

IoT Based Plant Watering Irrigation and Monitoring System

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Abstract

Before the advent of monitoring systems, farmers would spend hours daily tending to seedlings, which required meticulous care. This project report introduces an Internet of Things (IoT)-based plant irrigation and monitoring system designed to automate and streamline the watering process for various plant species. The system's primary goal is to maintain optimal soil moisture levels, which improves plant health while reducing water waste. The system continuously monitors the ambient parameters surrounding the plants using sensors for temperature, humidity, and soil moisture. Sensor data is sent to a central microcontroller when soil moisture drops below a preset threshold. After processing the input, the microcontroller turns on the irrigation system. Wireless connection protocols and cloud-based data storage enable this automation, giving customers real-time control and system monitoring via an easy-to-use software program. In order to create well-informed irrigation decisions, an intelligent algorithm analyses sensor inputs while accounting for weather, soil characteristics, and plant kind. The system was put through rigorous field testing, software algorithm refining, and hardware design validation during the implementation phase. The test findings showed notable increases in plant health and water-use efficiency when compared to conventional irrigation techniques. By using an ESP32 board module, the system makes it simple for users to monitor and manage the process via Arduino IoT Cloud, increasing convenience. The goal of this all-encompassing strategy is to provide a practical, effective answer for contemporary farming methods.

1. Introduction

In modern agriculture, long-term crop production depends on efficient use of water resources, particularly in light of shifting weather patterns and growing water scarcity. Traditional irrigation methods typically rely on human error-prone, labor-intensive, and time-consuming hand watering and monitoring. These techniques typically result in overwatering or underwatering, which wastes water, reduces crop yields, and increases farmers' operational costs. The Food and Agriculture Organization (FAO) estimates that agriculture accounts for over 70% of freshwater withdrawals worldwide, underscoring the pressing need for improved farming water management practices [1].

Novel approaches to these problems have been made possible by recent developments in Internet of Things (IoT) technology. Real-time monitoring and irrigation process automation are made possible by IoT-based

solutions, which guarantee efficient water use and encourage healthy plant growth. For example, research by S, P., Sathyanarayana [2] showed that IoT-enabled irrigation systems might maintain or even increase crop yields while consuming up to 30% less water. Instead of using fixed timers or user intervention, these systems use sensors to monitor temperature, humidity, and soil moisture.

This enables precise control over irrigation schedules based on actual plant needs. In this regard, the creation of an Internet of Things (IoT)-Based Plant Water Irrigation and Monitoring System integrates cutting-edge sensor technology, cloud-based data analytics, and automated control mechanisms to overcome the drawbacks of conventional irrigation techniques. Through intelligent decision-making and real-time monitoring, this system seeks to maximize crop health, minimize labour expenses, and optimize water usage. This project offers a scalable and intuitive solution for contemporary farming methods by utilizing the capabilities of the Arduino IoT Cloud, capacitive soil moisture sensors, and the ESP32 microcontroller.

By reducing water waste and encouraging environmentally friendly farming practices, the system not only guarantees effective water management but also advances larger sustainability objectives. Given how vulnerable seedlings and young plants are to environmental stressors in areas with harsh climates, this effort is especially pertinent there. The system enables farmers to make well-informed decisions, which eventually results in increased crop yields and resource conservation, by automating the irrigation process and delivering real-time data on soil and environmental conditions. IoT technology integration in agriculture is a big step toward solving the problems of global food security and encouraging sustainable water use.

2. Methodology

Fig 1 shows the flowchart of the system, the system starts with the project being activated, which starts the AHT10 and soil moisture sensors to detect the current temperature, humidity, and soil moisture levels [3] [4]. The sensors will send data and information to the ESP32, which will show the data it has gathered on the OLED display, if they notice that the soil and the surrounding area are too hot or dry. The temperature and humidity will be displayed on the screen. The Arduino IoT Cloud is then used to present the user a data display or another display. There, the cloud software will chart and record the soil's moisture content as a percentage. The water pump will keep running after it is turned on until a certain volume of water has been poured into the ground. On the other hand, the system will pause right away until it determines the soil's dryness using the Arduino IoT Cloud software without starting the watering process if the sensor readings show that the soil moisture and atmospheric conditions are within the desired range. This guarantees that the user is continually aware of the plants' state, enabling prompt action when required to preserve ideal growing circumstances.

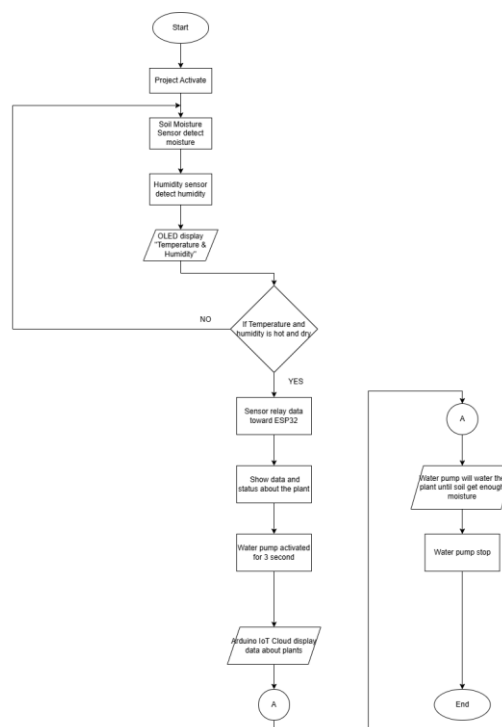


Fig 1: System flowchart

Fig 2 shows the project block diagram which consist of the main components that are needed in this project. The numerous pins on ESP32 Board Module are essential for connecting and managing various parts of a plant watering and monitoring system. In order to complete the electrical pathways for parts like the soil moisture sensor, the relay that controls the water pump, and other sensors, the GND (ground) pins are needed to create a common ground for the circuit. When powering components that need a lower voltage, the 3.3V pin's controlled 3.3V output is essential [4] [6].

An OLED display, a AHT10 temperature and humidity sensor, and a soil moisture sensor can all be powered by this steady power source, guaranteeing their dependable operation [3] [4] [5]. Multiple devices can communicate over the same bus thanks to the I2C pins, notably the SDA (A4) and SCL (A5) pins. This is especially helpful for attaching gadgets that can display real-time data from the system's sensors, such as an OLED display. Furthermore, only when the board is supplied via USB does the 5V pin give a regulated 5V output via the onboard regulator [6]. For parts that need a 5V power source, like some relays, this pin is perfect.

By effectively using these pins, the ESP32 Board Module can manage and monitor a plant watering system, ensuring that plants receive the right amount of water based on real-time environmental data. This setup provides a comprehensive solution for maintaining plant health through automated watering and monitoring.

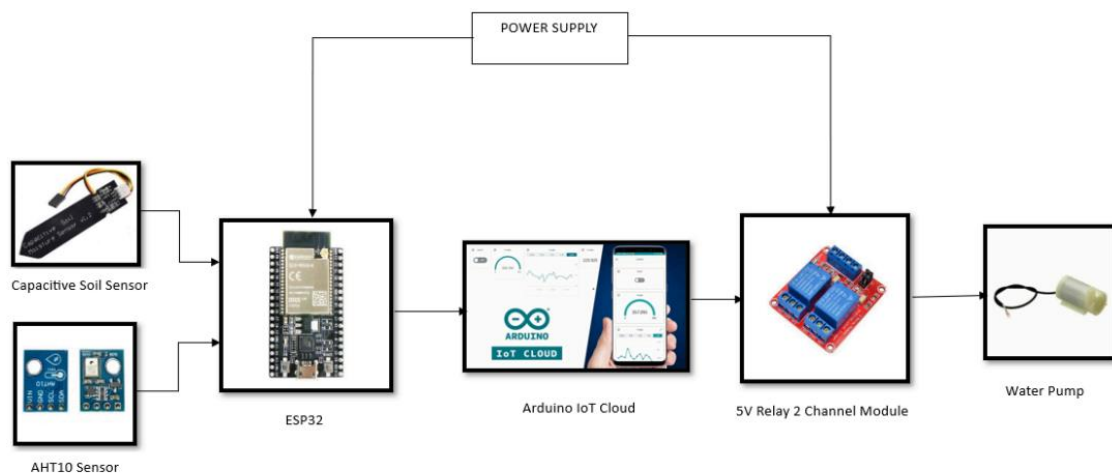


Fig 2: Project block diagram

Fig 3 (a) shows completed and setup of the project. The ESP32 Board is powered by power bank while the irrigation system powered by 5VDC. A hard plastic case is used to hold and encase the project while the water is being stored inside a plastic container. The plants use in this experiment project are limau purut seedlings. In Fig 3 (b), shows what shows up when the project is activated. It shows the name of the project that will appear for a split second. In Fig 3 (c) shows display on the OLED regarding the plant's environment. H1 stands for humidity sensor that is outside while the H2 stands for humidity sensor that inside the case. T1 and T2 stands for temperature same like the humidity sensors. S1 and S2

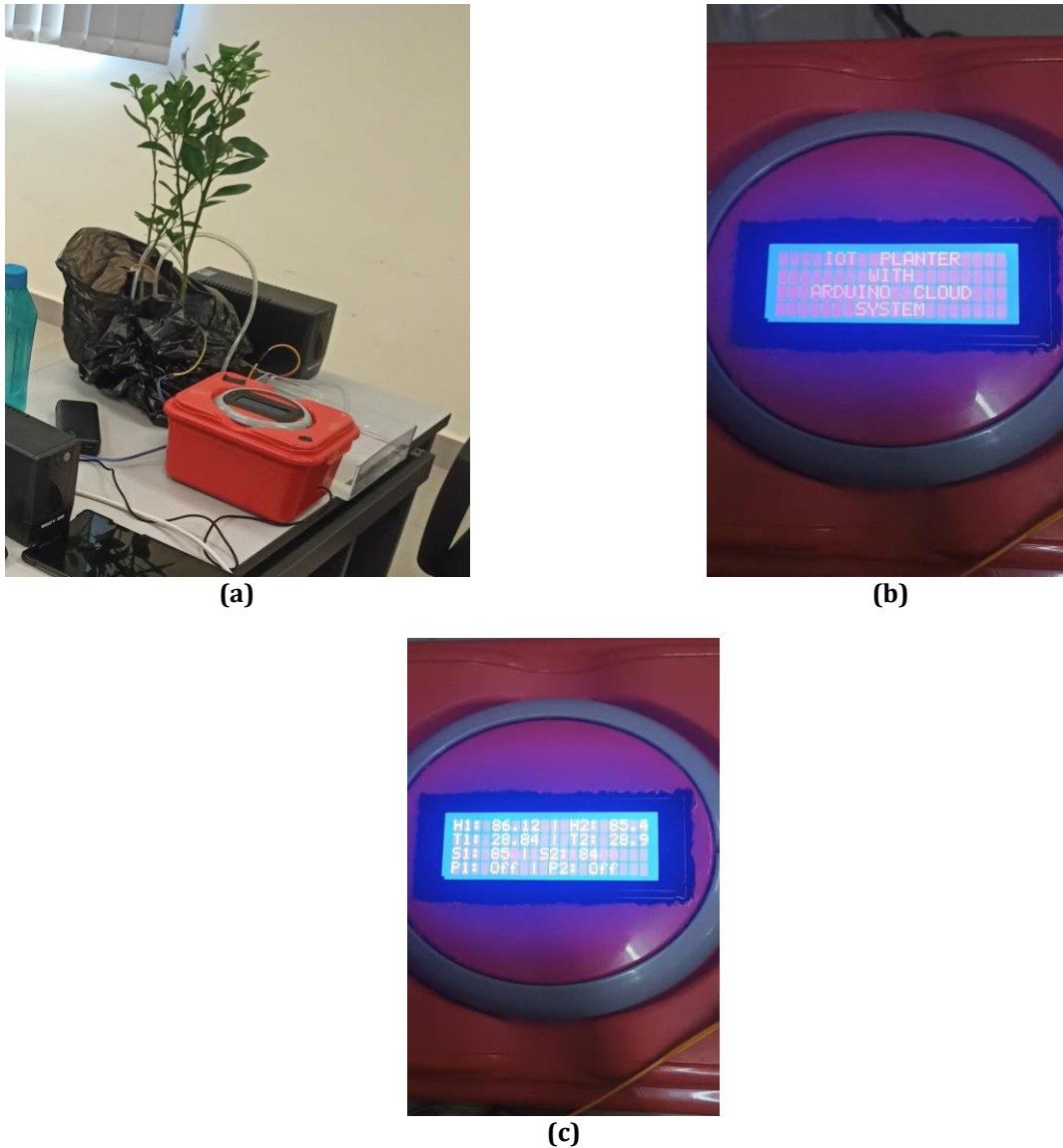


Fig 3: Project Design (a) Project hardware; (b) Display project name; (c) Display environment of project

3. Results

Fig 4 (a) shows the activity of both capacitive soil sensors detecting the moisture inside the soil. Each sensor detects value under the needed percentage which is 30 percent. The Arduino IoT Cloud dashboard here shows little activity. Meanwhile in Fig 4 (b), sensor one will keep pumping water because of its condition (under 30 percentage of needed moisture) while the sensor two will stay constant because the soil have enough moisture (have reached above 30 percentage). In Fig 4 (c), sensor one remains constant because it already reaches enough moisture which is 68 percent which is above 30 percent while sensor two keep pumping water because it has not reached the minimum value for triggering the water pump.

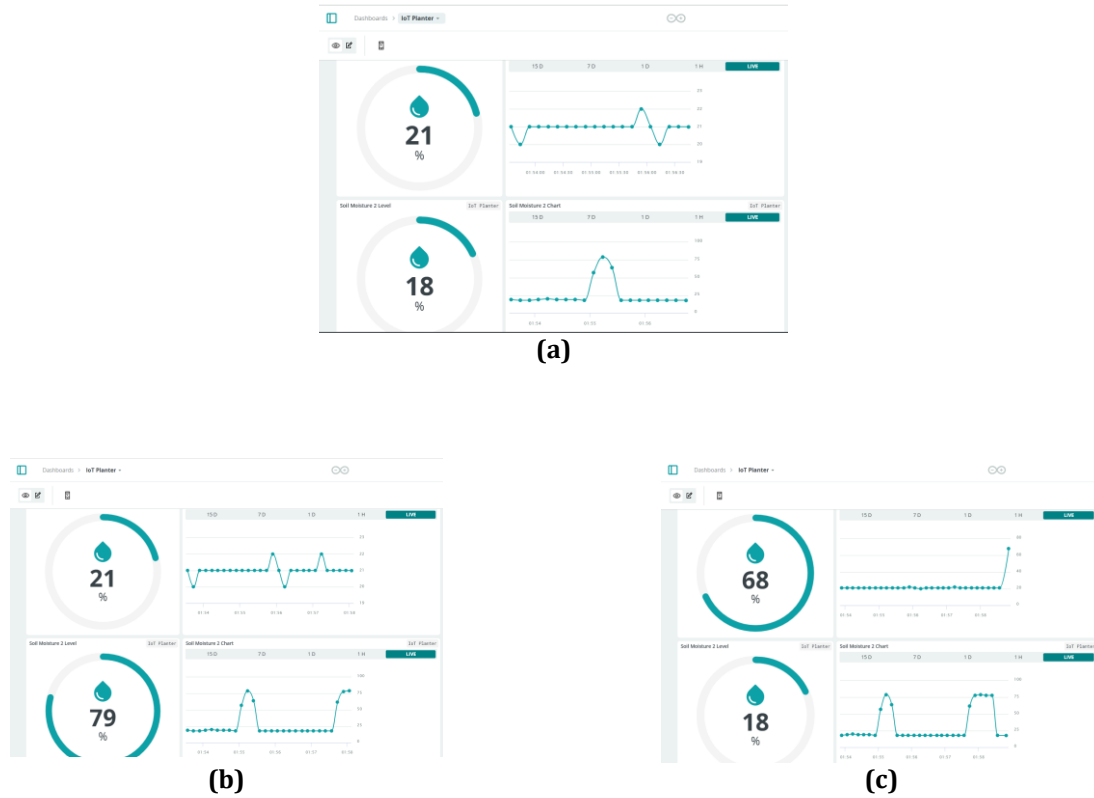


Fig 4: Results in IoT cloud (a) both pumps active; (b) First pump active; (c) second pump active

The project makes use of two 5VDC water pumps, which are operated every 20 seconds. It has three seconds after being triggered to pump out water for the soil. Calculation for this:

Assuming the flow of water is 50 L/h

Flow rate per second:

$$3600 \text{ seconds } 50 \text{ L/h} \approx 0.0139 \text{ L/s}$$

Water pumped:

$$0.0139 \text{ L/s} \times 3 \text{ seconds} \approx 0.0417 \text{ liters (41.7 mL)}$$

It is confirmed that every trigger in the span of three seconds pulled out a small amount of 41.7ml of water to water the plant. With the amount of water pumped out, the data collected is the amount of water pump in the span of certain times in the form of table.

Table 1 has shown the total intake of the water pump within two minutes and shows the way it operates between the interval of 20 and three seconds.

Table 1: Water pump taken

Time Taken	Water Pump One (1)	Amount of Water	Water Pump Two (2)	Amount of Water
20 sec	Off	0 ml	Off	0 ml
23 sec	On	41.7 ml	On	41.7 ml
43 sec	Off	0 ml	Off	0 ml
46 sec	On	41.7 ml	On	41.7 ml
1 m 6 se	Off	0 ml	Off	0 ml
1 m 9 sec	On	41.7 ml	On	41.7 ml
1 m 29 sec	Off	0 ml	Off	0 ml
1 m 32 sec	Off	0 ml	Off	0ml
1 m 32 sec	Off	0 ml	Off	0 ml

1 m 52 sec	Off	0 ml	Off	0 ml
Total		123 ml		123 ml
Total Both		246 ml		

4. Conclusions

The IoT-Based Plant Irrigation and Monitoring System represents a significant advancement in agricultural technology by combining automation, real-time monitoring, and resource optimization to overcome fundamental difficulties in traditional irrigation methods. The system uses capacitive soil moisture sensors and AHT10 humidity sensors to provide precise data collection, assisting in the maintenance of appropriate soil moisture levels as well as the monitoring of external factors like as temperature and humidity. The ESP32 microcontroller allows for smooth connection between sensors, the water pump, and the Arduino IoT Cloud, resulting in real-time data display for informed decision-making. This automation guarantees that water is only delivered when it is required, saving waste and preventing problems such as overwatering, which can affect plant health. Field experiments indicate significant gains in plant health and water efficiency over traditional approaches, demonstrating the system's efficacy. Its capacity to adapt to varying soil and environmental conditions makes it suited for a wide range of applications, from home gardens to large-scale farming. Furthermore, the method encourages sustainability by eliminating water waste and human labour, in line with worldwide initiatives to save resources and lessen agriculture's environmental footprint. In summary, this project demonstrates how IoT technology can revolutionize agriculture by improving plant growth, optimizing resource use, and providing a scalable solution for smart farming. It highlights the importance of technology in achieving sustainable and efficient agricultural practices, offering a strong foundation for future advancements in IoT applications for farming.

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References

- [1] Anand, T. (2015). AGRARIAN- Automatic plant irrigation system. *International Journal of Computer Applications*, 132(7), 22–26. <https://doi.org/10.5120/ijca2015907485>
- [2] S, P., Sathyanarayana, M. V., & Vikram, S. (2018). IoT based Automatic Drip Irrigation System with Plant Disease Detection. *International Journal of Engineering Research and Technology*, 6(13). <https://www.ijert.org/research/iot-based-automatic-drip-irrigation-system-with-plant-disease-detection-IJERTCONV6IS13136.pdf>
- [3] AHT10 High Precision Digital Temperature and Humidity Measurement Module | QQ Online Trading. (n.d.). <https://qqtrading.com.my/AHT10>
- [4] Bollinger, K. (2024, April 8). Soil moisture sensors—How they work. Why some are not research grade - METER Group. METER Group. <https://metergroup.com/measurement-insights/soil-moisture-sensors-how-they-work-why-some-are-not-research-grade/>
- [5] OLED I2C 0.96Inch 128x64 Blue Display. (n.d.). Cytron Technologies Malaysia. <https://my.cytron.io/p-oled-i2c-0.96inch-128x64-blue-display>
- [6] ESP32 Wi-Fi & Bluetooth SOC | Espressif Systems. (n.d.-c). <https://www.espressif.com/en/products/socs/esp32>