CPC357 PROJECT

SMART GARDEN IoT SYSTEM

SCHOOL OF COMPUTER SCIENCE

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1. Introduction

The Smart Garden Monitoring System represents a revolutionary approach to modern gardening, seamlessly integrating Internet of Things (IoT) technology with traditional horticultural practices. In an era where resource optimization and sustainable farming practices are becoming increasingly crucial, this system offers an innovative solution for both amateur gardeners and professional agriculturists.

The system addresses several key challenges faced in contemporary gardening and agriculture. Traditional gardening methods often rely heavily on manual monitoring and intervention, leading to inefficient resource usage and inconsistent plant care. Our Smart Garden Monitoring System transforms this approach by providing continuous, automated monitoring and precise control over essential growing conditions.

This project's scope encompasses the complete development and implementation of an automated garden monitoring and control system. The system utilizes advanced sensor technology to monitor critical environmental parameters, processes this data through a sophisticated control system, and provides users with real-time information and control capabilities through a cloud-based interface.

The primary applications of this system extend across various scenarios. In residential settings, it enables homeowners to maintain their gardens efficiently while reducing water waste and improving plant health. In educational institutions, it serves as both a learning tool and a practical solution for maintaining campus green spaces. Commercial greenhouses can leverage the system to optimize their operations and increase crop yields while reducing operational costs.

2. System Overview

2.1 System Description

The Smart Garden Monitoring System represents an integrated solution that combines advanced sensor technology with automated control mechanisms to create an efficient and reliable garden management system. At its foundation, the system operates through a continuous cycle of monitoring, analysis, and response, ensuring optimal growing conditions for plants while minimizing resource consumption.

The system architecture is built around the Maker Feather AIoT S3 microcontroller, which serves as the central processing unit. This controller orchestrates the interaction between various sensors, processing the collected data to make intelligent decisions about garden maintenance. Environmental parameters such as soil moisture, temperature, humidity, and water levels are continuously monitored through strategically placed sensors, providing a comprehensive view of the garden's condition.

2.2 Core Functionality

Real-time Monitoring

The system maintains constant vigilance over critical environmental parameters through its sensor network. Soil moisture sensors embedded at key locations provide accurate readings of soil water content, enabling precise irrigation control. Temperature and humidity sensors monitor atmospheric conditions, while water level sensors track irrigation system reserves. This continuous monitoring ensures that any significant changes in growing conditions are detected immediately.

Automated Control Systems

Based on the processed sensor data, the system implements automated control responses through its actuator network. The primary control mechanism is a servo-controlled irrigation system that precisely regulates water flow based on soil moisture readings. When soil moisture levels fall below predetermined thresholds, the system automatically initiates irrigation, ensuring plants receive optimal water levels without waste.

Alert and Notification System

An integrated alert system provides immediate notification of critical conditions through buzzer and remote channels. The cloud-connected interface delivers notifications to users' mobile devices or computers via email. These alerts can indicate conditions such as critically low soil moisture, unusual temperature variations, or low humidity.

Non-Contact Liquid Level Sensor

The system includes a non-contact liquid level sensor to detect the presence of water in the irrigation reservoir. If the sensor detects that water levels are critically low or absent, a buzzer is activated to alert the user to refill the water reservoir promptly. This feature ensures the irrigation system remains operational and prevents interruptions in plant care.

2.3 Data Management and Processing

The system employs a sophisticated data management approach that goes beyond simple data collection. Raw sensor data undergoes initial processing at the microcontroller level, where it is validated and converted into meaningful measurements. This processed data is then transmitted to the V-One IoT Platform, where it undergoes further analysis and storage.

Historical data is maintained and visualized to help users identify patterns and trends in the garden's environmental conditions. Through the V-One IoT Platform, users can access comprehensive historical records of soil moisture levels, temperature variations, humidity changes, and water usage patterns. This data collection and visualization capability enables users to better understand their garden's specific characteristics and requirements over time.

2.4 User Interface and Control

The system provides a comprehensive user interface through the V-One IoT Platform, offering both monitoring and control capabilities. Users can access real-time data through intuitive dashboards that display current conditions, historical trends, and system status. The interface also provides manual control options, allowing users to override automated systems when necessary.

Three primary visualization dashboards offer different perspectives on garden conditions:

- A soil moisture tracking interface showing moisture trends over time.
- A temperature and humidity monitoring display for environmental conditions.
- A comprehensive system overview combining all monitored parameters, temperature, humidity and soil moisture.

3. Hardware Components

3.1 Core Controller

3.1.1 Maker Feather AIoT S3

Specifications:

- 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 Soil Moisture Sensor

Specifications:

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

Calibration Requirements:

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

3.2.2 DHT11 Sensor (Temperature & Humidity Sensor)

Specifications:

- 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

3.2.3 Non-Contact Liquid Level Sensor

Specifications:

- 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.

Applications:

- 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 Micro Servo

Specifications:

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

Applications:

- Water valve control
- Flow regulation

3.4 Connectivity Components

3.4.1 Qwiic Cables

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

3.4.2 Jumper Wires

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

4. SDG Alignment

The Smart Garden IoT System contributes to global sustainability efforts by aligning with the following SDGs: SDG 12: Responsible Consumption and Production, SDG 15: Life on Land, and SDG 11: Sustainable Cities and Communities.

4.1 SDG 12: Responsible Consumption and Production

Goal Description: SDG 12 emphasizes the need to ensure sustainable consumption and production patterns. It aims to minimize waste, optimize resource use, and promote sustainability across production and consumption processes.

Project Contribution:

- Efficient Water Use: The project optimizes water usage by utilizing sensors (soil moisture) to ensure water is only used when needed, reducing wastage.
- Reduction of Resource Waste: By automating the irrigation process, the system eliminates the risk of overwatering or underwatering, contributing to resource-efficient gardening practices.
- Sustainable Gardening Practices: Encourages eco-friendly gardening by promoting the responsible use of water and electricity through IoT automation.

4.2 SDG 15: Life on Land

Goal Description: SDG 15 focuses on protecting, restoring, and promoting the sustainable use of terrestrial ecosystems, combating desertification, and halting biodiversity loss.

Project Contribution:

- Healthy Plant Growth: By monitoring soil moisture and ensuring proper irrigation, the system promotes healthy plant growth, improving soil fertility and reducing the risk of land degradation.
- **Promotion of Local Flora:** By enabling controlled environments for plant growth, the project facilitates the cultivation of native plants, which are crucial for maintaining biodiversity and supporting local ecosystems.

4.3 SDG 11: Sustainable Cities and Communities

Goal Description: SDG 11 aims to make cities inclusive, safe, resilient, and sustainable. It includes efforts to enhance urban greenery and sustainable practices to improve urban living conditions.

Project Contribution:

- Urban Gardening: The system supports sustainable urban gardening practices, which help improve air quality, reduce urban heat islands, and create green spaces in densely populated areas.
- Smart Infrastructure: Demonstrates how IoT technology can be integrated into smart cities to manage resources more efficiently, contributing to sustainable urban ecosystems.
- Community Engagement: Encourages community participation in sustainable gardening by making technology accessible and user-friendly, fostering a culture of sustainability.

5. System Architecture

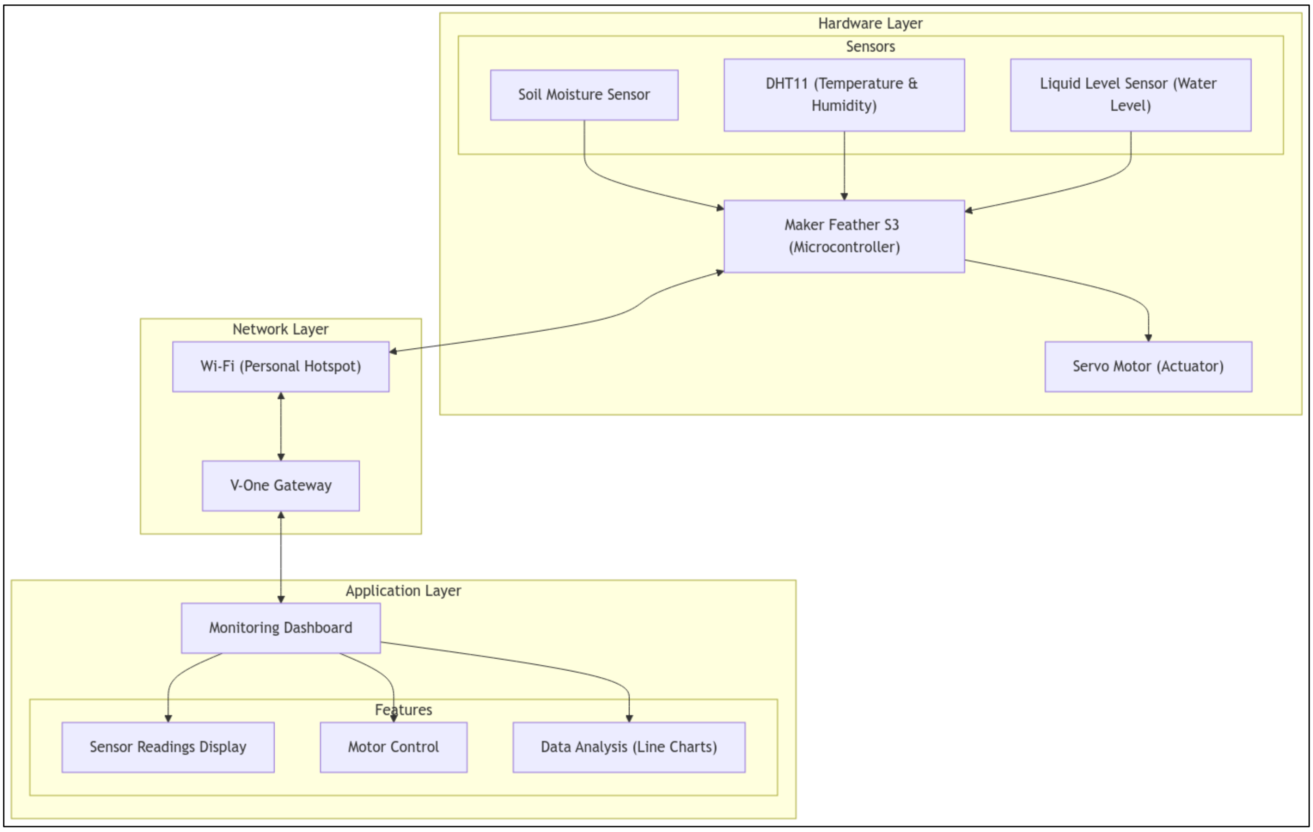


Figure 1: System architecture diagram

6. Setup Guide

6.1 Hardware Setup

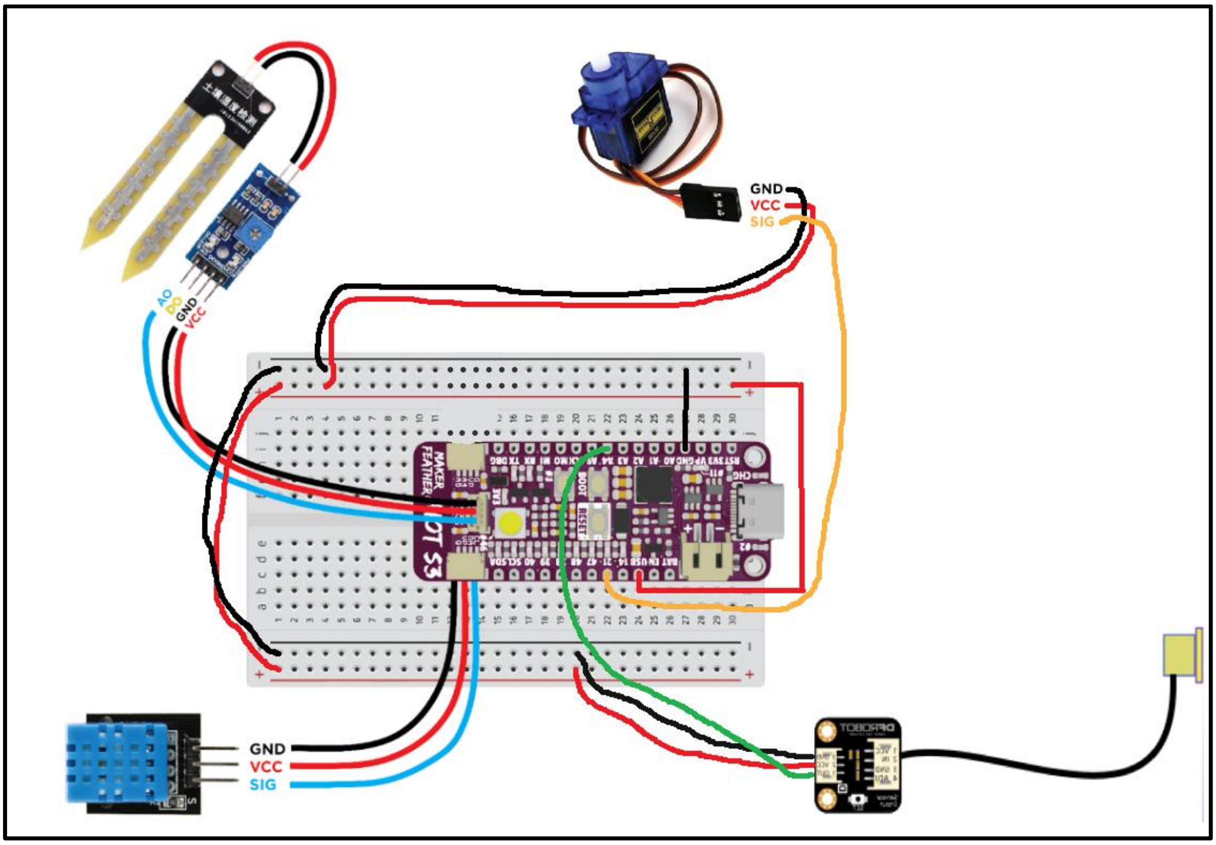


Figure 2: Circuit diagram of the hardware components

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: Hardware component of the Smart Garden IoT system

- Mount the DHT11 sensor in the plant's vicinity as shown in the picture for accurate temperature and humidity readings.
- Insert the soil moisture sensor into the soil.
- Connect the water container to a straw/tube and position it near the soil.
- Attach the straw/tube to the servo moto’s arm to make it as a valve to open and close the water flow.
- Attach the Non-Contact Liquid Level sensor to the outside of the irrigation reservoir at the appropriate height to detect low water levels.
- Connect the Maker Feather AIoT S3 microcontroller to a power source via USB or a LiPo battery.

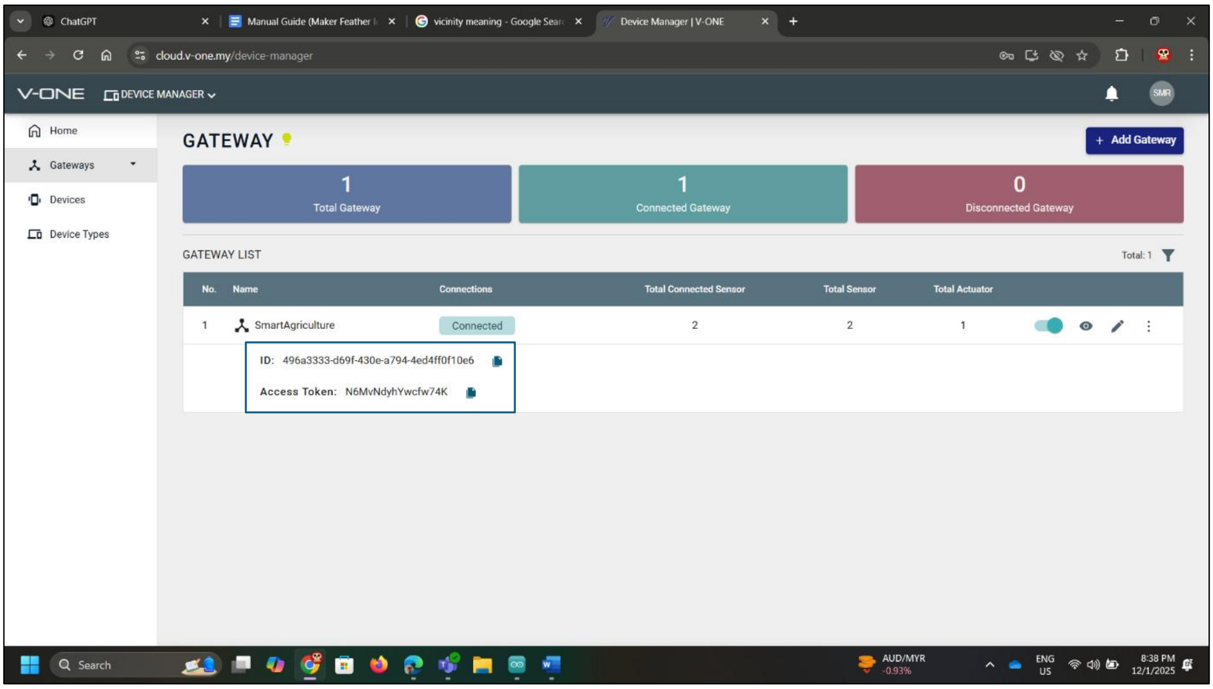
6.2 Software Setup

6.2.1 Arduino IDE

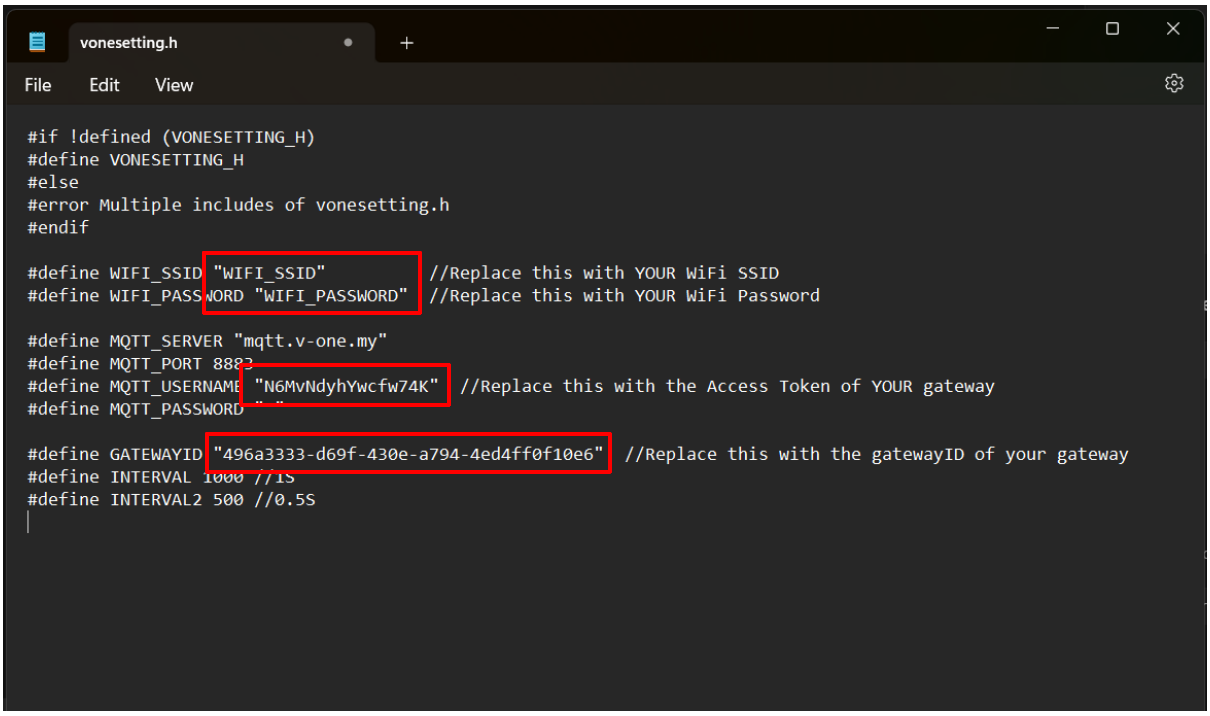
- Download and install the Arduino IDE from the official website.
- Install the ESP32 board package by adding the board manager URL: https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json
- Install the required libraries:
    - **DHT library** for the DHT11 sensor.
    - **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 WiFi and Cloud Settings

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



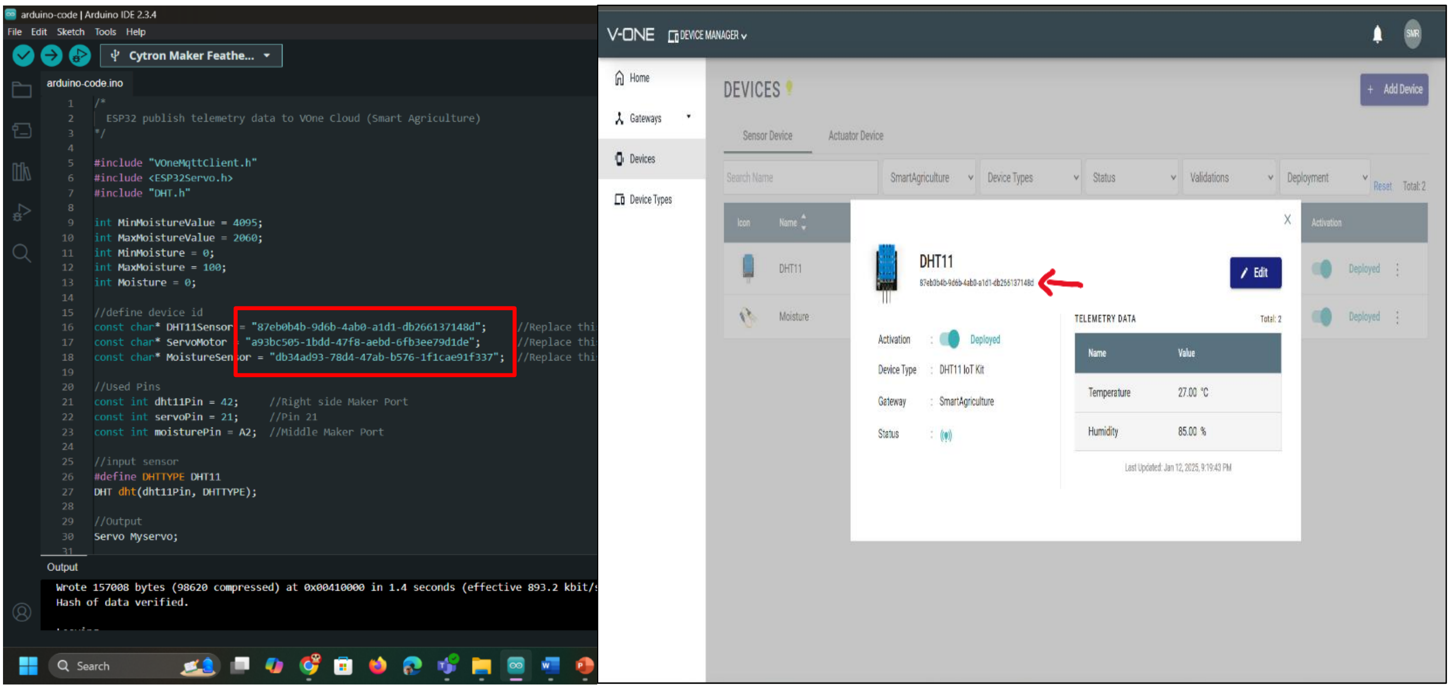
- Open the **"vonesetting"** file using Notepad or any text editor. Change the **WiFi SSID, WiFi Password, Gateway Access Token,** and **GatewayID**.



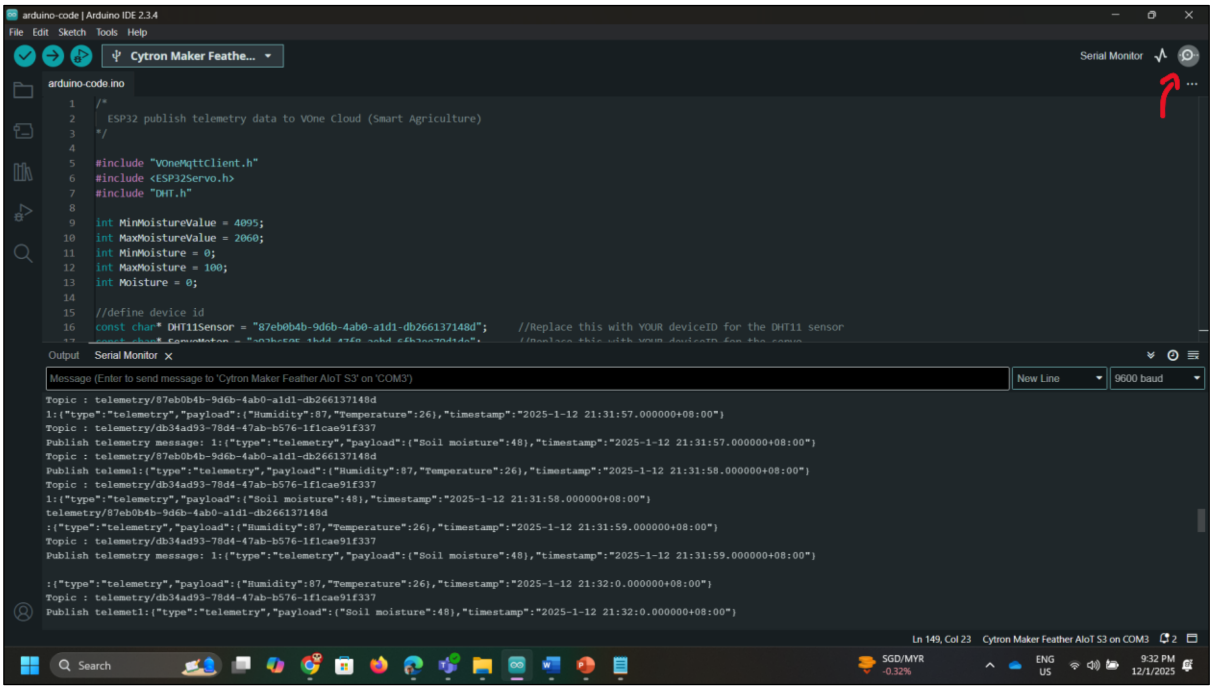
- Then, click the save button and close the file.

6.2.3 Upload 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** (in the red box) and replace them with your deviceID for each sensor. **Note:** You can get the deviceID (pointed by red arrow) from the V-One platform, **Device Manager > Devices > click on the related device.**



- 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.

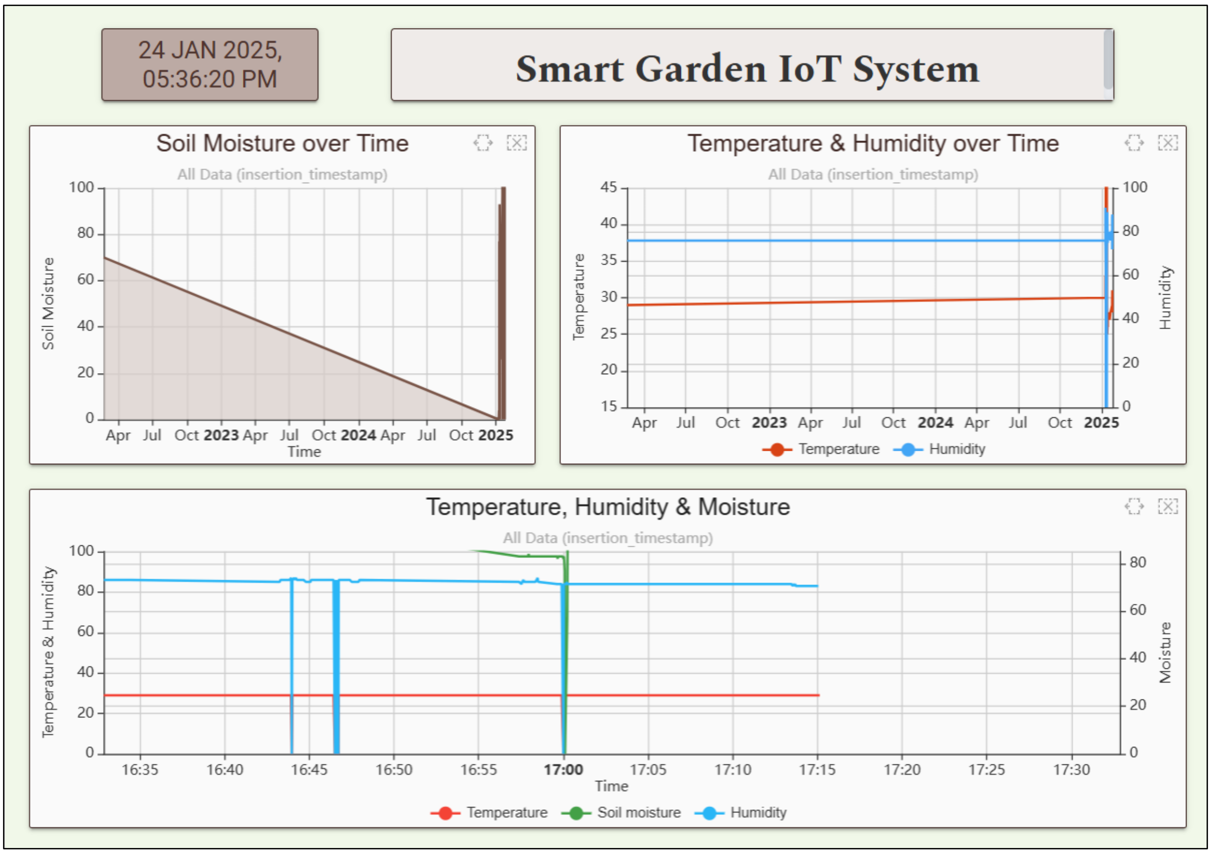


8. Appendix

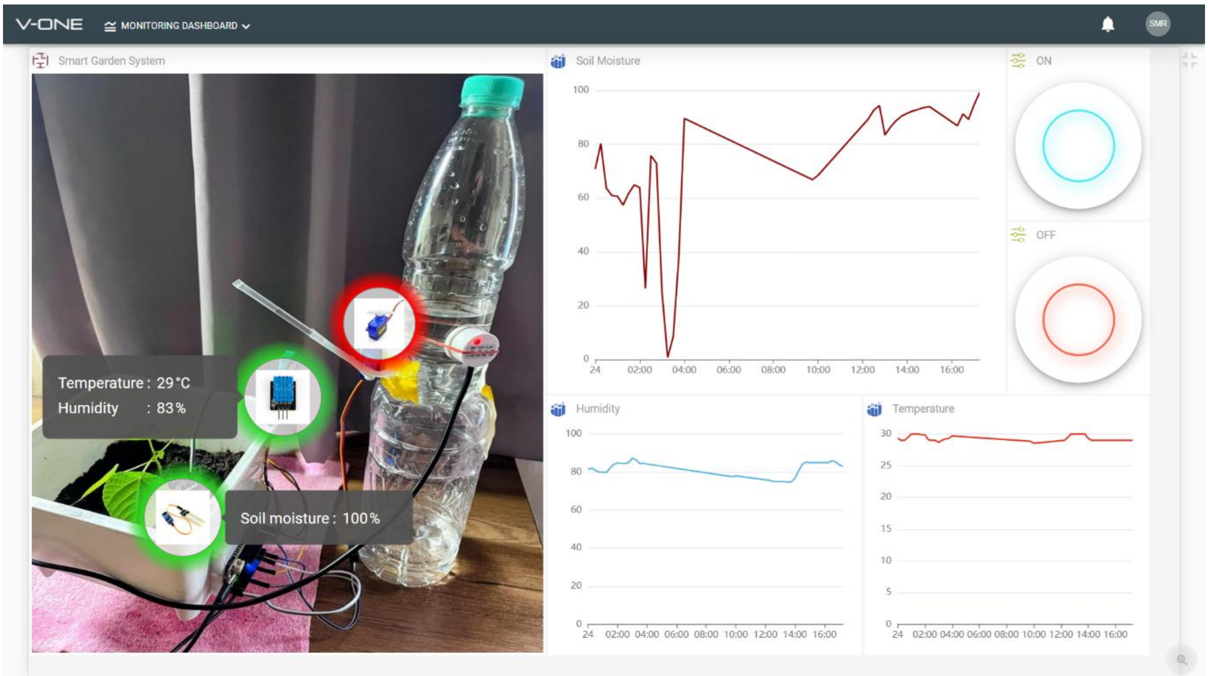
8.1 GitHub repositary link

https://github.com/mugunthantypical/CPC357-Project.git

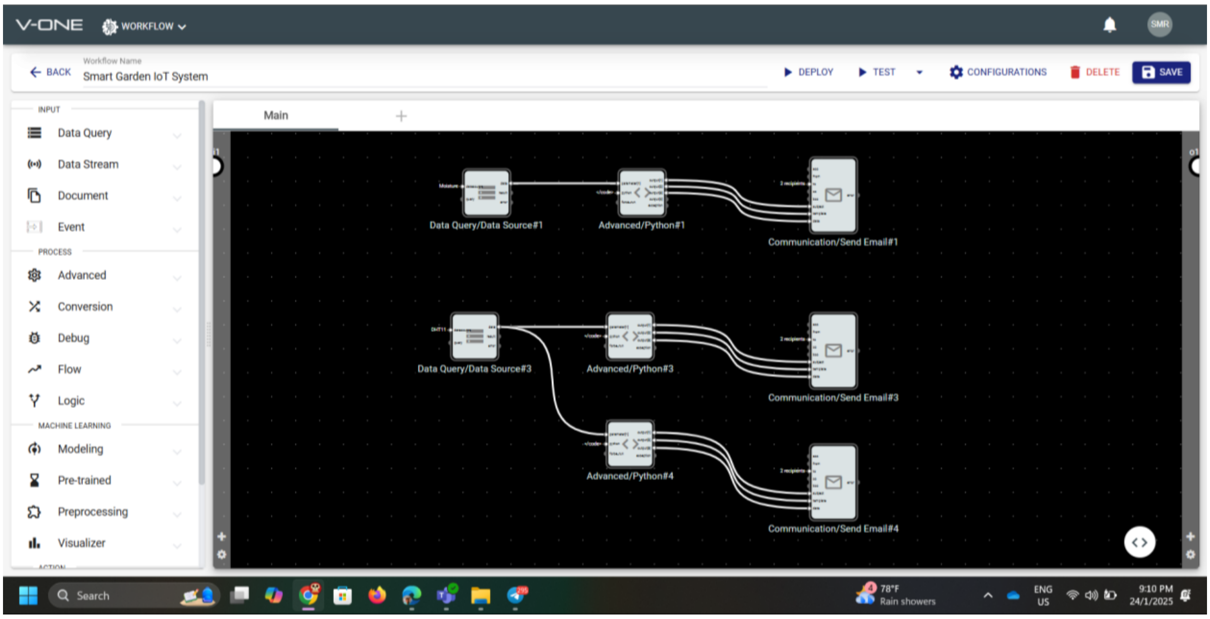
8.2 Smart Garden IoT System Dashboard (V-One Platform)



8.3 Smart Garden IoT System Monitoring Dashboard (V-One Platform)



8.4 V-One Workflow for email notification



8.5 Alert notification through email for all the sensor readings