Low-cost IoT-Based Smart Notification System for Rural Agriculture

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Abstract

At present, people in the countryside use a manual agricultural machine for harvesting. This contributes to global warming and agricultural safety problems as manual irrigation increases farmers' time on the farm. The use of manual machinery causes smoke during irrigation, which increases the heating of the earth's surface and thus reduces the green energy effect. So they do not spend a lot of money on buying crude oil when they use the system. On the other hand, there are bandits who come into conflict with farmers and animals that attack farmers in the bush, which makes it difficult for farmers to reach their farms. A simple but effective IoT system, as we have proposed in this study, helps to solve these problems to a large extent. In this study, we use a combination of a Raspberry Pi as the main processor and sensor modules as devices to collect agricultural data for further insights and analysis. Apart from automatic irrigation through the power-saving water pump, the developed systems have taken the initiative to reduce the time farmers have to spend on the farm and provide instant notifications to a mobile device at any time and place.

Keywords: *Internet of Things, Smart Irrigation, Smart Farming,*

1. Introduction

The Internet of Things (IoT) comprises a network of bodily objects "things" that are embedded with software, sensors, and other related IoT technologies for the motive of connecting and exchanging statistics with other sensing devices and components over the Internet. As the IoT grows dynamically, it has an important role in the field of agriculture. In smart agriculture systems, IoT gadgets such as microcontrollers and sensors will sense, gather, store, process, and transmit data to different parts of the deployed area so that the remote observer can have insights and take action based on the analysis of the received information. The aim of the system is to improve and increase crop yields in terms of quantity and quality by utilizing, integrating, and deploying the IoT and technology in farming agriculture.

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Viewing real scenarios, the challenge in managing crops in farming arises from the insecurity issue where farmers are unable to attend their farms due to bandits and kidnappers. To manage crops, often farmers need to stay at the farming site for hours individually and personally. This problem becomes intense for farmers in rural or low-standard-of-living areas with less security enforcement by the authorised party. As a result, the level of food shortage and poverty increased. According to India Brand Equity Foundation (IBEF), 58% of its citizens live in rural areas rely on agriculture as the source of income and sustainability for day-to-day living. However, with a high increase in population, the majority of land space reserves for agricultural purposes have been used for other development, thus causes a shortage in food production and supply. One solution to this issue seen in [3] where the authors proposed an idea that will increase the agricultural field by designing an automated system that is able to control the crop monitoring of agricultural fields which is a painstaking task for human beings.

Another challenge with the traditional agriculture systems is that there is a waste in water resources usage due to a lack of knowledge of water management. Poor farms water management including unawareness of the proper utilisation of such available valuable resources. In many cases, farmers use more resources for less crop production which leads to a shortage of groundwater and rivers, unbalanced crop growth, and a over-supply of soil nutrition. In short, traditional method for irrigation, fertilisation, and pest control leads to a waste of resources in general.

Several researchers have attempted to encounter these problems. A work from [2]designed and developed a smart irrigation technology based on IoT. The developed system monitors the water and the plant automatically with the use of a webcam by streaming on mobile. However, the system lacks warning features to send a prompt notification to the user. The IoT-based smart framework agriculture system by [3], introduces IoT technology into the agriculture domain to allow farmers to achieve high-yield crops and fruits with optimum resource usage. The authors implement different functionalities in real-time sensors, actuators, and location-assisted drones to perform irrigation, inject fertilizer, and spray pesticides. However, the work does not improve the water and nutrition issues which are the basic resources for the survival of farm crops.

This study developed an IoT-Based Agricultural Solution. The systems provide the solution to gauge the moisture level in the soil by using IoT sensors and devices. Information gained from the monitoring justify how much water to irrigate by pump-in or pump-out water to-and-from the farm. The process done automatically with a water pump. Another feature of the system is provide notification services to the farmer when the soil moisture level needed attention, depending on the amount of water in the soil.

Justification either the soil is wet, dry, too wet, or too dry is summarized prompt to the knowledge of the water level. As soon as the water were irrigated to the farm, notifications are sent to the farmer for further action. The procedures will help to reduce a lot of hassles and provide a better way of managing the water and soil, apart from understanding the status of moisture, temperature, and humidity level of the farm. With the study, we proposed an IoT-based agriculture solution, and the project under the study was implemented with the integration between middleware technology, cloud services, and notification systems.

2. Previous Work

There are numerous IoT agricultural applications that have been put into use for the purpose to improve farming activities. Authors in [4], proposed a smart agriculture system that utilizes cutting-edge technology like IoT, Wireless Sensor Networks, and Arduino to monitor environmental factors in agricultural areas like temperature, humidity, moisture, and animal activity. The technology may alert farmers to any differences via an SMS alert or an Android app. It is cost-effective, energy-autonomous, and practical in far-flung areas with little water access. The system's goal is to boost crop output by implementing automation and smart farming techniques.

In 2020, [3] implement a model that uses a real-time monitoring system of soil factors, such as moisture and pH, which helps to boost crop output and reduce fertilizer wastage, it was developed in three major "phases" where the uniqueness emerged. The system uses IoT sensors and cloud computing which allows data flow from the point at which data is collected to the point at which that data is passed from one phase to another as its most remarkable aspect.

Shaik et al. in 2020, [4] created an automated watering system with IoT sensors to monitor a farming field (soil moisture). The method was created using automation to see whether the environment's soil moisture falls below a certain threshold level. By integrating a GSM module, the proposed developed system has a power-efficient automation system that monitors and regulates the motor without the need for human interaction. System status based on soil moisture is provided as a message to the farmer's mobile device by the system.

[5] propose and developed a system to analyze and anticipate data from sensors linked to a Node MCU to monitor the condition of the soil with the help of WEKA. The Raspberry Pi 3 served as a broker for the MQTT protocol. The main benefit of this system is that it uses IoT and MQTT to obtain Volumetric Water Content (VWC) in the soil without requiring human intervention.

[6] in 2021, proposes and developed a system based on the Internet of Things and the Arduino Mega Development board. The device provides weather and soil monitoring and identifies nearby fires, insects, and other problems. It provides a sprinkler system for spraying water, organic pesticides, and insecticides based on the microcontroller's monitoring and analysis of data. The system is automated since it is powered by solar energy and the microcontroller is pre-programmed with the functions and geographic coordinates of each crop. By controlled watering, this method also contributes to water conservation and enhances the production rate.

In 2021, [7] introduces a system for remotely monitoring onion growth that is built on the internet of things (IoT) that uses Think speak Cloud and wireless sensor networks. With the assistance of wireless sensor networks and the internet of things, the proposed system improves the traditional method of growing onions in rural areas. To regulate appliances like fans and heaters in accordance with the ideal range of onion production and healthy onion development, the research suggests creating and deploying a thermal-based Internet of Things system within the onion farms.

Using the simulator, the proposed model is put into practice and verified. The technology lowers the amount of energy used in the agricultural sector that produces onions while also improving the quality of the output. The essential microcontroller control device is the Arduino UNO, which can communicate all the collected data to the Thing Speak cloud and receive commands from the Thing Speak service. The findings indicate that the suggested approach is quicker, and the suggested model offers a faster simulation time while being more effective.

IoT farming reduces the food shortage by requesting that the existing land be used in more practical ways at the lowest possible cost. A concept called "smart agriculture" is quickly catching hold in the agricultural industry. In 2022, [8] presents a novel concept for an automated system that is being created to control crop monitoring in agricultural areas, which is a challenging task for humans. The proposed system describes a sophisticated internet-based system for monitoring agriculture (IoT). Using a variety of sensors and IoT hardware, the proposed approach is put into practice. To boost the output of the crops on the land, the farmer might use this proposed design to continuously monitor the crop.

[9] In order to revitalize and restart faster growth in agricultural areas, there is a growing need to find a solution to the issue of monitoring and watering for long periods of time. A large-scale agricultural system necessitates a lot of upkeep, expertise, and oversight. The Proposed system is to automate maintenance, insecticide and pesticide control, water management, and crop monitoring. Moreover, [10] proposed an automatic watering system that is IOT-based.

Together, the Internet of Things (IoT) and cloud computing may successfully control the agriculture sector. This approach considers all environmental factors and sends the knowledge to the user over the cloud. With the aid of an actuator, the user is free to take control measures as he pleases. By watering more, the farmer can raise his or her yield thanks to this profit.

The Internet of Things is a network of interconnected electronic objects that can communicate or be controlled by one another without the need for direct human-computer interaction. The Internet of Things is the foundation for the system this article proposes. With the use of this technology, system monitoring and maintenance duties, data analysis, and data sharing between the device and the user can all be totally automated. Due to the stability of mobile networking in most rural areas, the system uses a GSM network for data transmission between users via SMS [6]. To perform sensing duties on each crop, GPS technology aids in guiding the system there. When the microcontroller detects a need, the system provides fertilizer, water, acidifier, lime, or insecticide through a spray mechanism. The system also refills liquid tanks by driving to the refill station, where another microcontroller controls the motors. Agriculture in rural areas has improved dramatically over traditional agriculture by adapting the use and rapid growth of IoT devices.

3. Methodology

In the Previous Section, we reviewed some of the designed systems. Therefore, in this section, we will explore more on our proposed system, explore more on the component which includes Raspberry Pi, sensors, Wi-fi connection, a relay module, water pump, connection wires, USB cables, and a breadboard. Table 1 lists hardware components used in the study.

Table 1: Components Specifications

Component	Model	Specification
Raspberry Pi	Pi 3 Model B+	Broadcom BCM2837B0, Cortex-A53 64-bit, 1.4 GHz, 1 GB LPDDR2 SDRAM
Soil Moisture Sensor	FC-28	Sensing element: Soil hygrometric transducer Operating voltage: 3.3V-5V DC Current: 35mA Accuracy: 0~300: dry soil 300~700: humid soil 70050: in water
Temperature & Humidity Sensor	DHT22	Sensing element: Polymer humidity capacitor Operating range: Humidity 0-100%RH; Temperature: 40~80° Celcius Accuracy: Humidity ±2%RH (Max ±5%RH, Temperature: ±0.5° Celcius
Relay Module	5V Single Channel Relay Module	Supply voltage: – 3.75V to 6V Quiescent current: 2mA Current when the relay is active: ~70mA Relay maximum contact voltage: – 250VAC or 30VDC Relay maximum current: – 10A

Water Pump	Submersible DC 3V-5V	Suction Distance: 0.8 meters (Max) Operation Temperature: 80 °C Operating Current: 0.1-0.2A
Battery	9V (6LR61)	Nominal voltage: 9 V
Mobile Device	Infinix X688B	Processor: Octa-core (4x2.3 GHz Cortex-A53 & 4x1.8 GHz Cortex-A53) Chipset: MediaTek MT6765G Helio G35 (12 nm) GPU: PowerVR GE8320 RAM & Storage: 4GB RAM, 64GB ROM External Storage: MicroSD (dedicated slot) OS: Android 11, Dolphin v7.6.0

3.1. Block Diagram

The below diagram shows the connection between different compartments of the system. It contains the main model, which is Raspberry Pi 3B+, relay, and sensors. The main system contains two sensors which include the soil moisture sensor and the DHT22 sensor that are used to sense the humidity, temperature, and moisture of the soil.

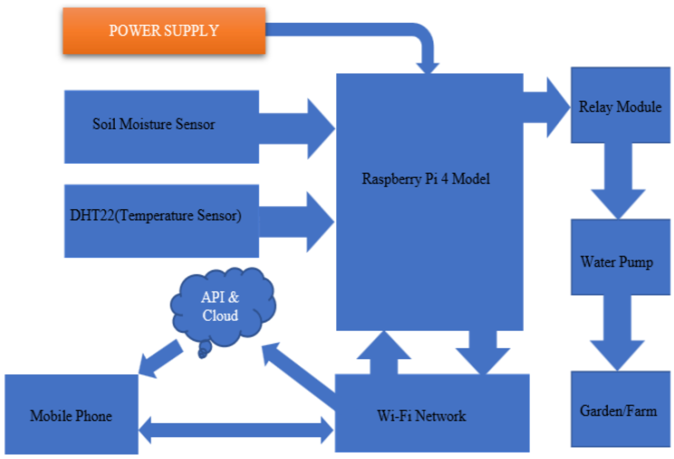

Figure 1: Block Diagram

3.2. System Flowchart

The system works based on a Soil Moisture Sensor, which provides an electrical signal to the Raspberry Pi GPIO input. The Raspberry Pi will process the signal and decide if the soil is dry or wet. If the soil is dry, the water pump will start automatically, and if it is not sufficient, a notification message will be sent. If the soil is wet, a notification message will be sent, and the system will stop. Figure 2 shows the system flow of the proposed study, followed by depiction of the algorithms that implement the system.

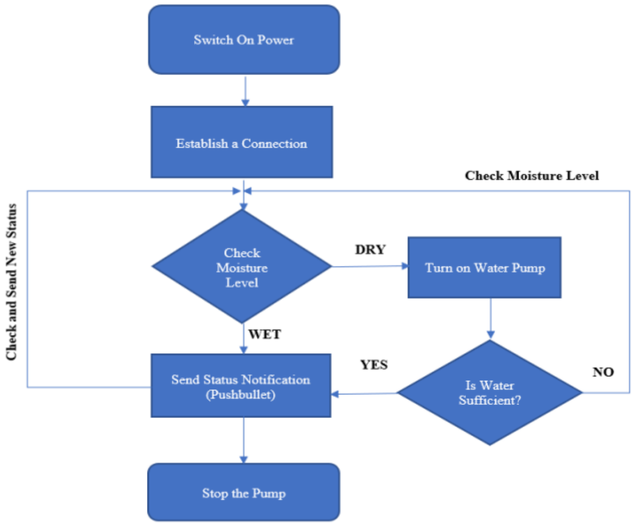

Figure 2: System Flow Chart

Algorithm

Step 1: Switch on the power/Import required libraries.
Step 2: Establish a Connection
Pushbullet: pb <- Pushbullet("API Key")
GPIO's
Step 3:Main loop: Check Moisture Level
Step 4: Check: if_moisture_level_high >=90%):
Loop Back: Send Notification: Moisture Level is At least 90% (Wet)
Stop_irrigation(Water Pump Stopped)
Else:
Step 5: Turn on the Water Pump (moisture_level_low <=20%):
start_irrigation()
DHT_Read <- read_temperature_humidity()
send_alert(dev, "Moisture Level is now 20%, Pump Start Irrigation")
send_alert(dev, DHT_Read)
Step 6: Check: is Water Sufficient?
If **Yes:**
Loop Back Step 4
If **No**:

Loop Back: Step 5
End: (Stop)

All the components that make the system are interconnected using a breadboard. In short, these components are links to the Raspberry Pi that acts as the main controller and processor of data being gathered by all sensor modules. Figures 3 and 4 illustrate the connection in a form of circuit diagram and schematic diagram.

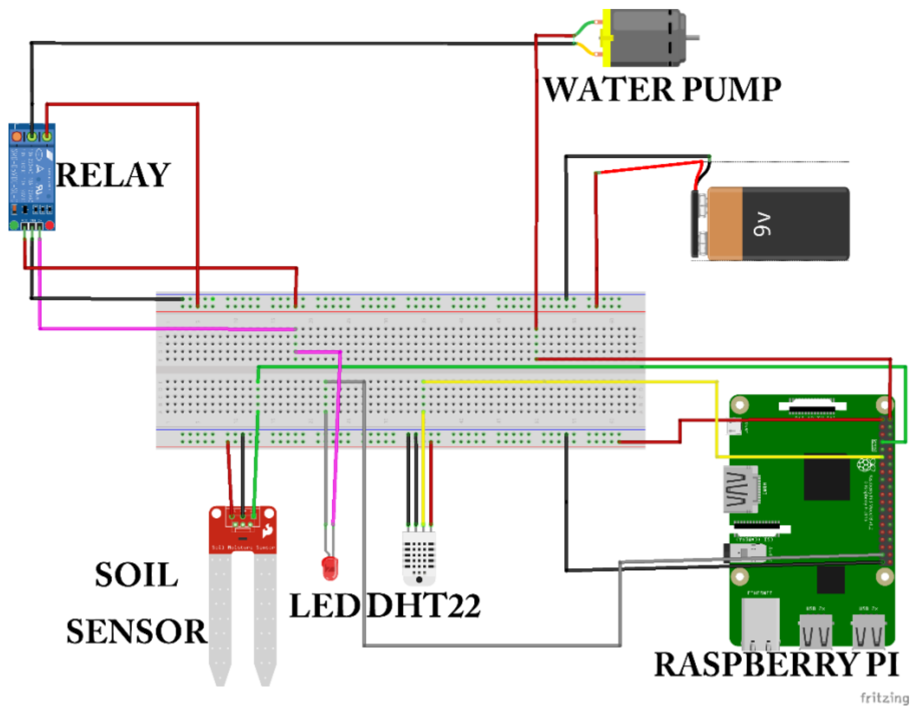

Figure 3: Circuitry View of the Components Connection

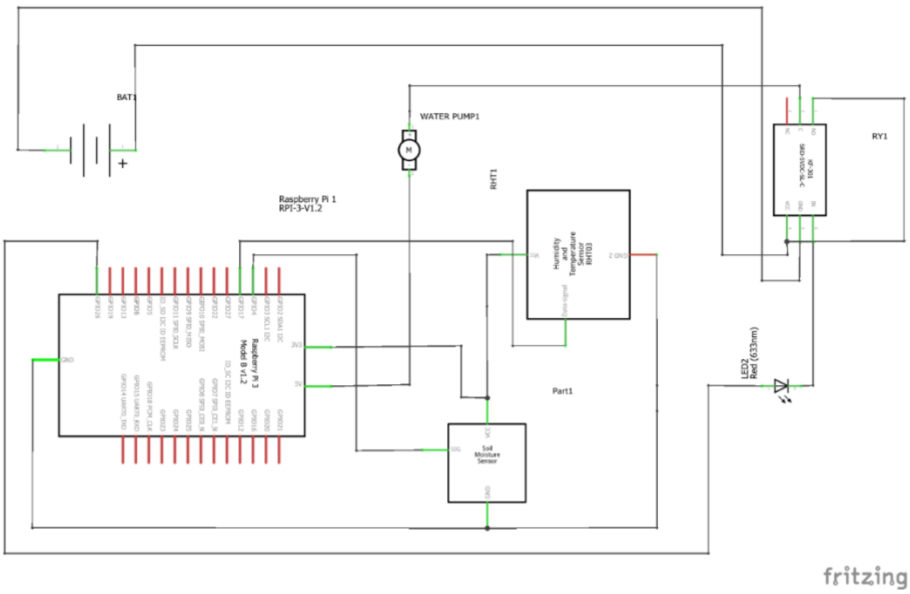

Figure 4: Schematic View of the Components Connection

4. Experiment and Analysis

The main goal is to offer a Low-cost IoT-Based Smart Notification System for Rural Agriculture that supports automatic irrigation based on sensed data. The solution also supports and minimizes water resource waste while using minimal energy. Additionally, it offers notifications over a wireless network on the farm's status (Wi-Fi).

4.1. Hardware and Software Setup

In this section, we will explore more on our proposed system, explore more on the component which includes Raspberry Pi, Sensors, Wi-fi Connection, a Relay module, Water Pump, Connection Wires, USB Cables, and a breadboard.

4.2. Raspberry Pi, Sensor, and Actuators Integration

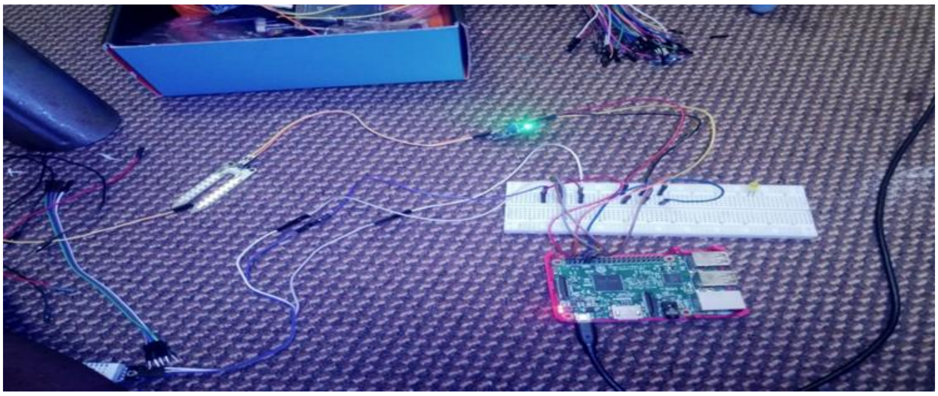

Figure 5. Hardware Integration

4.3. Notification

Notification can be received from the system to individual phones, and it can be achieved by using push bullet API integrated within the python code. The Pushbullet must be installed on a smartphone and registered with the same account used with the website. An ACCESS KEY will be required to be used and some imported library to the RPi code.

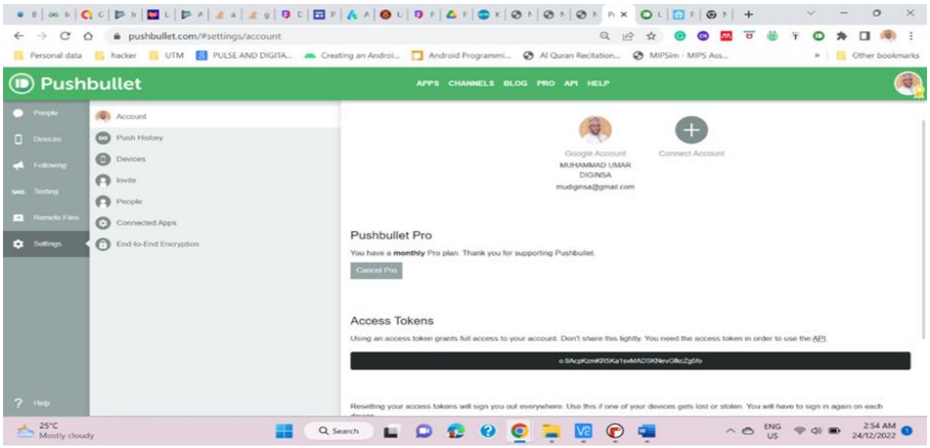

Figure 6: Push Bullet Setup

4.4. Testing the system

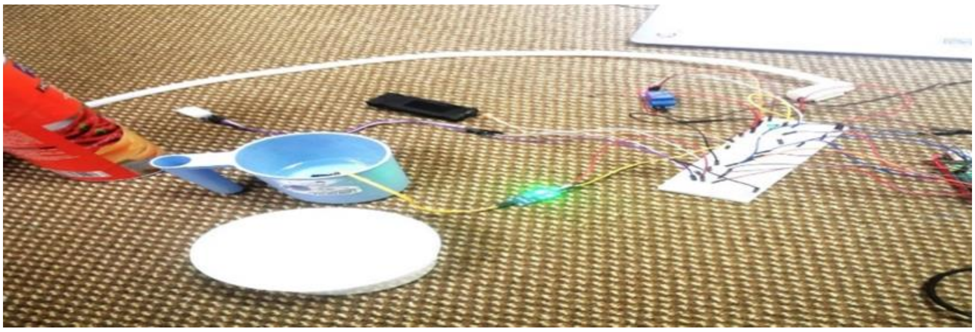

Figure 7: System Testing

4.5. Testing the Temperature

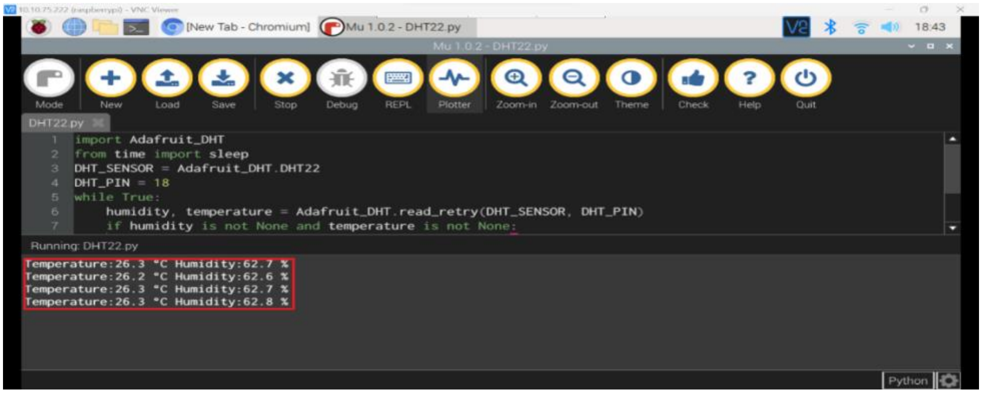

Figure 8: Temperature and Humidity Output

4.6. Testing the Notification

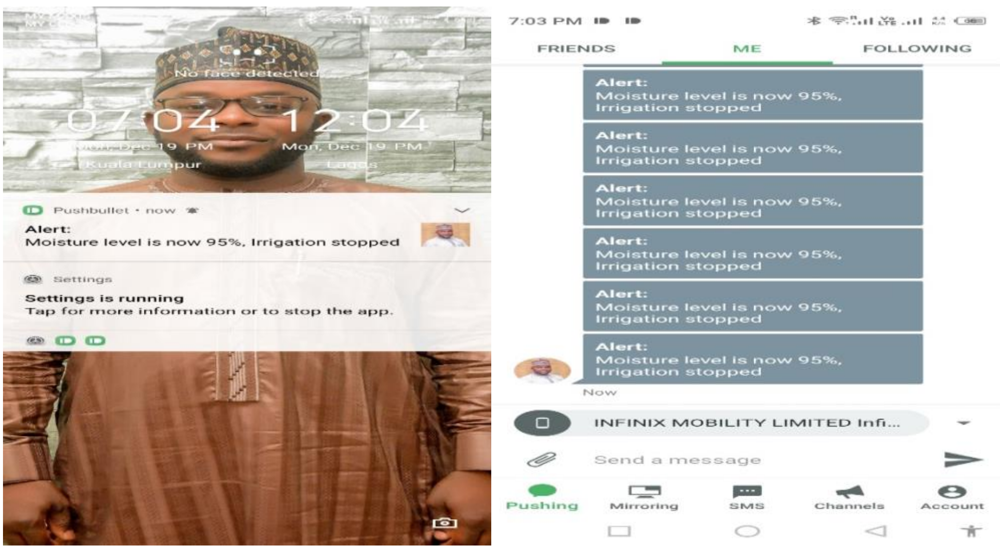

Figure 9: Notification Testing

5. Results

The result of the project is the output of what the project delivers, which includes the moisture level of the soil, temperature, humidity, and auto-irrigation of the crop. The system can also send notification message to the individual phones. The DH22 sensor gets the continuous values and converts them to discrete values of temperature and humidity in real time.

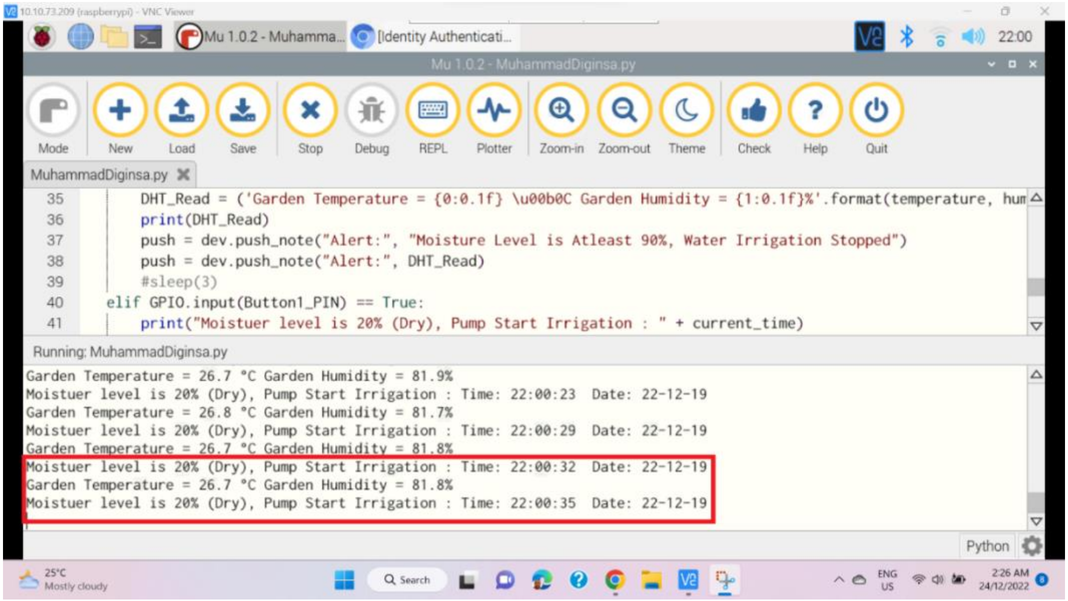

Figure 10: Temperature and Humidity Result

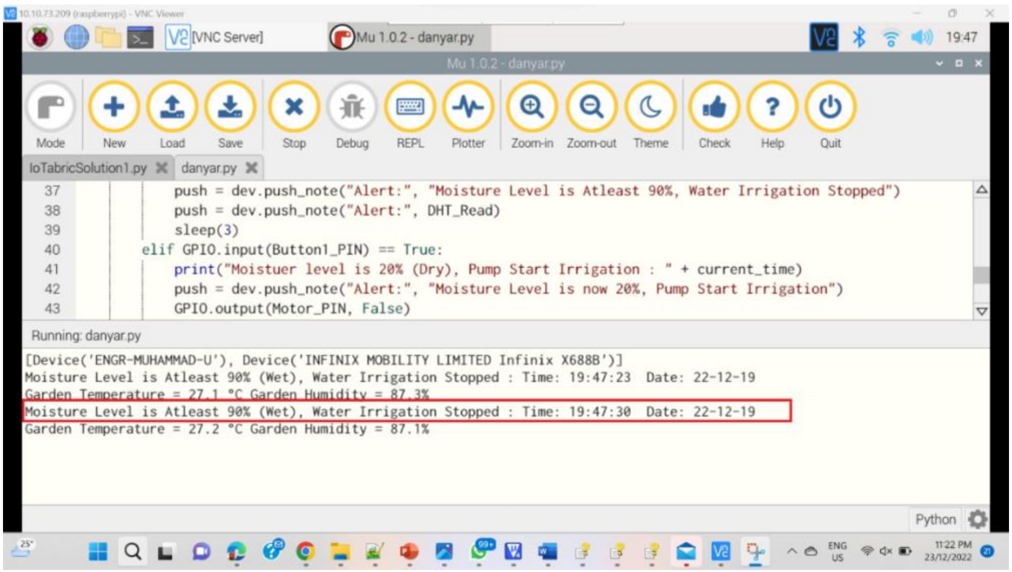

Figure 11: Soil Moisture Result

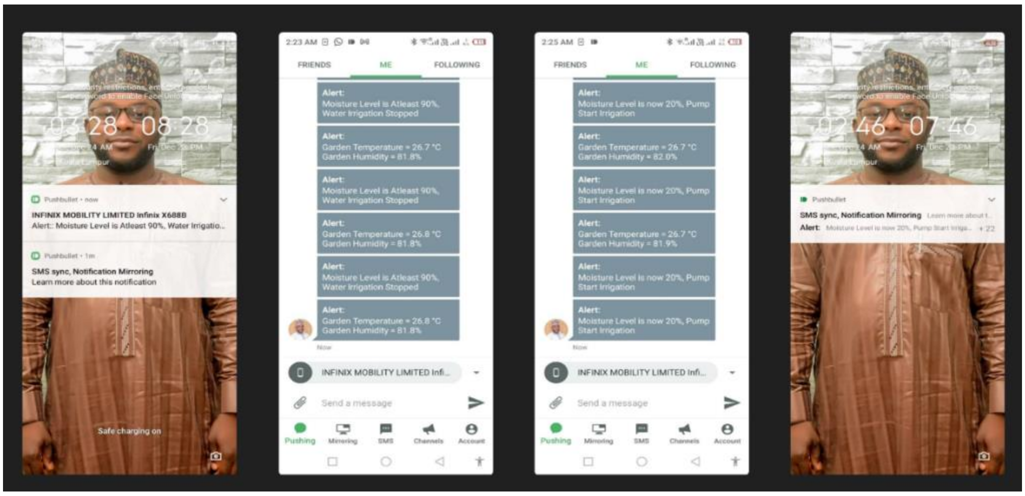

Figure 12: Result from Notification

6. Discussions

From the different outputs, we can see the result altogether, Figure 11 gives us the result from the surrounding environment which is the farm/garden where we have the temperature and humidity in real-time, and we get it as a notification from our phone as shown in Figure 12. We were also able to get the soil moisture level from our soil sensor, which can clearly be seen in Figure 11 in real-time and its notification also can be seen in Figure 12. Moreover, the water pump result also shows that if the moisture level is dry by at least 20% the water pumps can automatically start to water the crops. Similarly, if a certain level of soil moisture reaches at least 90% it indicates that the soil is now wet, then the pumps can stop watering the crop automatically and notifications will be sent also as shown in Figure 12.

6.1. System Performance

The average temperature during the experiment was 26.93 degrees celsius, while the temperature was between 26.7 and 27.2 degrees celsius, Table 2 below shows the recorded temperature and other factors in real time.

Average Temperature = (Summation of Total Temperature Recorded) / (Number of times Recorded)

$$Av_t = 242.4/9 = \mathbf{26.93^o c}$$

Table 2: Reading from DHT and Soil Sensor

Timestamp	Temperature (°C)	Humidity (%)	Moisture Level (%)
19:13:02	27.1	81.1	95.0
19:13:30	27.2	81.1	95.0
19:47:23	27.1	87.3	90.0
19:47:30	27.2	87.1	89.0

21:59:02	26.8	81.7	80.0
21:59:17	26.8	82.1	79.8
22:00:23	26.8	81.7	79.5
22:03:03	26.7	82.4	79.2
22:30:32	26.7	81.8	65.2

7. Conclusion and Future Work

The study proposed the smart implementation of a an IoT-based agricultural solution system. The automated system helps the farmers to know the factors to be considered when growing the crops such as temperature, humidity, soil, and moisture. The developed system also helps to utilize the water resources as water is the most important resource that needs to be utilized in a proper way. Moreover, no need for farmers to use crude oil machinery that cost them a lot to buy fuel. It also helps farmers to focus on other day-to-day activities.

In the future, we would like to expand the system with implementation of a live view of the farming area using cameras. We would also embed it with other capabilities that will determine the level of water and its PH level. Solar as the source of power will be considered, since there's abundant sunlight on the farm.

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