approach that utilizes modern technologies such as sensors, microcontrollers, and Internet of Things (IoT) to optimize water usage. By continuously monitoring environmental parameters like soil moisture, temperature, and humidity, the system can automatically control water supply based on real-time conditions. This ensures that plants receive the required amount of water without wastage. The integration of automation and data-driven decision-making not only improves irrigation efficiency but also reduces human intervention and operational costs. Smart systems can be implemented in agricultural fields, gardens, and urban landscapes, contributing to water conservation and sustainable development. This study focuses on the design and implementation of a Smart Watering System that enhances irrigation efficiency while minimizing water usage. The proposed system aims to provide a reliable, cost-effective, and eco-friendly solution for modern water management challenges.

II. LITERATURE REVIEW

This paper related work has done uniquely by two different ways, for example, one is physically and the alternate one is either mechanically or semi mechanically. The smart way systems embody IoT and the normal system. Name itself says IoT described project [1] has been introduced to irrigate the field by fully automatic by using GSM. The GSM module is used to control the irrigation system by sending text messages and alert messages from the module for a flood control system. Then, it is overcome by [2] consists of a water flow level sensor which is used to measure and monitor the flow level of water in the drip irrigation pipe lines to minimize the excess of water by enhancing the plant growth. But for wheat and paddy fields always having excess of water in the field. Nitrogen in percolation water is used in paddy and wheat fields' soil to predict rice and wheat rotation. And another takes an advantage for this one by detect a disease in nutrient growth and how far its growth rate [3] such other things will be same as that of [2]. Someone developed in more way as mobile app by integrated with IoT to monitor and controlling the

irrigation [4]. The system developed by [5] will not notify the required amount of fertilizer to the farmer. Mobile app is not provided for the framers for ease of use. The developed system [6] requires human power to irrigate the garden and it will not notify the farmer with proper notifications about the crops or plants. [7] has interfaced the sensors with the microcontroller with wireless communication. If the sensor disconnects due to power failure, again it cannot connect to the system automatically. In order to control the usage of water resources for irrigation, this [8] proposes the design of an automated organic irrigation system in controlling and properly allocating the available water resources for the irrigation system and available electricity for the use of the pump. It deals with the overview of the smart irrigation software development [9]. [10] Deals with the smart irrigation system with microcontroller is integrated with raspberry pi to transfer the data. It also deals with the smart irrigation system [11] with water efficiency to reduce wastage of water.[12] Is also same but its disadvantage is fully manually controlled system. [13] Involves a wireless short distance mesh network to collect the sensor parameters to make a decision for the irrigation system development. The mesh network consists of Xbee module which is used to transfer data in the means of radio frequency. The Xbee in module provides only a short distance network transmission since there is no proficiency for satellite network system. The fuzzy logic is complicated than our system and this system requires more manual operations [14]. Here the systems are connected with lan network so it requires long cables to transmit the data from the field to the controller. And this system will not notify or indicate any operation to the farmer.

III. METHODOLOGY

The development of the Smart Watering System follows a systematic approach involving system design, hardware integration, software development, and performance evaluation.

1. System Design

The system is designed to automate irrigation based on real-time environmental conditions. It consists of soil moisture sensors, a microcontroller unit, a water pump, and a relay module. The overall architecture ensures continuous monitoring and automatic control of water supply.

2. Hardware Components and Setup

- Soil Moisture Sensor: Measures the water content in the soil and sends analogue/digital signals to the controller.
- Microcontroller (e.g., Arduino/NodeMCU): Acts as the central processing unit that reads sensor data and makes decisions.
- Relay Module: Controls the switching of the water pump.
- Water Pump: Supplies water to the plants when required.
- Power Supply: Provides necessary electrical energy to the system.

All components are connected as per the circuit design, ensuring proper signal flow and reliable operation.

3. Data Acquisition and Processing

The soil moisture sensor continuously monitors soil conditions and transmits data to the microcontroller. The controller compares the sensor values with predefined threshold levels:

- If moisture level is below the threshold → irrigation is activated
- If moisture level is above the threshold → irrigation is stopped

4. Control Algorithm

A simple control logic is implemented in the microcontroller:

1. Read soil moisture value
2. Compare with threshold value
3. Activate/deactivate pump using relay
4. Repeat the process at regular intervals

For advanced systems, IoT modules can transmit data to cloud platforms for remote monitoring and control.

5. Implementation and Testing

The system is implemented in a controlled environment (garden or test field). Multiple tests are conducted under different soil conditions to verify:

- Accuracy of moisture detection
- Response time of the system
- Water usage efficiency

6. Performance Evaluation

The performance of the system is evaluated based on:

- Reduction in water consumption
- Automation efficiency
- Reliability and consistency of operation

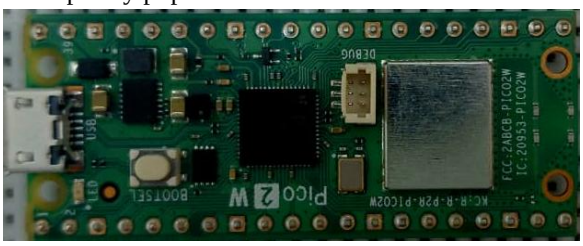
IV. COMPONENTS AND PROCESS

Process-

Soil moisture is continuously monitored by the sensor. If moisture falls below the threshold: Pump is automatically switched ON, once optimal moisture is reached: Pump is switched OFF. Sensor data is processed using data-driven decision logic. Wi-Fi enables real-time monitoring and remote control via web/mobile app.

Components

- Raspberry pi picoW

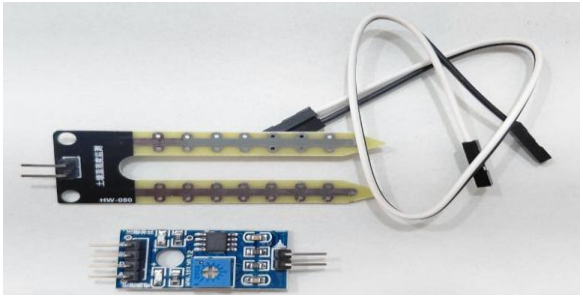


The Raspberry Pi Pico W is a compact and affordable microcontroller board designed for embedded and IoT applications. It is built around the RP2040 chip, featuring a dual-core ARM Cortex-M0+ processor that can run up to 133 MHz. The Pico W includes 264 KB of SRAM and 2 MB of flash memory, providing sufficient resources for control and automation projects. What makes it special is the built-in Wi-Fi, which enables wireless communication for smart devices. It supports programming in MicroPython and C/C++, making it suitable for beginners, students, and hobbyists working on IoT and automation systems.

- Relay Module

A relay module is an electronic switching device used to control high-voltage or high-current loads using a low-power control signal. It acts as an electrically operated switch, allowing microcontrollers like Arduino or Raspberry Pi Pico W to safely control appliances such as motors, pumps, lights, and fans. A relay module typically consists of an electromagnetic relay, driver circuit, indicator LED, and protection components like a diode. When the control signal is applied, the relay energizes and changes its contact state. Relay modules provide electrical isolation between control and load circuits, improving safety in automation and IoT-based control systems.

- Soil moisture sensor



A soil moisture sensor is a device used to measure the water content in soil. It helps monitor soil conditions and is widely used in smart irrigation and agricultural automation systems to ensure efficient water usage.

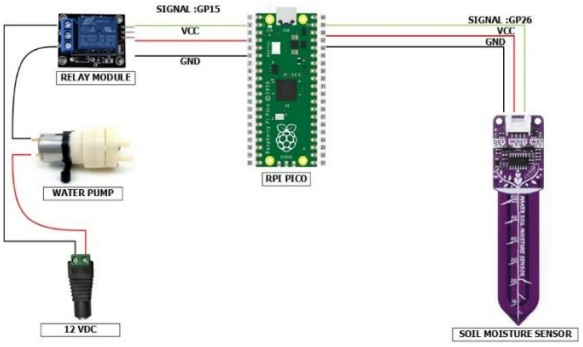
- Water Pump

A water pump is a mechanical or electrical device used to move water from one place to another by increasing its pressure or flow. It is widely used in homes, agriculture, and industries for purposes such as irrigation, water supply, drainage, and cooling systems. Water pumps can be powered by electricity,

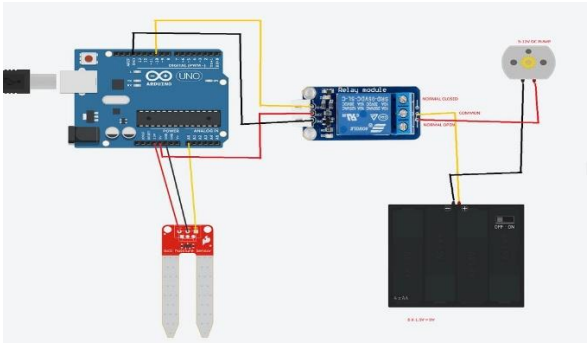
fuel, or solar energy, depending on the application. Common types include centrifugal pumps and submersible pumps. In automation and smart irrigation systems, water pumps are controlled using microcontrollers and relay modules to supply water only when required, helping conserve water and improve efficiency.

V. BLOCK DIAGRAM AND CIRCUIT DIAGRAM

- Block Diagram

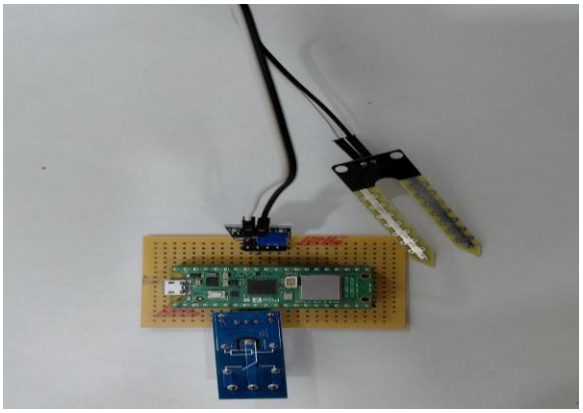


- Circuit Diagram

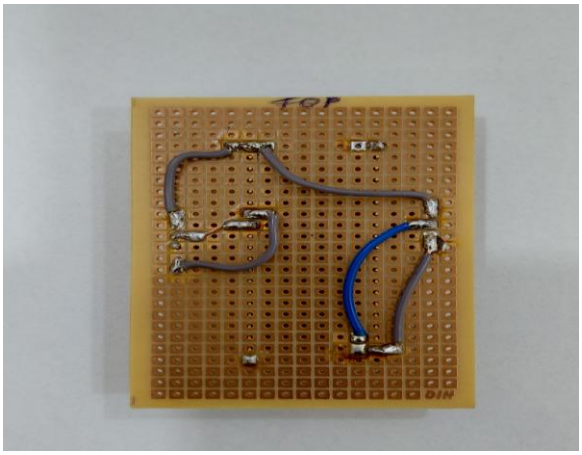


VI. RESULTS AND OUTPUT

- Model



- Soldering



VII. CONCLUSION

The Intelligent Watering System presented in this project successfully demonstrates how IoT and embedded systems can be applied to address water scarcity and inefficient irrigation practices in agriculture. By continuously monitoring soil moisture and automating water pump operation using the Raspberry Pi Pico W, the system ensures that crops receive the required amount of water at the right time. This prevents both over-irrigation and under-irrigation, leading to efficient water usage and improved crop health.