CPC357 PROJECT

Smart Agriculture IoT System

SCHOOL OF COMPUTER SCIENCE

UNIVERSITI SAINS MALAYSIA

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Youtube Video Link:
https://youtu.be/DnK4xBTe95A

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1.0 Introduction

The Smart Agriculture System is an innovative system of what modern gardening and farming signify which combines the Internet of Things (IoT) technology with the conventional ones flawlessly. Living in the time when the optimization of resources and the environmentally-friendly approach to agriculture becomes more significant and more urgent, this system presents a rather novel solution to amateur gardeners or professional agriculturalists.

The system is able to work on some of the major issues that modern day agriculture grapples with. The old system of gardening and agricultural practices is highly dependent on manual surveillance and intervention that result in poor use of resources and lack of uniformity in the care of plants. The Smart Agriculture System changes this strategy in the way that it offers constant and automatic process monitoring and remote control of critical growing environments.

The scope of this project includes the full realization of automated agricultural monitoring and control system. The system is based on the high level sensor technology that would monitor some essential parameters of the environment, process this information with the help of a sophisticated control mechanism and deliver the real time information and control possibilities to the user with the help of a cloud-based application.

The overall uses of this system are spread out in different situations. In the residential environment, it allows owners to cultivate gardens in an efficient way and decrease water waste as well as enhance the well-being of plants. It is a learning tool and an effective solution in keeping green spaces in campuses in educational institutions. Commercial greenfield and farms can take advantage of the Smart Agriculture System to streamline the operations, maximize crop production, and minimize the total costs of operation.

2.0 System Overview

2.1 System Description

The Smart Agriculture Monitoring System is an integrated solution to the application of the innovative sensor technology in the field of agriculture management that will integrate high-quality sensor technology with automated control mechanisms to achieve a reliable and efficient agricultural management system. The main principle of the system is a high rotation cycle of monitoring, analysis, and response that provides the best possible growing conditions of plants with a minimum use of resources.

The design of the system is based on the Maker Feather AIoT S3 microcontroller that is the single-board computer in the system architecture. The interaction between several sensors is organized by this controller where the obtained information is processed to make those intelligence decisions on plant care and the functioning of the system. The moisture levels, temperature, humidity and the water levels of the soil are watched through strategically placed sensors, and they give a holistic picture of the agricultural environment.

2.2 Key Functionality

2.2.1 Real Time Monitoring

The system keeps under the watch of close critical parameters of the environment via an embedded sensor network. The sensor is also the soil moisture sensors located at strategic points of the location will give clear measurements of the soil water content to ensure that the irrigation control is effective and accurate. Atmospheric conditions are constantly followed by temperature and humidity, water level sensors constantly monitor the irrigation resources. This online tracking system will guarantee the detection of any drastic fluctuations in the growth environment and prevent any harm to the system through the timely reaction and following proper plant health efforts.

2.2.2 Automated Control System

The system responds automatically to sensor data in the form of predefined control measures based on the processed sensor data in an integrated actuator network. The main type of control is the use of a servo-controlled irrigation system which will specifically control the flow of water based on the real time soil moisture levels. Upon the decrease in moisture content of the soil to predetermined threshold parameters, the system automatically triggers irrigation process made sure that plants obtain adequate water content with little wastage hence efficient use of resources.

2.2.3 Alert and Notification System

A unified warning system gives instant details of local and remote warning systems to notify critical environmental conditions. Local warnings are provided through an onboard-buzzer and the remote messages are sent into the mobile devices or computers of the user through email by a cloud-linked interface. Such warnings warn the user of the essential circumstances, like excessive dryness of soil, so that it is possible to implement necessary actions in time to avoid any possible stress in crops or plants.

2.2.4 Non-Contact Liquid Level Sensor

The system also has the non-contact liquid level sensor to help in checking the sufficiency of water in the irrigation reservoir. An audible warning to alert the user that the water level is too low or there is none at all is activated by the sensor when the level of water is considered to be critical or empty. Such a function will guarantee stable performance of the irrigation system and eliminate any inconveniences in the maintenance of the plants caused by the lack of water.

2.3 Data Management & Processing

The system has an elaborate data management strategy that goes beyond simple data-acquisition. Raw sensor data is initially processed at microcontroller level where it gets validated, filtered and converted into useful engineering values. This is then sent to the V-One IoT Platform where further analysis and safe possession is carried out.

The past data is organized and presented in a form of visuals to allow the users to discover patterns and trends of the situation in the environment over the time. Using the V-One IoT Platform, the user will be able to see in-depth historical data on levels of soil moisture, temperature, moisture, water consumption patterns, etc. Such data visualization and analysis feature enables the users to comprehend more about the specific features and needs of the agricultural environment surrounding in the context of time so that to make appropriate decisions and plan resources more efficiently.

2.4 User Interface & Control

The system offers a complex user interface on the basis of V-One IoT Platform, which offers both real-time monitoring and controlling facilities. The users are able to view live sensor information through user-friendly dashboards that show the current conditions of the environment, historical trends and the general system status. Besides automated functions, the interface has manual control facilities that allow a user to override system activities where necessary to suit certain agricultural needs.

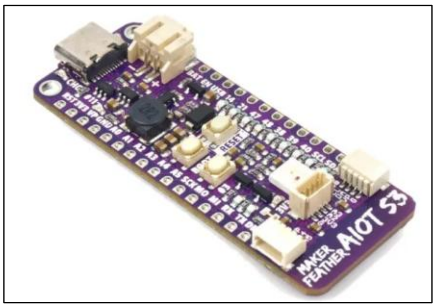
There are three key visualization dashboards that give various ways of looking at the environment under surveillance:

- Dashboard of soil moisture monitoring giving the trend with time of the moisture level to aid in making irrigation decisions.
- The temperature and humidity panel that displays real-time weather progression of the atmosphere that affects the growth of plants.
- Detailed system overview dashboard of all the parameters observed to give an all-encompassing picture of the system performance such as soil moisture, temperature and humidity.

3.0 Hardware Components

3.1 Core Controller

3.1.1 Maker Feather AIoT S3



Specification:

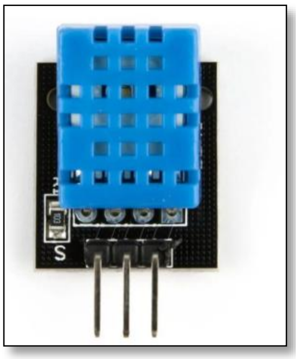
- Processor: ESP32-S3 Dual-Core 240MHz
- Memory: 512KB RAM
- Flash: 4MB
- Wireless: WiFi 802.11 b/g/n
- Battery Management: Built-in LiPo charging
- Operating Voltage: 3.3V

Key Features:

- Native USB
- Battery monitoring
- Deep sleep capabilities
- Multiple GPIO pins
- I2C and SPI support
- In-Built Buzzer

3.2 Sensors

3.2.1 DHT 11 Sensor (Temperature & Humidity)



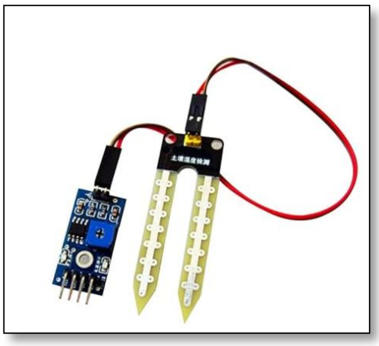
Specification:

- Operating Voltage: 3.3V
- Protocol: I2C
- Temperature Range: -40°C to 85°C
- Humidity Range: 0-100%
- Accuracy: ±0.5°C,±2%RH

Features:

- Built-in ADC
- Digital output
- Low power consumption
- High precision

3.2.2 Soil Moisture Sensor



Specification:

- Operating Voltage: 3.3-5V
- Output: Analog (0-1023)
- Measurement Range: 0-100%
- Response Time: <1s
- Accuracy: ±3%

Calibration Requirement:

- Dry soil calibration point
- Wet soil calibration point
- Temperature compensation

3.2.3 Non-Contact Liquid Level Sensor

Specification:

- Operating Voltage: 5V
- Detection Range: Up to 10mm
- Output: Digital (High/Low signal)
- Response Time: <500ms

Features:

- No direct contact with liquids, ensuring durability and preventing corrosion.
- High sensitivity for accurate water level detection.

Application:

- Monitors water levels in the irrigation reservoir.
- Triggers an alert via a buzzer when water levels are critically low or absent.

3.3 Actuators

3.3.1 Servo Motor

Specification:

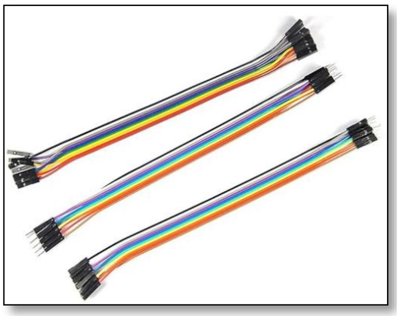
- Operating Voltage: 4.8-6V
- Torque: 1.8 kg-cm
- Rotation Range: 180°
- Speed: 0.1s/60°
- Weight: 9g

Application:

- Water valve control
- Flow regulation

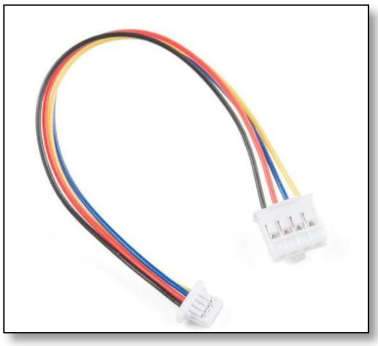
3.4 Connectivity Components

3.4.1 Jumper Wires



- Male-to-male connections
- Male-to-female connections
- Female-to-female connections
- Length: 15cm
- Current Rating: 1A

3.4.2 Qwicc Cables



- Length: 10cm
- Connector: JST SH
- Wire Gauge: 28AWG
- Pin Configuration: 4-pin (VCC, GND, SDA, SCL)

4.0 SDG Alignment

The Smart Agriculture IoT System promotes the sustainability efforts in the world by bringing the (SDGs) to fruition, specifically SDG 11: Sustainable Cities and Communities and SDG 12: Responsible Consumption and Production. The system encourages efficient use of resources and sustainable environmental practices by incorporating an IoT-based monitoring, automation and data-driven decision-making.

4.1 SDG 11: Sustainable Cities & Communities

Goal Description:
SDG 11 aims to make cities inclusive, safe, resilient, and sustainable. It emphasizes the importance of green spaces, efficient resource management, and smart technologies to improve urban living conditions.

Project Contribution:

- **Support for Urban Agriculture**: The system facilitates sustainable urban agriculture by enabling efficient plant management in limited spaces, contributing to improved air quality, reduced urban heat island effects, and enhanced urban greenery.

- **Smart Infrastructure Integration**: The project demonstrates how IoT-based systems can be incorporated into smart city infrastructure to enhance resource efficiency and promote sustainable urban ecosystems.

- **Community Engagement and Awareness**: By providing a user-friendly and accessible platform, the system encourages community participation in sustainable agricultural practices, fostering environmental awareness and a culture of sustainability among users.

4.2 SDG 12: Responsible Consumption & Production

Goal Description:
SDG 12 emphasizes the need to ensure sustainable consumption and production patterns. It focuses on minimizing waste, optimizing resource utilization, and promoting environmentally responsible practices across all stages of production and consumption.

Project Contribution:

- **Efficient Water Utilization:** The system optimizes water usage by employing soil moisture sensors to ensure irrigation is performed only when necessary, significantly reducing water wastage.

- **Reduction of Resource Waste:** Automated irrigation control prevents overwatering and underwatering, thereby minimizing unnecessary water and energy consumption while maintaining optimal plant growth.

- **Promotion of Sustainable Agricultural Practices:** By leveraging IoT automation, the system encourages eco-friendly practices through responsible use of water and electricity, supporting long-term sustainability in plant care and agriculture.

5.0 System Architecture

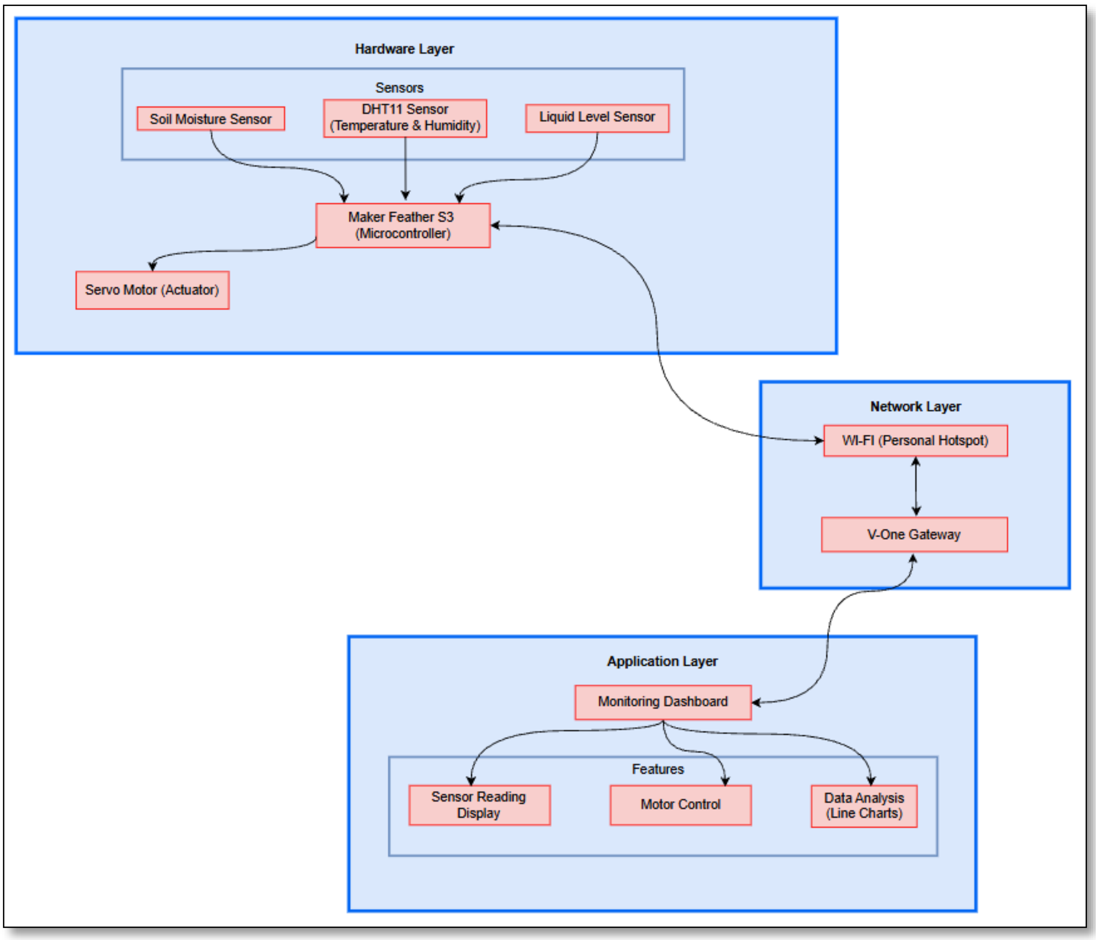


Figure 1: Shows System Architecture Diagram

6.0 Setup Guide

6.1 Hardware Setup

6.1.1 Wiring Components

- DHT11 Sensor -> Maker Port (right)
  - VCC pin → VP
  - GND pin → GND
  - Data pin → Pin D42

- Soil Moisture Sensor -> Maker Port (middle)
  - VCC pin → 3.3V
  - GND pin → GND
  - Analog pin → Pin A2

- Servo Motor:
  - Signal pin → Pin D21
  - VCC pin → 5V (VUSB)
  - GND pin → GND

- Liquid Level Sensor:
  - Data pin → Pin D4
  - VCC pin → 5V (VUSB)
  - GND pin → GND

6.1.2 Assembly

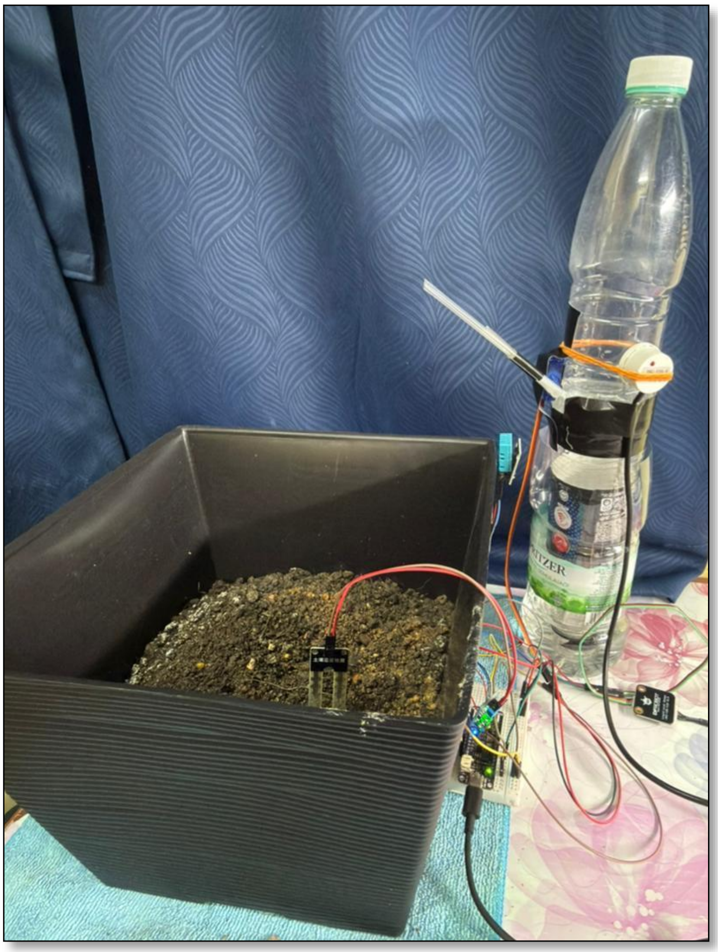


Figure 3: Shows Hardware Components of the Smart Agriculture IoT System

- Place the DHT11 sensor in the area around the plant as demonstrated in the picture to get proper temperature and humidity readings.
- Place the soil moisture sensor on soil.
- Place water container in a tube and place it next to the soil.
- Connect the tube to the arm of the servo moto to create a kind of a valve to allow the water flow to be opened and shut.
- Fix the Non-Contact Liquid Level sensor to the external surface of the irrigation reservoir at an adequate height to sense when there is a drop in the water supply level.
- Connect the Maker Feather AIoT S3 microcontroller to a power Cable either through USB or LiPo battery.

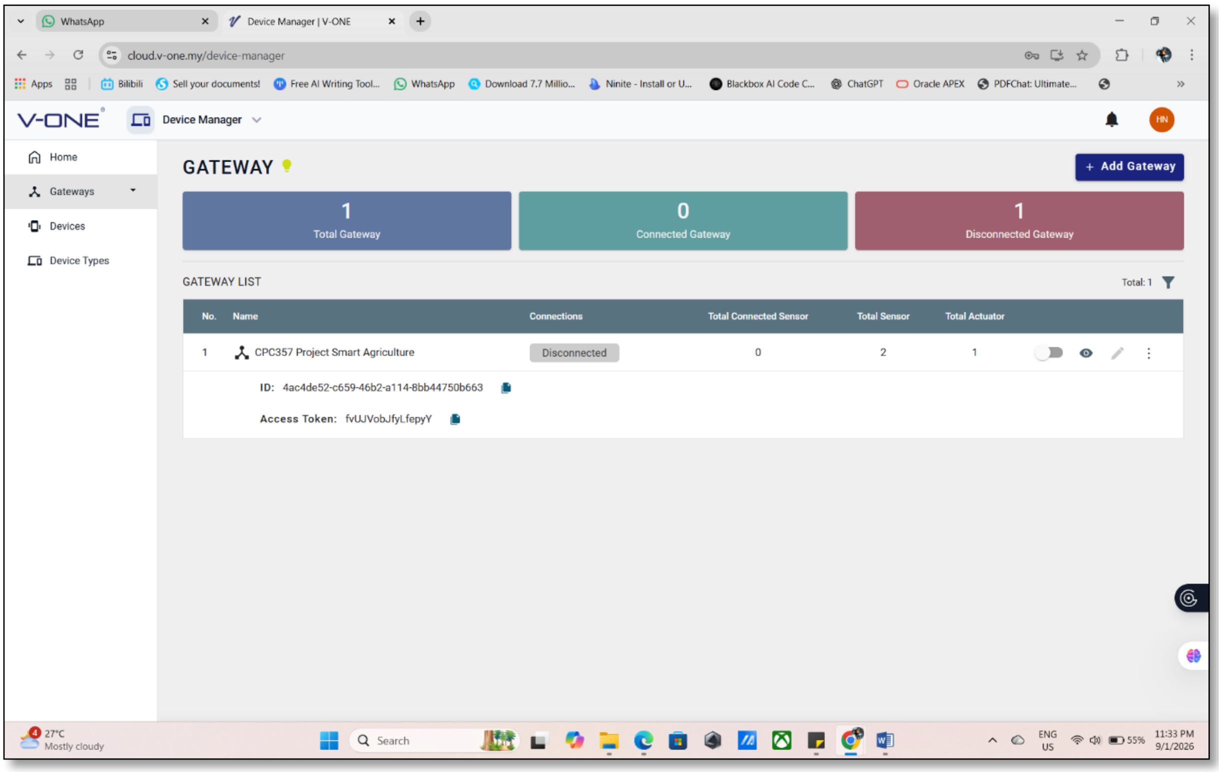
6.2 Software Setup

6.2.1. Arduino IDE

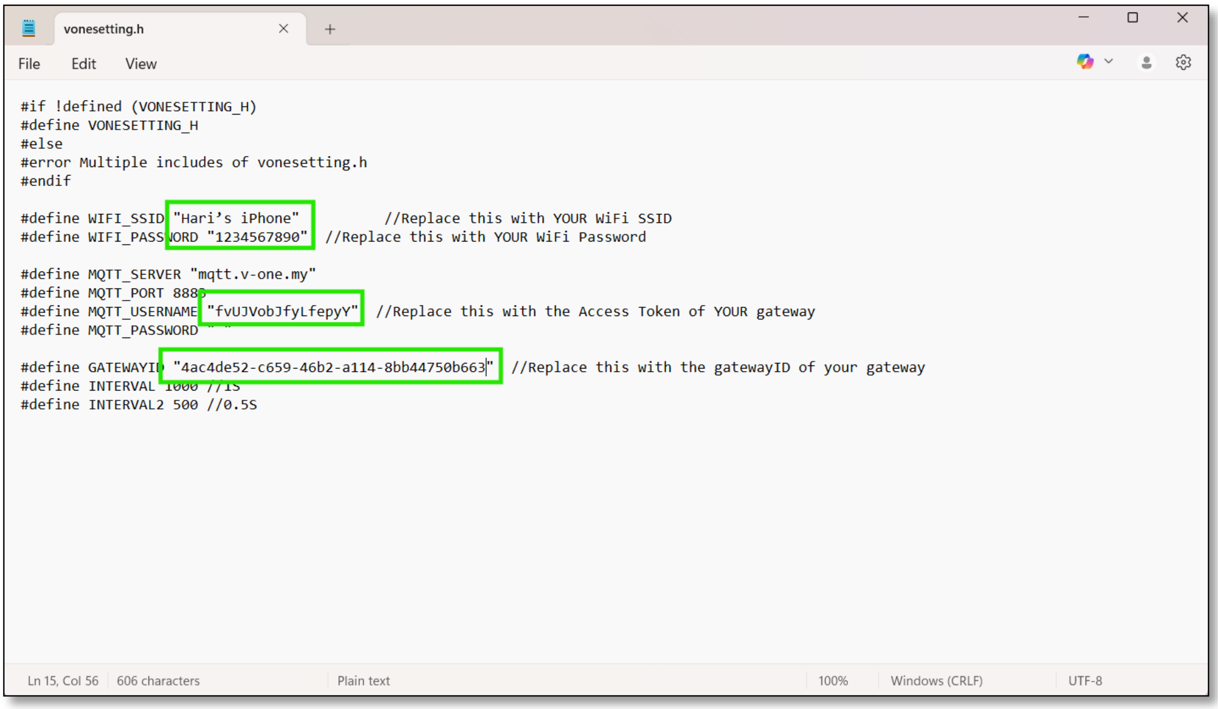
- Download and install the Arduino IDE from the official website.
- Install the ESP32 board package by adding the board manager URL: https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json
- Install the required libraries:
  - **DHT library** for the DHT11 sensor.
  - **ESP32Servo** library for servo motor control.
  - **Arduino_JSON** library for JSON parsing.
- To install **V-One Libraries**, download the ZIP file from the following link: https://github.com/CytronTechnologies/IoT-Kit-V-One
- Open Arduino IDE. Go to Sketch > Include Library > Add ZIP Library. Choose the ZIP file that you have downloaded. The file name should be "IoT-Kit-V-One-Main".
- Navigate to the V-One libraries to modify the **WiFi and gateway credentials**. The libraries for Arduino IDE are usually stored in this path: **Documents\Arduino\libraries\IoT-Kit-V-One-main**

6.2.2 Configure Wi-Fi & Cloud Settings

- Take note of the Access Token and GatewayID that can be found in the V-One platform at **Device Manager > Gateways**.



- Open the **"vonesetting"** file using Notepad or any text editor. Change the **WiFi SSID**, **WiFi Password**, **Gateway Access Token**, and **GatewayID**.

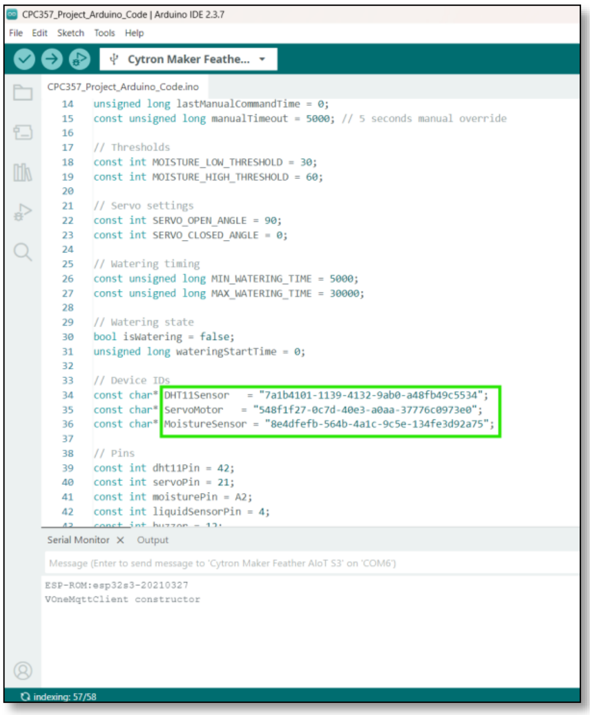


```
#if !defined (VONESETTING_H)
#define VONESETTING_H
#else
#error Multiple includes of vonesetting.h
#endif

#define WIFI_SSID "Hari's iPhone"          //Replace this with YOUR WiFi SSID
#define WIFI_PASSWORD "1234567890" //Replace this with YOUR WiFi Password

#define MQTT_SERVER "mqtt.v-one.my"
#define MQTT_PORT 8883
#define MQTT_USERNAME "fvUJVobJfyLfepyY" //Replace this with the Access Token of YOUR gateway
#define MQTT_PASSWORD " "

#define GATEWAYID "4ac4de52-c659-46b2-a114-8bb44750b663" //Replace this with the gatewayID of your gateway
#define INTERVAL 1000 //1S
#define INTERVAL2 500 //0.5S
```

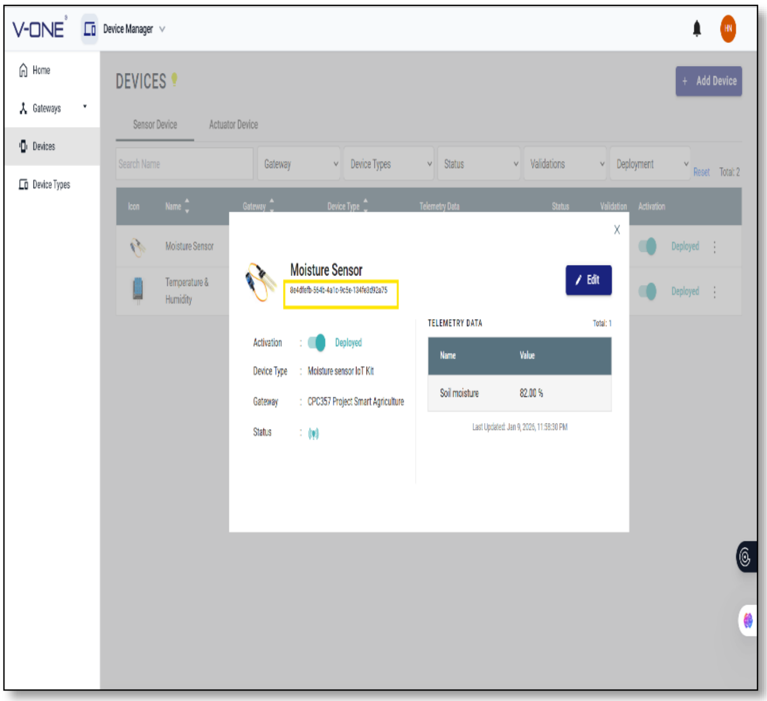
- Then, click the save button and close the file.

6.2.3 Upload Arduino Code

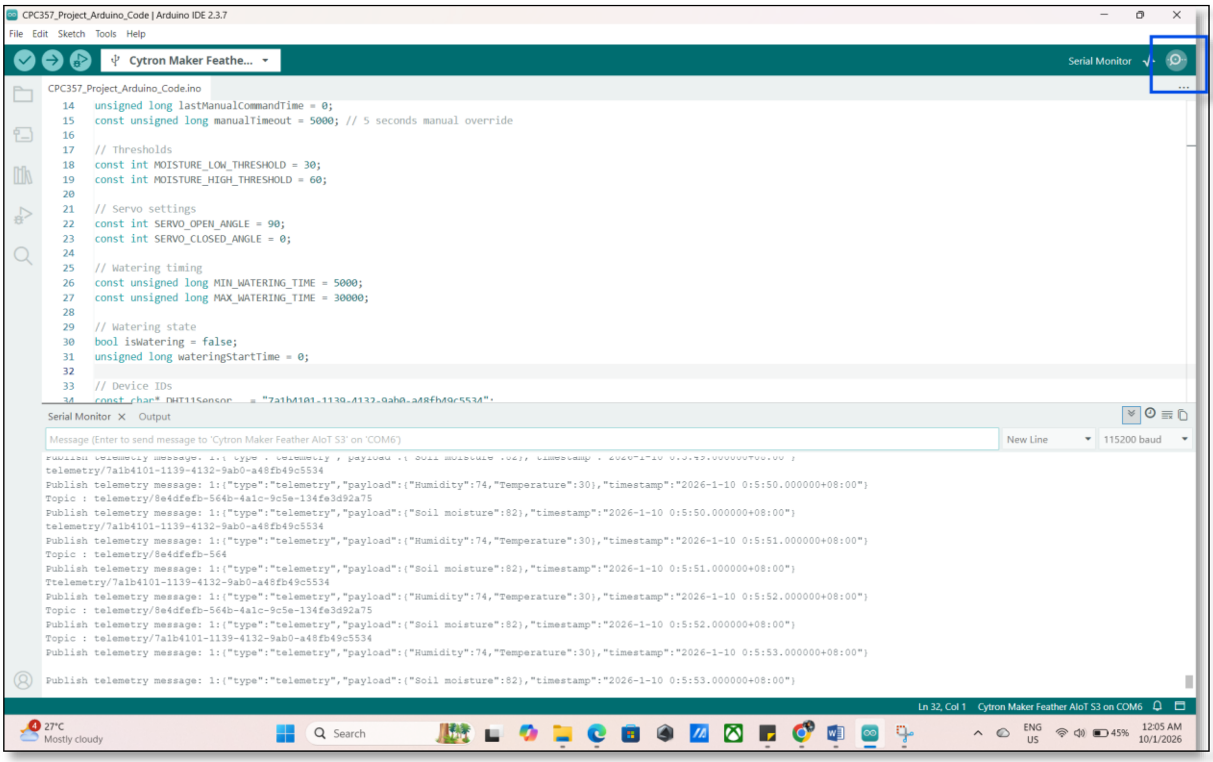
- Go to **Tools** > **Board** > **Boards Manager** in Arduino IDE.
- Type in "esp32" and install the esp32 board manager by Espressif Systems.
- After pasting the project code, find the lines that define the **deviceID** and replace them with your deviceID for each sensor. **Note:** You can get the **deviceID** (marked in yellow box) from the V-One platform, **Device Manager** > **Devices** > **click on the related device.**



```
unsigned long lastManualCommandTime = 0;
const unsigned long manualTimeout = 5000; // 5 seconds manual override

// Thresholds
const int MOISTURE_LOW_THRESHOLD = 30;
const int MOISTURE_HIGH_THRESHOLD = 60;

// Servo settings
const int SERVO_OPEN_ANGLE = 90;
const int SERVO_CLOSED_ANGLE = 0;

// Watering timing
const unsigned long MIN_WATERING_TIME = 5000;
const unsigned long MAX_WATERING_TIME = 30000;

// Watering state
bool isWatering = false;
unsigned long wateringStartTime = 0;

// Device IDs
const char* DHT11Sensor    = "7a1b4101-1139-4132-9ab0-a48fb49c5534";
const char* ServoMotor     = "548f1f27-0c7d-40e3-a0aa-37776c0973e0";
const char* MoistureSensor = "8e4dfefb-564b-4a1c-9c5e-134fe3d92a75";

// Pins
const int dht11Pin = 42;
const int servoPin = 21;
const int moisturePin = A2;
const int liquidSensorPin = 4;
```



- Before you start to upload the code, you will need to enter the ROM Bootloader mode of the Maker Feather AIoT S3. Follow these steps:
  - ➢ Connect the Maker Feather AIoT S3 to the computer.
  - ➢ Press and hold the **BOOT** button.
  - ➢ Press and release the **RESET** button. Make sure the **BOOT** button is still pressed while resetting the board.
  - ➢ Now you can release the **BOOT** button. You should see a new COM port on your computer. Note: You need to enter ROM Bootloader mode for **first-time use only.**
- Choose the corresponding board and COM port before uploading the code.
  - ➢ **Tools > Boards > esp32 > Cytron Maker Feather AIoT S3**
  - ➢ **Tools > Port > Your COM port**
  - ➢ Change the **USB Mode to Hardware CDC and JTAG.**
- Click the Upload button and it will take some time to finish uploading. Once the code has been successfully uploaded, press the RESET button on your Maker Feather AIoT S3 board and your Maker Feather AIoT S3 will start to run the code.
- Then, click the Serial Monitor button on the top right of the screen where we can see whether the sensor data is successfully sent to the V-One platform.

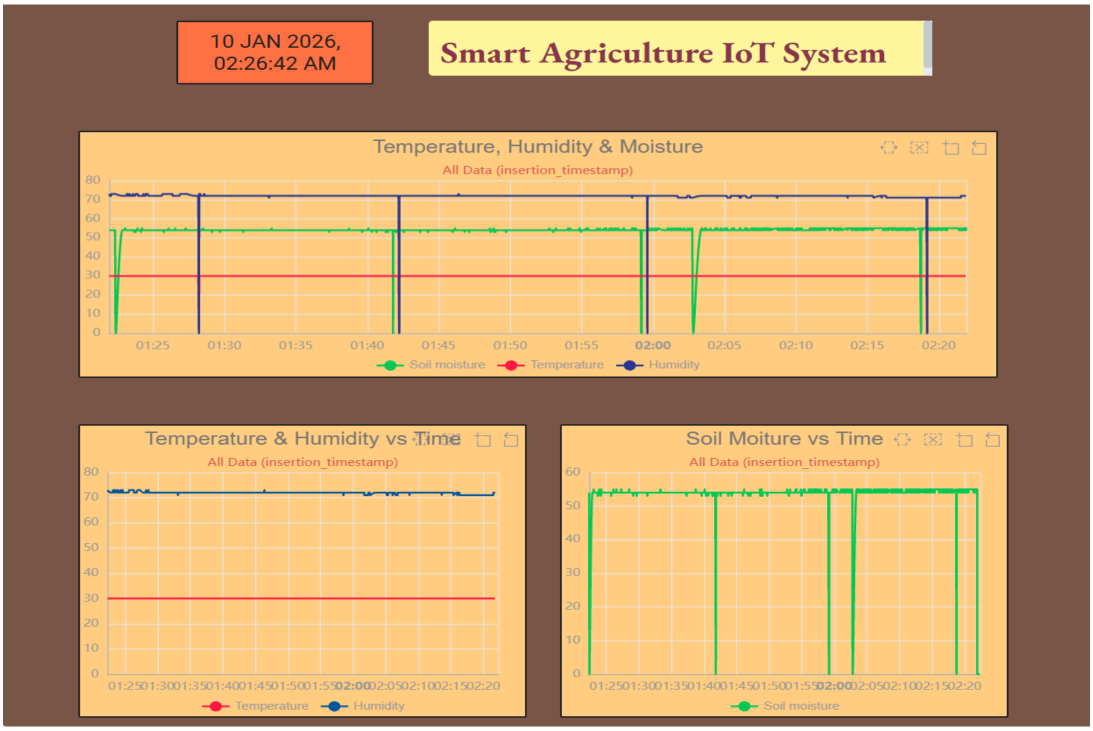


7.0 Appendix

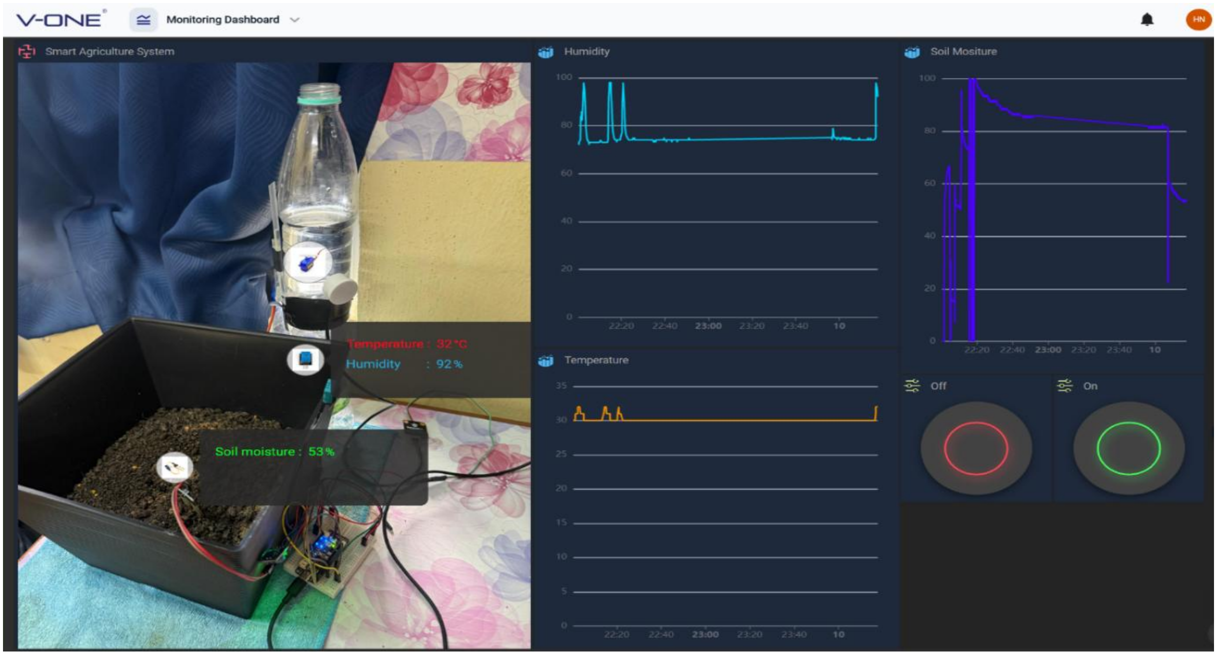
7.1 GitHub Repository Link:

- https://github.com/harinethiran1306/Smart-Agriculture-IoT-System-.git

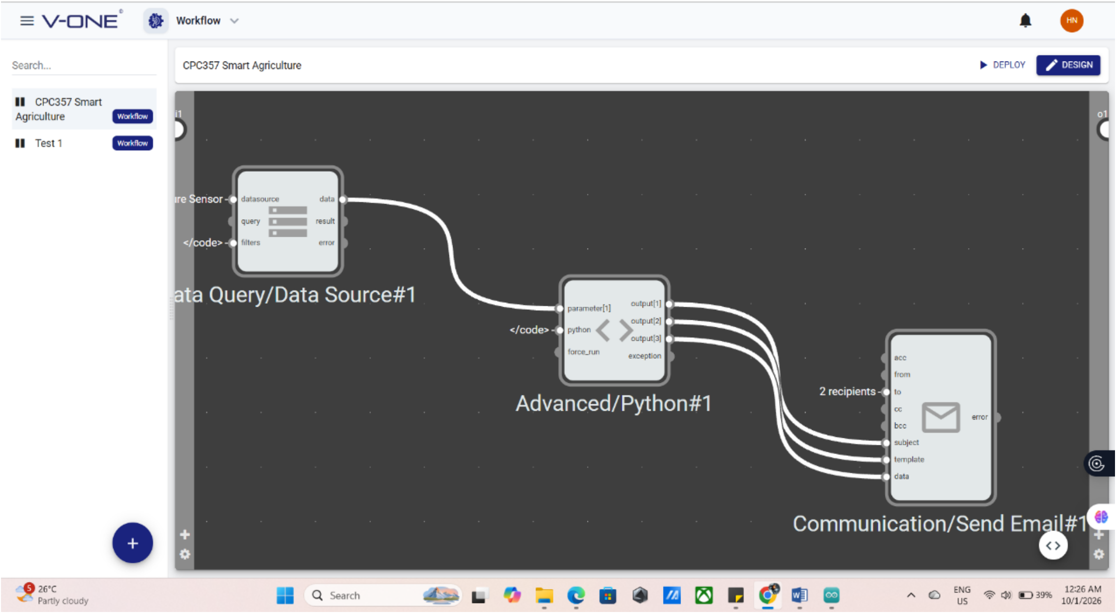
7.2 Smart Agriculture IoT System Dashboard (V- One Platform)



7.3 Smart Agriculture IoT System Monitoring Dashboard (V- One Platform)



7.4 V- One Workflow (Email Notification)



7.5 Alert Notification Through Email (Low Soil Moisture Reading)