

IOT BASED SMART AGRICULTURE MONITORING SYSTEM

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Technology degree in Biotechnology
Interdisciplinary project

By

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SCHOOL OF BIO AND CHEMICAL ENGINEERING**

SATHYABAMA

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(DEEMED TO BE UNIVERSITY)**

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of Ajaay Sha P H (Reg. No. 41230005), Karthikeyan S (Reg. No. 41230025), Satheyosh M (Reg. No. 41230056), who carried out the Interdisciplinary Project entitled "IOT BASED SMART AGRICULTURE MONITORING SYSTEM" under our supervision from January 2024 to April 2024.

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ABSTRACT

The evolution of agriculture has been propelled by advancements in technology, particularly in the realm of smart agriculture systems. In response to the complexities of modern farming, this study introduces a sophisticated smart agriculture system aimed at revolutionizing traditional farming methodologies. In response to the evolving needs of modern agriculture, our system offers real-time monitoring and optimization of key environmental parameters critical to crop health and productivity. In response to the evolving needs of modern agriculture, our system offers real-time monitoring and optimization of key environmental parameters critical to crop health and productivity. By integrating cutting-edge sensor technologies and advanced data analytics, our system offers real-time monitoring and optimization of key environmental parameters critical to crop health and productivity. Leveraging ThingSpeak, an open-source IoT analytics platform and various monitoring sensors, our system provides farmers with remote access to comprehensive environmental data, enabling informed decision-making from anywhere with network connectivity. Drawing from insights gleaned from previous methodologies reliant on manual observation, Intervention, and using wired systems, our system represents a significant leap forward in agricultural efficiency and sustainability. Initial results indicate the system's efficacy in enhancing agricultural productivity through precise monitoring of precipitation, temperature, soil moisture, and water levels. By facilitating proactive resource management and minimizing waste, our smart agriculture initiative aims to address the pressing challenges facing modern agriculture, including water scarcity, climate change, and food security. Through the seamless integration of technology and sustainable farming practices, our system holds promise for transforming agricultural landscapes and ensuring the long-term viability of global food production systems.

KEYWORDS:

Customized algorithms, Data visualization, IoT sensors, Raspberry Pi Pico W, ThingSpeak-IoT analytics platform, User interface

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LIST OF ABBREVIATIONS

1. IoT	-	Internet of Things
2. AWS	-	Amazon Web-Services
3. NH ₃	-	Ammonia
4. NO ₂	-	Nitrogen Dioxide
5. CO	-	Carbon Monoxide
6. N ₂	-	Molecular Nitrogen
7. SO ₂	-	Sulfur Dioxide
8. ADC	-	Analog to Digital Signal Convertor
9. DAC	-	Digital to Analog Signal Convertor
10.Ah	-	AMPERE HOURS
11.BLE	-	BLUETOOTH LOW ENERGY
12.mm	-	Millimeter
13.cm	-	Centimeter
14.ppm	-	Parts per million
15.MVP	-	Minimum viable product
16.WIFI	-	Wireless Fidelity

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CHAPTER 1

INTRODUCTION

In the modern era, the agricultural industry is witnessing a transformative shift driven by technological advancements, particularly in the realm of Internet of Things (IoT). Smart agriculture systems, empowered by IoT technologies, offer innovative solutions to address the challenges faced by farmers in optimizing crop yield, enhancing resource efficiency, and promoting sustainability. Our project embarks on this journey of agricultural innovation by presenting a comprehensive smart agriculture system designed to revolutionize traditional farming practices.

At the heart of our endeavour lies a sophisticated integration of sensors, data processing algorithms, and intelligent control mechanisms aimed at monitoring and optimizing crucial parameters influencing plant growth and environmental conditions. By leveraging a diverse array of sensors including the MQ135 gas sensor for air quality assessment, soil moisture sensor for soil hydration monitoring, water level sensor for water availability assessment, DS18B20 temperature sensor for temperature monitoring, and a raindrops detection sensor for precipitation evaluation, our system provides real-time insights into the plant's ecosystem.

Central to our system architecture is the Raspberry Pi Pico W microcontroller, acting as the nerve centre orchestrating data collection, processing, and control operations. Augmented with an ADS1115 analog-to-digital converter for precise sensor readings, the Raspberry Pi Pico W enables seamless integration of sensor data into a unified platform for analysis and decision-making.

A distinguishing feature of our smart agriculture system is the incorporation of plant nutrient APIs, which offer tailored recommendations for optimizing nutrient levels based on plant type, growth stage, and environmental variables. By dynamically adjusting nutrient levels in the soil, our system ensures that plants receive optimal nutrition for healthy growth and maximum yield potential.

In addition to its robust functionality, our system boasts a user-friendly interface implemented using ThingSpeak or similar libraries, providing farmers with intuitive access to real-time data and actionable insights. Furthermore, data collected by the system is transmitted to ThingSpeak, an open-source IoT analytics platform, facilitating comprehensive analysis and visualization of agricultural data.

With sustainability as a guiding principle, our smart agriculture system integrates a solar panel for eco-friendly power supply, coupled with efficient power management techniques to optimize energy usage and ensure continuous operation even in remote agricultural settings.

In essence, our project represents a pioneering effort in the realm of smart agriculture, offering farmers a transformative tool to enhance agricultural productivity, promote sustainability, and meet the challenges of feeding a growing global population in a resource-constrained world. Through innovation, integration, and commitment to excellence, we envision a future where technology empowers farmers to cultivate bountiful harvests while stewarding the planet for generations to come.

CHAPTER 2

LITERATURE SURVEY

2.1 A SUSTAINABLE AGRICULTURE SYSTEM USING IOT

Sustainable Agriculture System using IoT is a development of a system that can automatically monitor agricultural fields, as well as performing live video streaming for monitoring the agriculture field from the server, through a raspberry pi camera. The agriculture fields are monitored for environmental temperature, humidity and soil moisture using sensors. IOT and wireless sensor node helps to decrease the efforts for observing the agricultural fields. IOT also avoids the loss of agriculture parameter databases and saved in the storage device or cloud for long life. It also provides continuous monitoring in all places including the critical areas. Agriculture product rely on environment factory like relative humidity, PH of soil, temperature etc. The proposed system model is developed in order to get more yields by identifying the causes. (Ramya Venkatesan & Anandhi Tamilvanan April 6-8,2017)

2.2 A MODEL FOR SMART AGRICULTURE USING IOT

Climate changes and rainfall has been erratic over decade. Due to this, climate smart methods called smart agriculture is adopted by many farmers. In the existing system, village farmers may have planted the same crop for centuries, but over period, weather patterns and soil conditions and epidemics of pests and disease have been changed. By using the proposed system approach, which senses the local agricultural parameters, identify the location of sensor, transfer the data crop fields and crop monitoring. The Received updated information allows the farmers to cope with and even benefit from these changes. The Complete real-time and historical environmental information is expected to help to achieve efficient management/monitoring and utilization of resources. (Prof K.A. Patil& N.R. Kale, July 2011)

2.3 SMART AGRICULTURE SYSTEM USING IOT TECHNOLOGY

In the existing system agriculturists used to figure the ripeness of soil and presumptions to develop certain kind of products. They didn't think about the level of water, dampness and climatic conditions. The profitability relies totally upon the last phase of the harvest in which they depend. In this proposed system, they improved the efficiency of the product which appraises the nature of the harvest. To go up against the challenges in the field, IOT is used in providing accuracy and conservative cultivation. They also used wireless sensor networks in precision Agriculture by separating the solitary plants for checking in the tens or several square feet. Also used different kinds of sensors such as Temperature sensor, Humidity sensor, Soil moisture sensor, Water level sensor and ARM processor. (Muthunoori Naresh & P.Muna sw June 2016)

2.4 IOT BASED MONITORING SYSTEM IN SMART AGRICULTURE

The farmers are still using traditional methods for Agriculture, which results in low yielding of crops and fruits, so the crop yield can be improved by using automatic machineries. But by using IOT, we can expect the increase in production with low cost by monitoring the efficiency of the soil, temperature and humidity monitoring. In existing System, they used only the traditional methods for the crop yield. But in the proposed system, the combination of traditional methods with IOT and wireless sensor networks can lead to agriculture modernization. The developed System is more efficient and beneficial for farmers. The application of such system in the field can definitely help to advance the harvest of the crops and global Production. (S.R. Prathibha, Anupama Hongal, et.al., 2017)

2.5 SMART AGRICULTURE MONITORING SYSTEM USING IOT

The implementation of a framework comprising of different sensors and devices which are interconnected by means of remote correspondence modules. The sensor data is been sent and received from client end utilizing Internet connectivity which was

enabled in the Node MCU mode the same time, dule- an open source IOT platform. The system is used to maintain the optimal conditions of the irrigation system effectively. The data can be viewed on the Thing Speak app or any web page. The farmer can go through each and every information regarding the levels, at what time it's been functioning, any fluctuations appearing or not, whether the operations are been performed in time. The foremost function is to monitor the crop growth using digital means. This will provide the accurate values of various parameters upon which growth depends. Besides, this model will help the farmer to monitor more than one land at the same time. Monitoring through this system requires less man power, people with physical disabilities can be employed for monitoring fields. (P.Lashitha Vishnu Priya, & N.Sai Harshith, et.al., 2017)

2.6 SMART FARMING USING IOT

Implement of a smart GPS based remote controlled vehicle that performs various tasks like monitoring fields to prevent thefts, scaring birds and animals, sensing soil moisture content, spraying fertilizers and pesticides, weeding, sensing soil moisture, etc. Smart irrigation, by usage of optimum amounts of water, depending on the requirement of each crop type and the soil will be executed. Finally, we plan on enforcing smart warehouse management, with temperature and humidity sensing for the benefit of the products being stored, and detection of presence of any invader who tries to steal from the warehouse. Controlling and monitoring of all these operations will be through a remote smart device with Internet connectivity and the operations will be performed by interfacing sensors, ZigBee modules, with micro-controller. (Amandeep, Arshia Bhattacharjee, Paboni Das, et.al., 2018)

2.7 IOT BASED AGRICULTURE MONITORING AND SMART IRRIGATION SYSTEM USING RASPBERRY PI

Agriculture monitoring system uses wireless sensor network that collect data from different sensors deployed at various nodes and send it through the wireless protocol. The collected data provide the information about the various environmental

factors. Monitoring the environmental factors is not the complete solution to increase the yield of crops. There are number of other factors that decrease the productivity. Hence, automation must be implemented in agriculture to overcome these problems. In order to provide solution to such problems, it is necessary to develop an integrated system which will improve productivity in every stage. But, complete automation in agriculture is not achieved due to various issues. Though it is implemented in the research level, it is not given to the farmers as a product to get benefitted from the resources. Hence, this paper deals about developing smart agriculture using IOT and given to the farmers. Implementation of such a system in the field can definitely help to improve the yield of the crops and aids to manage the water resources effectively reducing the wastage. (T.Vineela , J. Naga Harini ,let.al., 2016).

CHAPTER 3

AIM AND SCOPE

3.1 AIM

The primary aim of the project is to combine various sensors to detect parameters of agricultural soil using a IoT based development board like Raspberry Pi Pico W and link it with an open-sourced cloud based IoT website like ThingSpeak using Wi-Fi. In which data can be viewed time to time to monitor the agricultural field for better agricultural practices and resource usage. This leads to leverage advanced technologies to monitor, analyze, and optimize various aspects of crop growth, environmental conditions, and resource utilization.

3.2 OBJECTIVES

- To enable Remote Monitoring, from any place, farmers should be able to examine the data that IoT sensors have acquired remotely. This enables rapid decision-making and, if needed, intervention by enabling them to monitor the state of their crops even when they are not physically present on the farm.
- To Provide Timely Information, Farmers must be provided with accurate and timely information regarding critical elements that impact crop growth, such as soil moisture, temperature, and other pertinent factors. This guarantees that farmer will be informed as soon as conditions depart from the intended range, giving them the opportunity to take the necessary precautions to lessen any possible threats to their crops.
- To ensure Data Access, Farmers should be able to quickly understand and evaluate the data that IoT sensors have acquired in an easily comprehensible way. In addition to making sure that farmers can make well-informed decisions based on the data available, this accessibility makes it easier to integrate farming practices or other technology to increase productivity and efficiency.
- To optimize Resource Usage, Farmers can make the best use of resources like pesticides and fertilizers by having access to seasonal data. Farmers can apply these inputs more effectively thanks to this data-driven strategy, which also

minimizes waste and their impact on the environment while preserving the yield and health of their crops.

- To ensure Scalability and Flexibility, To accommodate farmers' changing needs, Internet of Things (IoT) devices for agriculture should be extremely scalable and versatile. This means that in order to efficiently monitor different areas of the farm, they should be able to move to different positions inside it and simply expand their coverage area as the farm grows. Because of its adaptability, farmers may easily modify their IoT configuration to meet their unique needs without facing significant obstacles.
- To uphold the Right to Repair, Farmers should have the freedom to replace or repair any damaged IoT setup components without having to deal with onerous regulatory requirements or outside compliances. This guarantees that farmers may promptly return their IoT devices to operational status, reducing downtime and guaranteeing ongoing crop condition monitoring.

3.3 SCOPE

- Instead of relying on third-party IoT microcontroller boards, we can create our own Agricultural Monitoring IoT boards internally, using PCB module development with the necessary microcontroller and insert pins. This approach offers greater control over the hardware and customization options.
- By developing this system in-house, we can potentially create a Minimum Viable Product (MVP), facilitating easier access for users and elevating the standards within the agricultural industry.
- Instead of utilizing an open-sourced IoT cloud system, we can establish a product-specific cloud system tailored to optimize and analyze data. This customization can lead to a more user-friendly experience, catering to different crop types and ecological conditions.
- Implementing machine learning technologies with suitable algorithms enables the generation of monthly, yearly, seasonal, and crop-specific reports. These reports can be invaluable to both government and private institutions, aiding in the development of more effective techniques to manage adverse conditions and enhance agricultural practices.

CHAPTER 4

MATERIALS AND METHOD

4.1 MATERIALS

Temperature sensor (DS18B20), MQ – 135, Soil Moisture Sensor, Water Level Sensor, Rain Detection Sensor, Solar Panel, Rechargeable Battery, Jumper wires (male to male, male to female, female to female), Resistors, Raspberry Pi Pico W, Breadboards

4.1.1 Input devices incorporated in the smart agriculture monitoring system

4.1.1.1 Temperature sensor (DS18B20)

The DS18B20 (Figure 4.1) is a digital temperature sensor manufactured by Maxim Integrated. It is widely used in various applications due to its high accuracy, wide temperature range, and simple interface. In our smart agriculture monitoring project, we use the DS18B20 temperature sensor to monitor ambient temperature conditions in the environment surrounding the plants. You can deploy multiple DS18B20 sensors at different locations within your agricultural field to capture temperature variations across the area. By integrating the DS18B20 sensors with Raspberry Pi Pico W microcontroller, we can read temperature data from the sensors and incorporate it into our data processing and control algorithms.



Figure 4.1 DS18B20 sensor

We can visualize temperature data collected from the DS18B20 sensors using our user interface, allowing farmers to monitor temperature conditions remotely and make informed decisions about crop management practices. The Raspberry Pi Pico W can then read temperature data from the DS18B20 sensor and process it, such as logging data to a database, triggering alerts, or adjusting control parameters based on temperature readings.

4.1.1.2 MQ – 135 Sensor

The MQ-135 (Figure 4.2) sensor is designed to detect a wide range of gases, including ammonia (NH₃), nitrogen oxides (NO_x), benzene, alcohol, smoke, and other harmful gases commonly found in agricultural environments. In our smart agriculture monitoring project, we use the MQ-135 gas sensor to monitor air quality and detect the presence of harmful gases in the environment surrounding the plants. You can deploy multiple MQ-135 sensors at different locations within your agricultural field to capture variations in gas concentrations across the area.



Figure 4.2 MQ-135 sensor

Gas concentration data collected from the MQ-135 sensors can be used to Monitor air quality levels and identify potential sources of pollution or contamination, detect harmful gases that may affect plant growth, such as ammonia or nitrogen oxides emitted from fertilizers or animal waste, implement gas-based control strategies for environmental regulation, such as activating ventilation systems or adjusting pesticide application rates based on gas concentrations.

The Raspberry Pi Pico W converts the voltage values into gas concentration values using calibration algorithms or mathematical models. Gas concentration data collected from the MQ-135 sensors can be processed and analysed by the Raspberry Pi Pico W according to your project requirements, such as logging data to a database, generating alerts, or adjusting control parameters based on gas concentration readings.

4.1.1.3 Soil moisture sensor

Soil moisture sensors (Figure 4.3) use capacitive sensing techniques to measure the volumetric water content of the soil. They determine soil moisture levels by measuring the dielectric constant of the soil, which varies with water content. In our smart agriculture monitoring project, soil moisture sensors play a crucial role in monitoring and managing soil moisture levels to optimize plant growth and water usage efficiency.

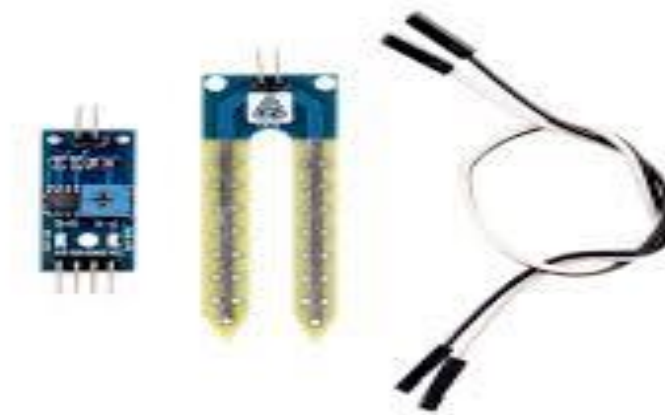


Figure 4.3 Soil Moisture Sensor

Soil moisture data collected from the sensors can be used to Monitor soil moisture trends over time and identify optimal irrigation timing to prevent under or overwatering of crops, implement precision irrigation strategies based on localized soil moisture conditions, such as drip irrigation or soil moisture-based watering schedules,

detect soil moisture imbalances that may indicate drainage issues, soil compaction, or inadequate water infiltration.

The Raspberry Pi Pico W processes soil moisture data and implement irrigation control algorithms based on user-defined thresholds or setpoints. Soil moisture data collected from the sensors can be logged to a database, displayed on a graphical interface, or used to trigger irrigation systems automatically based on preset conditions.

4.1.1.4 Water level sensor

Water level sensors (Figure 4.4) measure the depth or height of liquid in a container or reservoir using various sensing techniques. Common methods include ultrasonic, pressure-based, and float-based sensing. Water level sensors are available in various configurations, including submersible, external, and wireless options, to accommodate different installation requirements and environmental conditions.

In our smart agriculture monitoring project, water level sensors can be used to monitor water levels in irrigation reservoirs, tanks, ponds, or drip irrigation systems.

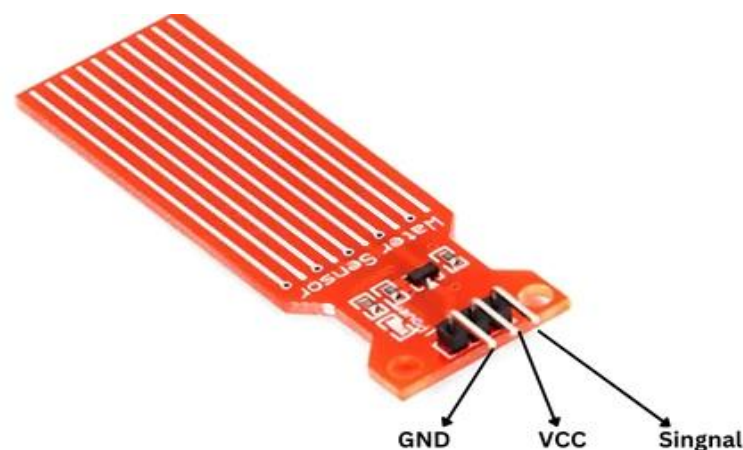


Figure 4.4 Water Level Sensor

They can be used to monitor water levels in real-time and trigger alerts or notifications when levels exceed or fall below predefined thresholds, automate irrigation systems based on water level readings, ensuring timely and precise delivery

of water to crops, estimate water consumption rates and forecast future water requirements based on historical data and crop water needs.

The Raspberry Pi Pico W processes water level data and implement control algorithms to manage irrigation systems, trigger alerts, or adjust water flow rates based on sensor readings. Water level data collected from the sensors can be logged to a database, displayed on a graphical interface, or used to control actuators such as pumps or valves to regulate water flow.

4.1.1.5 Rain detection sensor

A rain detection sensor (Figure 4.5) is a type of sensor used to detect the presence of raindrops or moisture on a surface. It typically operates on the principle of conductivity or resistance changes in the presence of water. These sensors are commonly used in weather monitoring systems, automatic irrigation systems, and smart home applications to detect rain and trigger appropriate actions or alerts.

In our smart agriculture monitoring project, a raindrop detection sensor can be used to monitor rainfall and automate irrigation systems or alert farmers about changing weather conditions. We can install raindrop sensors in key locations within your agricultural field to detect the onset of rain and adjust irrigation schedules accordingly to conserve water and prevent overwatering.

By interfacing the raindrop sensor with your Raspberry Pi Pico W microcontroller, you can read sensor data and implement logic to trigger irrigation systems, close greenhouse vents, or send notifications to farmers when rain is detected. Raindrop sensor data can be integrated with other environmental sensors, such as soil moisture sensors and temperature sensors, to provide a comprehensive view of weather conditions and optimize crop management practices.

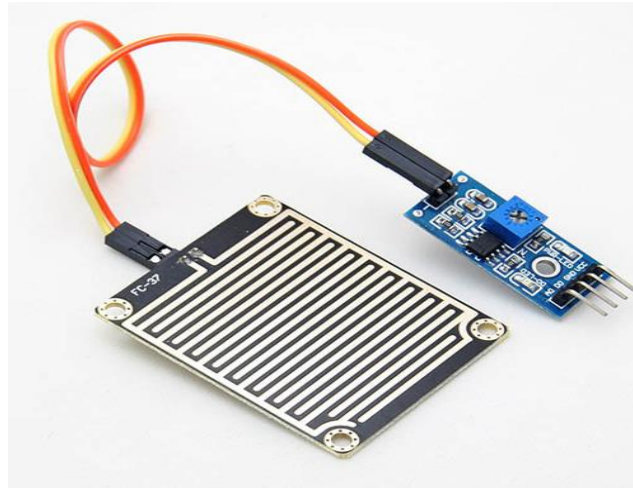


Figure 4.5 Rain Detection Sensor

The Raspberry Pi Pico W can then process raindrop sensor data and implement control logic to adjust irrigation schedules, activate water pumps, or trigger alerts based on rainfall events.

4.1.1.6 Solar panel

A solar panel (Figure 4.6) is a device that converts sunlight into electricity through photovoltaic cells. It consists of multiple solar cells interconnected and encapsulated within a protective layer to form a panel. Solar panels are commonly used in off-grid and grid-tied solar power systems to generate clean and renewable energy for various applications, including residential, commercial, and agricultural use.

In our smart agriculture monitoring project, solar panels can be used to power various electronic components and systems, including sensors, microcontrollers, actuators, and communication devices. By integrating solar panels with energy storage systems, such as batteries or capacitors, you can store excess solar energy during the day and use it to power devices at night or during periods of low sunlight. Solar panels can also be used to power remote monitoring and control systems, allowing farmers to monitor crop conditions, control irrigation systems, and receive real-time alerts from anywhere with internet connectivity. The modular and scalable nature of solar panels makes them suitable for a wide range of agricultural

applications, from small-scale hobby farms to large commercial operations, providing flexibility and adaptability to changing energy needs and environmental conditions.



Figure 4.6 Solar Panel

The Raspberry Pi Pico W can communicate with other components of your smart agriculture system, such as sensors and actuators, to optimize energy usage and maximize system efficiency based on environmental conditions and user preferences.

4.1.1.7 Rechargeable battery

Rechargeable batteries, also known as secondary batteries, are energy storage devices that can be charged and discharged multiple times. They are commonly used in various electronic devices, renewable energy systems, and portable applications due to their ability to store and deliver electrical energy efficiently.

Rechargeable batteries serve as the primary or backup power source for our smart agriculture monitoring system, providing energy to operate microcontrollers, sensors, actuators, and communication modules.

In our smart agriculture monitoring project, the utilization of rechargeable batteries serves as a cornerstone for ensuring uninterrupted functionality and sustainability of our monitoring system. By incorporating rechargeable batteries into our system design, we mitigate the need for frequent battery replacements, thus reducing operational costs and minimizing environmental waste associated with

disposable batteries. These rechargeable batteries are carefully selected for their high energy density, longevity, and compatibility with our monitoring devices. Their rechargeability feature enables us to harness renewable energy sources such as solar panels to replenish their power reserves, ensuring continuous operation even in remote agricultural locations where access to traditional power grids may be limited.

Furthermore, the use of rechargeable batteries aligns with our commitment to environmental stewardship by reducing our carbon footprint and promoting energy efficiency. By opting for rechargeable batteries over disposable ones, we contribute to the conservation of natural resources and the reduction of hazardous battery waste in the environment. The versatility of rechargeable batteries allows for flexible deployment and scalability within our smart agriculture system. Whether powering individual sensors, controllers, or communication modules, rechargeable batteries provide a reliable and sustainable power source to support various components of our monitoring infrastructure.

4.1.2 Controller devices incorporated in the smart agriculture monitoring system

4.1.2.1 Raspberry pi Pico W

We use the GPIO pins of the Raspberry Pi Pico W (Figure 4.7) to interface with various sensors such as the MQ-135 gas sensor, soil moisture sensor, water level sensor, DS18B20 temperature sensor, raindrop detection sensor, and other environmental sensors. Sample sensor data at regular intervals to monitor environmental conditions such as air quality, soil moisture levels, water levels, temperature, and rainfall.

We Developed a firmware using MicroPython to process sensor data and implement control algorithms based on environmental parameters. We can Use the data collected from sensors to make decisions about irrigation scheduling, nutrient management, pest control, and other aspects of crop management. We can Implement control logic to regulate irrigation systems, adjust greenhouse ventilation, activate pumps or valves based on soil moisture levels, water availability, and weather forecasts. We utilize the built-in ESP32-based wireless module of the Raspberry Pi Pico W for Wi-Fi and Bluetooth Low Energy (BLE) communication. This Enables

remote monitoring and control of our smart agriculture monitoring system by sending sensor data to a cloud-based platform or a local server for analysis and visualization. Implement wireless notifications and alerts to notify farmers about critical events such as water shortages, pest outbreaks, or adverse weather conditions. Design an intuitive dashboard to display real-time and historical data on soil moisture levels, temperature, humidity, water levels, and other relevant parameters.

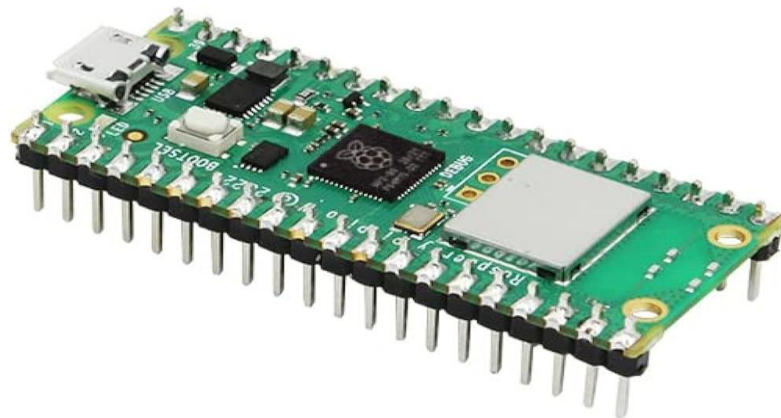


Figure 4.7 Raspberry Pi Pico w

4.2 METHODS

Developing a smart agriculture system involves a comprehensive methodology that encompasses various stages, from system design and development to deployment and maintenance. The concept of integrating a multitude of sensors into a smart agricultural monitoring system was meticulously conceived. Essential components and materials were procured and skilfully soldered and assembled to form the backbone of the project. Each circuit connection was carefully established and subjected to rigorous manual testing to ensure flawless operation.

In addition, we employed MicroPython for programming the system, enabling efficient data collection from the sensors. The collected data was then wirelessly transmitted to ThingSpeak, an Internet of Things (IoT) platform, facilitating real-time data analysis and visualization. This seamless integration of technology significantly enhanced the system's capabilities, providing a comprehensive and dynamic view of the agricultural environment.

4.2.1 Circuit diagram

The circuit setup (Figure 4.8) for our smart agriculture monitoring system is designed to efficiently monitor and manage various environmental parameters crucial for crop growth and health. At its core, the setup revolves around the Raspberry Pi Pico W microcontroller, serving as the central processing unit for data acquisition and control. Connected to the Pi Pico W are a multitude of sensors, including soil moisture sensors, temperature sensors, humidity sensors, rainfall sensors, gas sensors (MQ-135), water level sensors, and raindrop detection sensors. These sensors are strategically positioned within the agricultural field to gather real-time data on soil conditions, weather patterns, and air quality. Additionally, renewable energy sources, such as solar panels, are integrated into the circuit to provide sustainable power, ensuring continuous operation of the system even in remote locations. With a robust wireless communication module, the circuit enables seamless connectivity to the ThingSpeak IoT platform, facilitating data transmission, analysis, and visualization

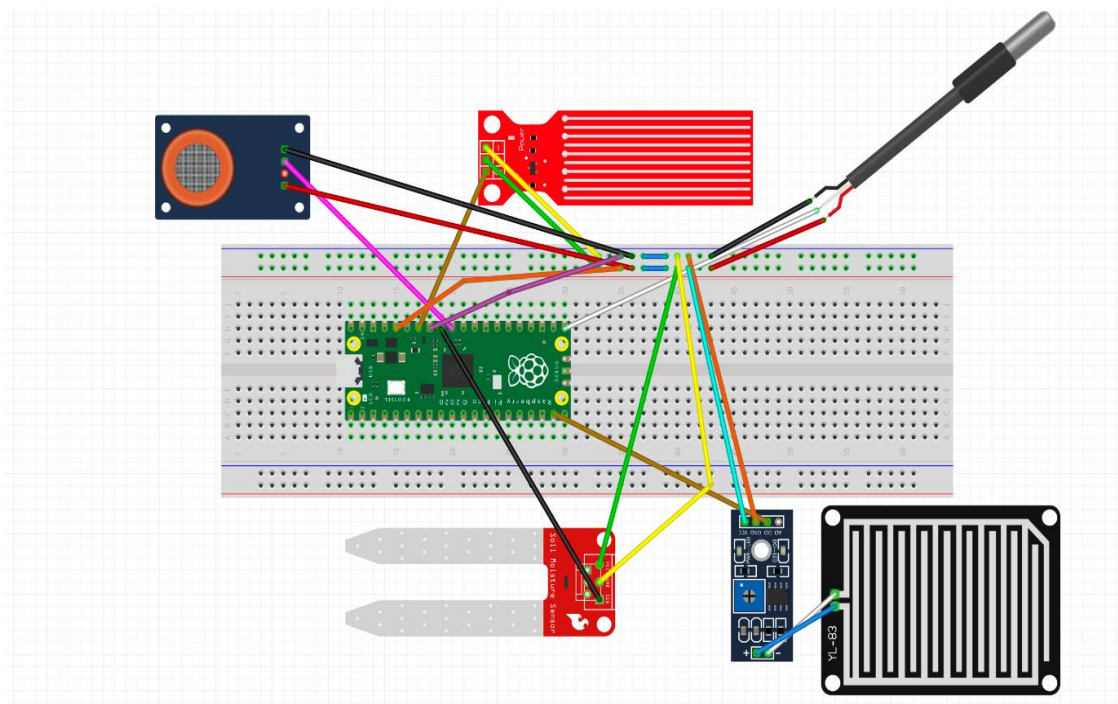


Figure 4.8 Breadboard Diagram

4.2.1.1 Programming

```
import machine
import network
import urequests
import time
import ds18x20
import onewire

# Wi-Fi settings
WIFI_SSID = "Freedom"
WIFI_PASSWORD = "123456789"

# ThingSpeak API settings
THINGSPEAK_API_KEY = "6B4A2IZJANS79K8V"
THINGSPEAK_URL = "https://api.thingspeak.com/update"
TEMPERATURE_PIN = machine.Pin(16) # GP16 for DS18B20 temperature
sensor
MQ135_SENSOR_PIN = machine.ADC(26) # GP26 for MQ135 gas sensor
SOIL_MOISTURE_PIN = machine.ADC(27) # GP27 for soil moisture
sensor
RAIN_SENSOR_PIN = machine.Pin(14, machine.Pin.IN) # GP14 for rain
sensor
WATER_LEVEL_SENSOR_PIN = machine.ADC(28) # GP28 for water level
sensor
CO_CALIBRATION = (0.2, 3.3) # Calibration values for CO (min_voltage,
max_voltage)
NH3_CALIBRATION = (0.2, 3.3) # Calibration values for NH3 (min_voltage,
max_voltage)
SO2_CALIBRATION = (0.2, 3.3) # Calibration values for SO2 (min_voltage,
max_voltage)
def read_temperature():
    # Define the pin connected to DS18B20 sensor
    ds_pin = machine.Pin(TEMPERATURE_PIN)
    # Create a OneWire bus object
```

```

ds_bus = onewire.OneWire(ds_pin)
# Create a DS18X20 sensor object
ds_sensor = ds18x20.DS18X20(ds_bus)
# Scan for DS18B20 sensors on the bus
roms = ds_sensor.scan()
if len(roms) > 0:
    # Read temperature from the first DS18B20 sensor found
    ds_sensor.convert_temp()
    time.sleep_ms(750)
    temperature = ds_sensor.read_temp(roms[0])
    print("Temperature: {:.2f} degrees Celsius".format(temperature))
    return temperature
else:
    print("No DS18B20 sensor found.")
    return None
def read_gas_voltage(pin):
    # Read analog value (0-65535) and convert to voltage (0-3.3V)
    adc_value = pin.read_u16()
    voltage = adc_value * (3.3 / 65535.0)
    return voltage
def convert_to_ppm(voltage, calibration):
    # Convert voltage to gas concentration in ppm using linear interpolation
    min_voltage, max_voltage = calibration
    if voltage < min_voltage:
        ppm = 10.0
    elif voltage > max_voltage:
        ppm = 1000.0 # Assuming 1000 ppm as maximum measurable
concentration
    else:
        # Linear interpolation between min_voltage and max_voltage
        ppm = (voltage - min_voltage) / (max_voltage - min_voltage) * 1000.0
    return ppm
def detect_gas_levels():
    # Read gas levels from MQ135 sensor and convert to ppm

```

```

co_voltage = read_gas_voltage(MQ135_SENSOR_PIN)
nh3_voltage = read_gas_voltage(MQ135_SENSOR_PIN)
so2_voltage = read_gas_voltage(MQ135_SENSOR_PIN)
co_ppm = convert_to_ppm(co_voltage, CO_CALIBRATION)
nh3_ppm = convert_to_ppm(nh3_voltage, NH3_CALIBRATION)
so2_ppm = convert_to_ppm(so2_voltage, SO2_CALIBRATION)
return {'co_ppm': co_ppm, 'nh3_ppm': nh3_ppm, 'so2_ppm': so2_ppm}

def read_soil_moisture():
    # Read analog value (0-65535) and map to moisture percentage (0-100%)
    adc_value = SOIL_MOISTURE_PIN.read_u16()
    moisture_percentage = (adc_value / 65535.0) * 100
    return moisture_percentage

def is_raining():
    # Read rain sensor digital input
    return RAIN_SENSOR_PIN.value()

def read_water_level():
    # Read analog value (0-65535) and convert to water level percentage (0-100%)
    adc_value = WATER_LEVEL_SENSOR_PIN.read_u16()
    water_level_percentage = (adc_value / 65535.0) * 100
    water_level_mm = (water_level_percentage / 100) * 42
    return water_level_mm

def connect_wifi():
    wlan = network.WLAN(network.STA_IF)
    wlan.active(True)
    if not wlan.isconnected():
        print("Connecting to Wi-Fi...")
        wlan.connect(WIFI_SSID, WIFI_PASSWORD)
        while not wlan.isconnected():
            pass
    print("Wi-Fi Connected:", wlan.ifconfig())

```

```

def send_data_to_thingspeak(data, n2_ppm, water_level_mm):
    if 'temperature' not in data:
        print("Temperature data not available.")
        return

    params =
    "api_key={}&field1={:.2f}&field2={:.2f}&field3={:.2f}&field4={:.2f}&field5={:.2f}
    &field6={}&field7={:.2f}&field8={:.2f}".format(
        THINGSPEAK_API_KEY,
        data['temperature'],
        data['co_ppm'],
        data['nh3_ppm'],
        n2_ppm,
        data['so2_ppm'],
        data['soil_moisture'],
        data['is_raining'],
        water_level_mm
    )
    url = "{}?{}".format(THINGSPEAK_URL, params)
    response = urequests.get(url)
    print("ThingSpeak Response:", response.text)
    response.close()

def main():
    connect_wifi()

    while True:
        temperature = read_temperature()
        gas_levels = detect_gas_levels()
        soil_moisture = read_soil_moisture()
        rain_status = is_raining()
        water_level = read_water_level()

```

```

sensor_data = {
    'temperature': temperature,
    'co_ppm': gas_levels['co_ppm'],
    'nh3_ppm': gas_levels['nh3_ppm'],
    'so2_ppm': gas_levels['so2_ppm'],
    'soil_moisture': soil_moisture,
    'is_raining': rain_status,
    'water_level': water_level
}

print("Sensor Data:", sensor_data)

n2_ppm = 0.8225 * gas_levels['nh3_ppm']
print("N2 ppm: {:.2f}".format(n2_ppm))

send_data_to_thingspeak(sensor_data, n2_ppm, water_level)

time.sleep(20) # Send data to ThingSpeak every 20 seconds

if __name__ == "__main__":
    main()

```

4.2.2 Assembly and fabrication

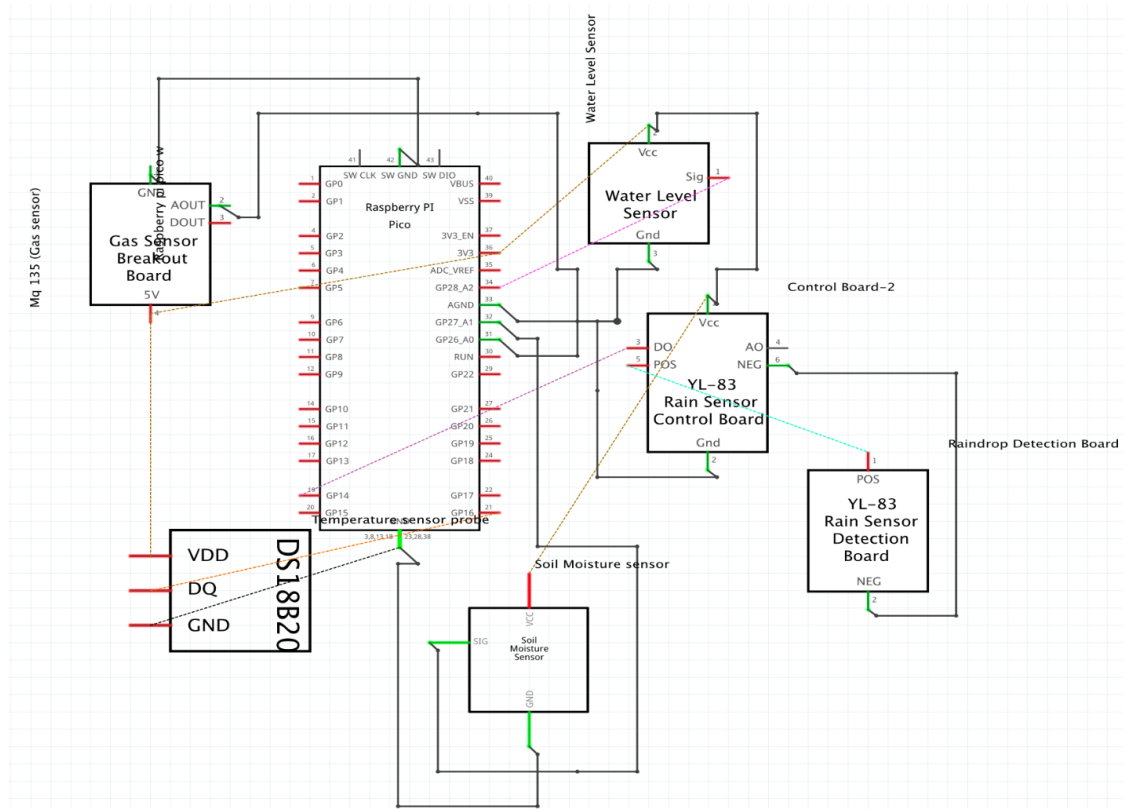


Figure 4.9 Schematic Diagram

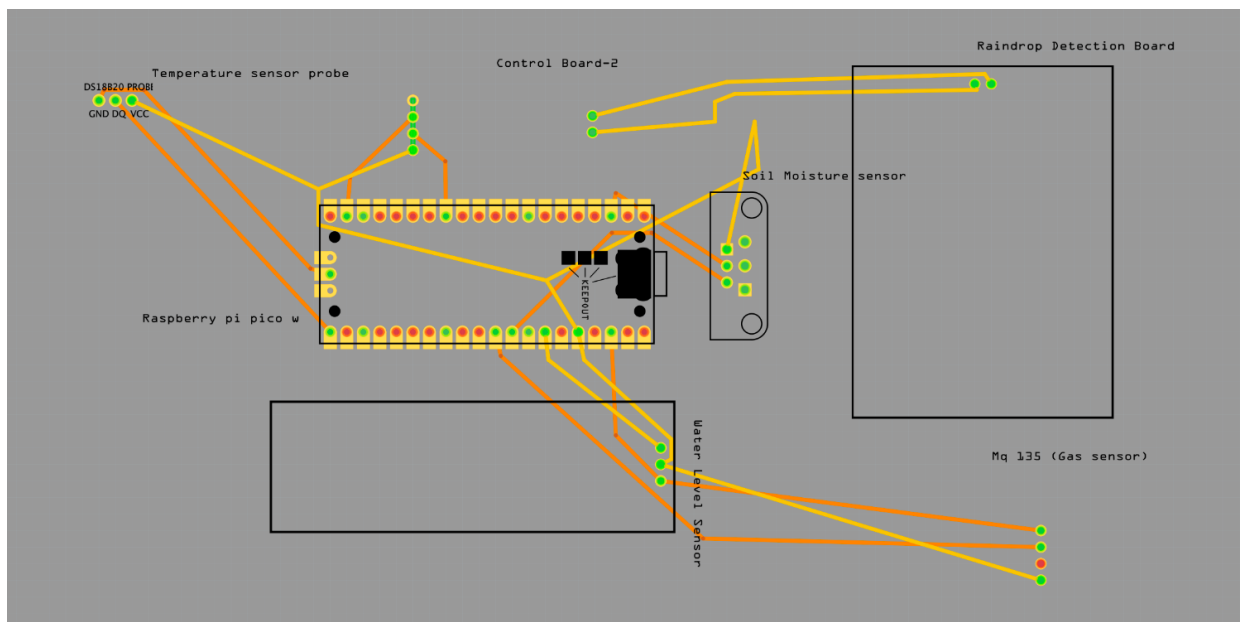


Figure 4.10 PCB Diagram

CHAPTER 5

RESULTS AND DISCUSSION

The implementation of our smart agriculture monitoring system (Figure 5.16) has yielded robust outcomes, affirming its efficacy in monitoring and managing a diverse array of environmental parameters critical to crop vitality and productivity using ThingSpeak IoT.

- Our findings provide remote monitoring using the web-based IoT platform ThingSpeak (Figure 5.1), so that sensor data may be accessed anywhere in the world by going to the relevant channel.
- A LAMP widget can be used to analyze the data, making data analysis easier by giving prompt indicators when values fall below or beyond predetermined limits.
- The ability for users to access all data in an Excel sheet makes it easier to keep track of past data for comparison and trend research.
- Access to seasonal data helps farmers optimize their usage of fertilizers and pesticides through data-driven resource management.
- Our system's sensors are easily scaled to accommodate varying monitoring requirements and are highly versatile, adaptable to a wide range of settings.
- The system's sensors and gadgets are user-friendly and easily maintained, which makes repairs and maintenance procedures simpler and ensures smooth functioning.

We have also used,

- Rain Status Widget (Figure 5.2) - A visually intuitive indicator alerts users to precipitation events on the agricultural farm, facilitating timely response measures.
- Temperature Widget (Figure 5.3) - Real-time temperature readings enable effective monitoring of ambient conditions, crucial for crop health and growth.
- Soil Moisture Sensor - Color-coded indication signals moisture levels below the critical threshold of 55 ml per 10 square area, aiding in precise irrigation management.

- Water Level Lamp Indicator Widget (Figure 5.6)- Illuminates when water levels exceed 30 mm-cm, ensuring optimal water resource utilization and irrigation scheduling.
- Graphical Data Visualization - Historical data graphs for temperature (Figure 5.8), carbon monoxide (Figure 5.9), NH₃ (Figure 5.10), N₂ (Figure 5.11), and SO₂ (Figure 5.12), soil moisture (Figure 5.13), rain status (Figure 5.14), water level (Figure 5.15) offers valuable insights for trend analysis and anomaly detection over the past 1-2 weeks.
- Comprehensive Environmental Monitoring - Soil moisture, rain status, and water level graphs provide a holistic overview of environmental conditions, enhancing decision-making capabilities.
- Moisture Level Indicator Widget (Figure 5.4)- Precise percentage representation of water moisture content assists in irrigation planning and crop health management.. Also include lamp indication for soil moisture level less than 55% (Figure 5.5).

Furthermore, the seamless integration of renewable energy sources, notably solar panels, has underscored the sustainability and autonomy of our system. The adoption of solar panels as a reliable, eco-conscious power source has substantially diminished reliance on conventional energy grids while substantially mitigating the environmental footprint of agricultural operations. This sustainable energy paradigm not only ensures uninterrupted system operation, even in remote or off-grid locales but also heralds substantial long-term cost efficiencies and environmental conservation dividends.

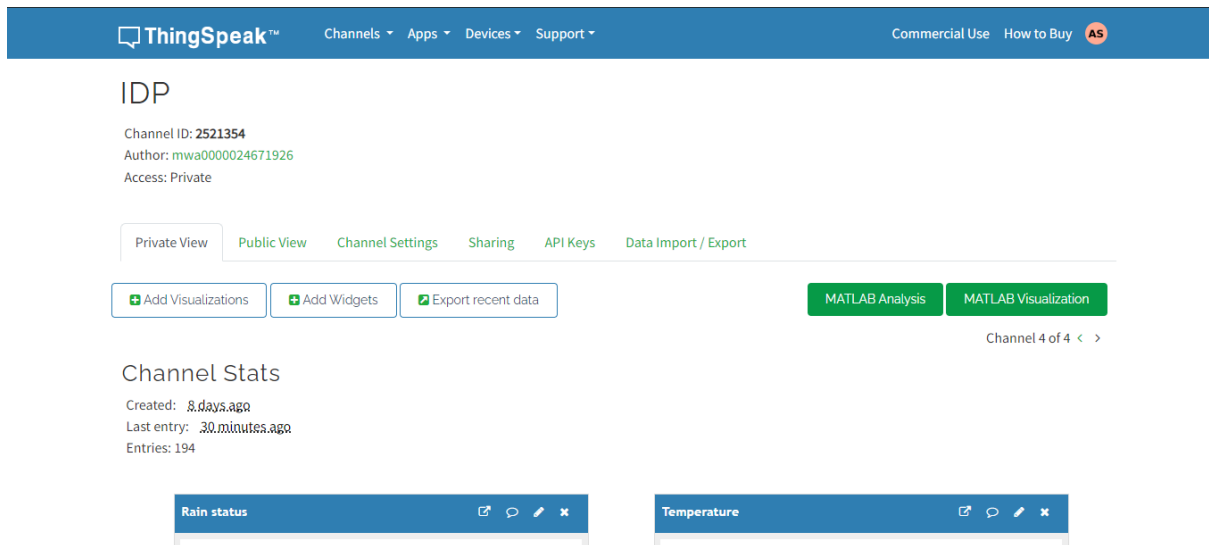


Figure 5.1 ThingSpeak Interface

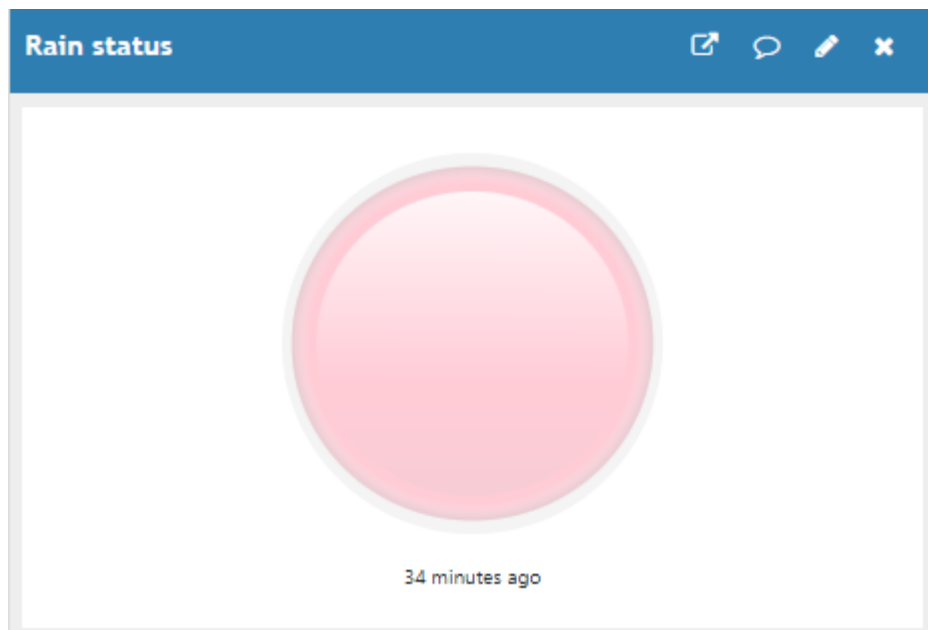


Figure 5.2 Rain Status Lamp Indicator

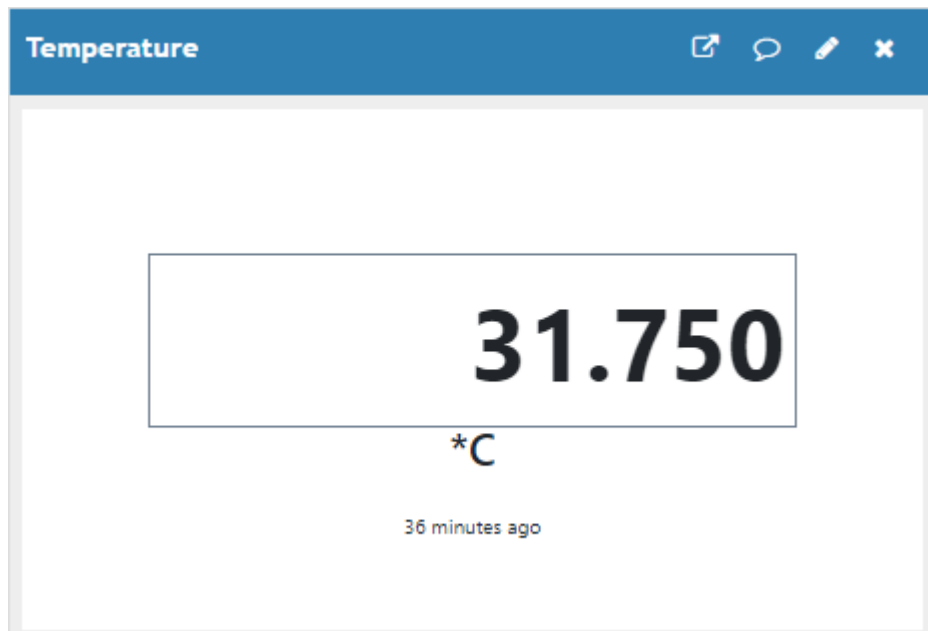


Figure 5.3 Temperature Numerical Display

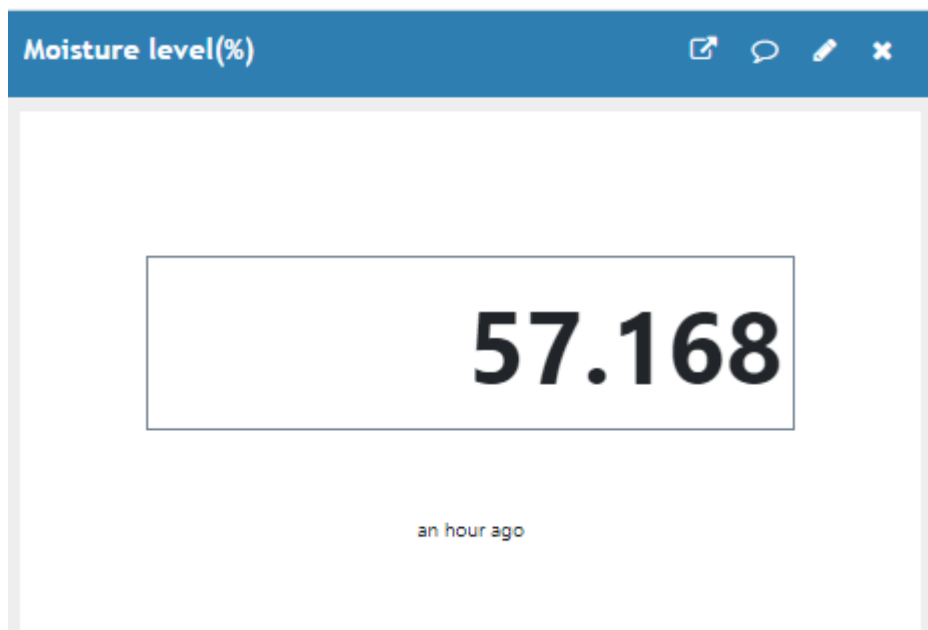


Figure 5.4 Moisture level (%) Numerical Display

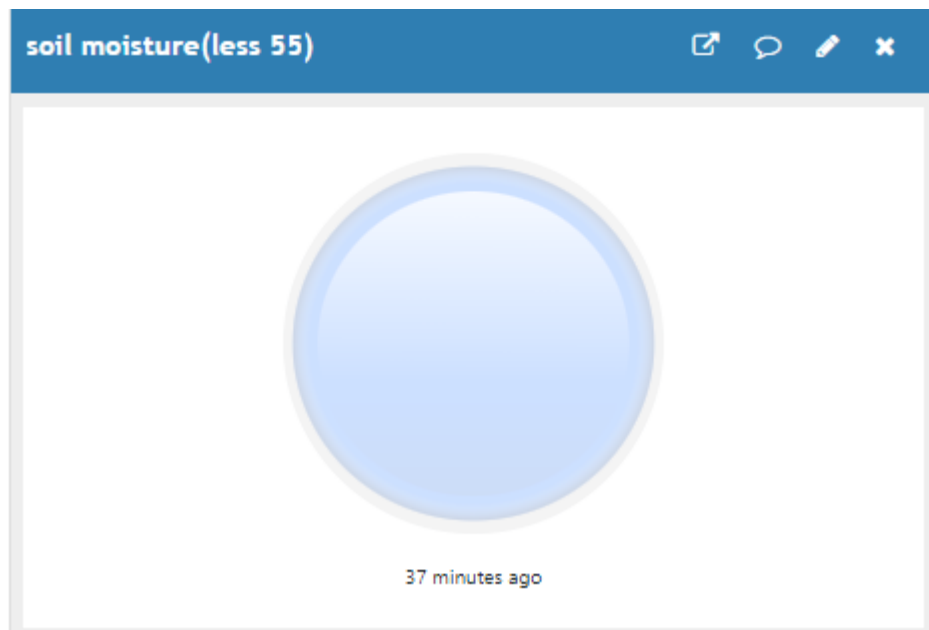


Figure 5.5 Soil Moisture Lamp Indicator for moisture less than 55%

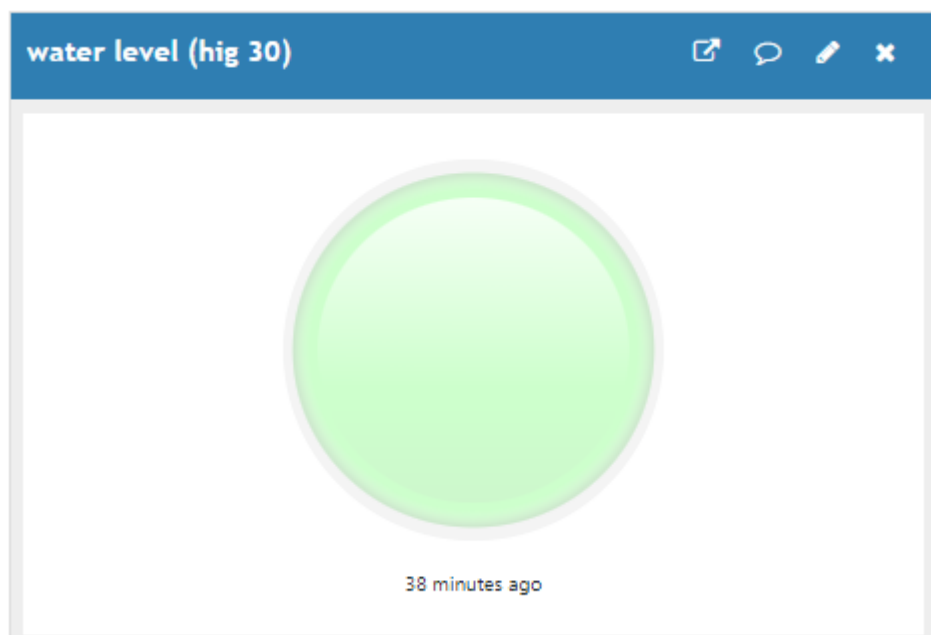


Figure 5.6 Water Level Lamp Indicator for Water level higher than 30mm

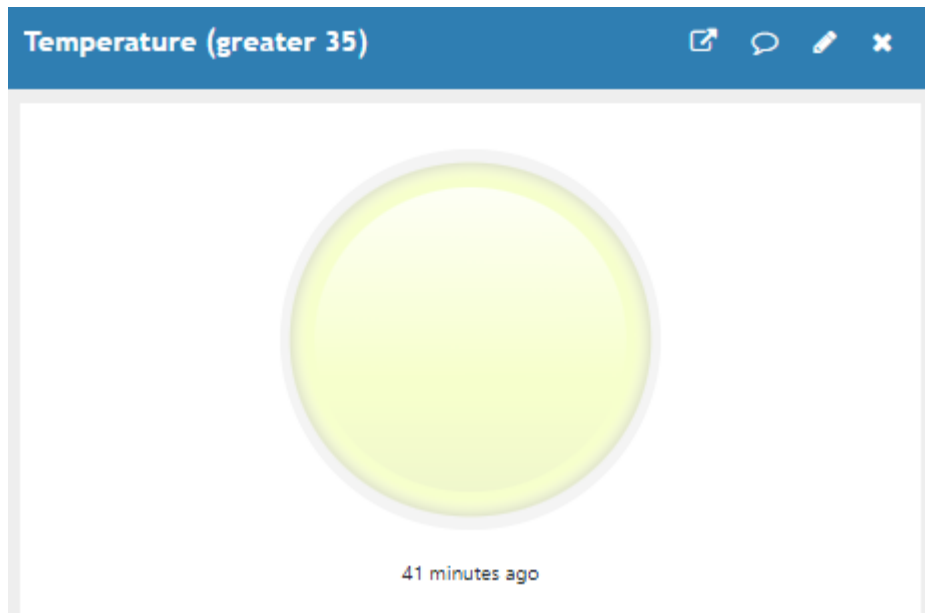


Figure 5.7 Temperature Lamp Indicator for Temperature Higher than 35 degrees Celsius

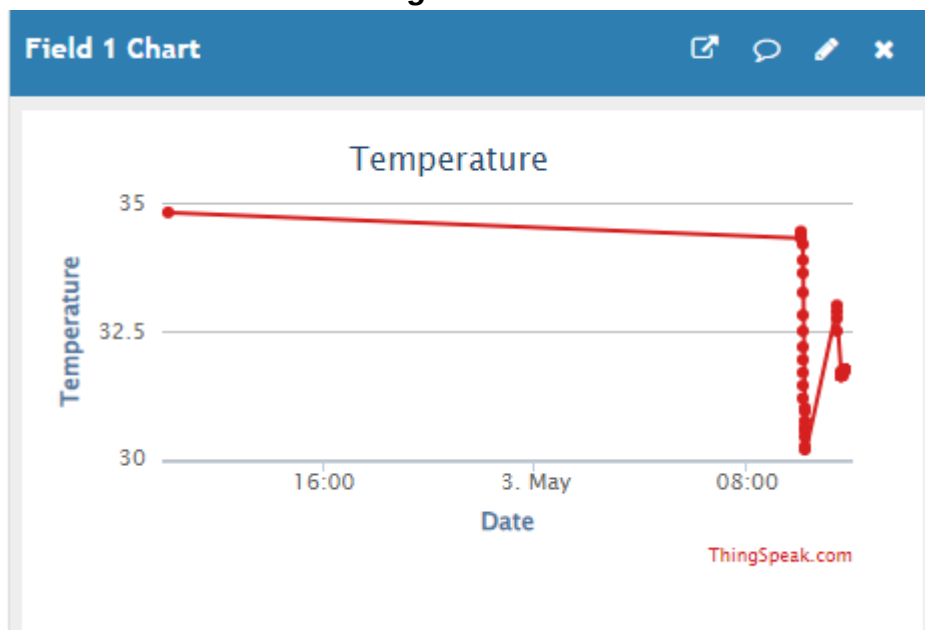


Figure 5.8 Temperature Data Visualization Chart

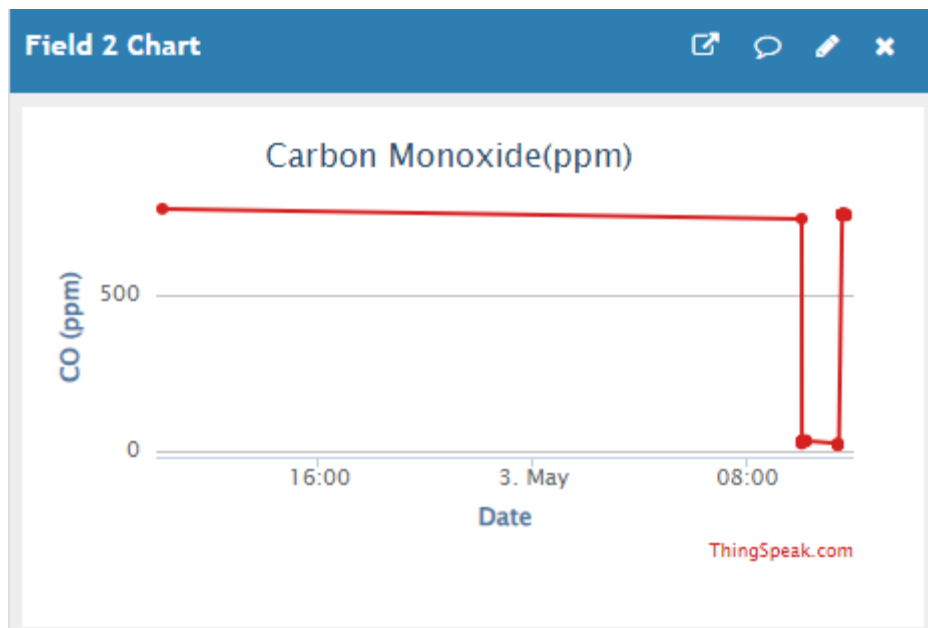


Figure 5.9 Carbon Monoxide(ppm) Data Visualization Chart

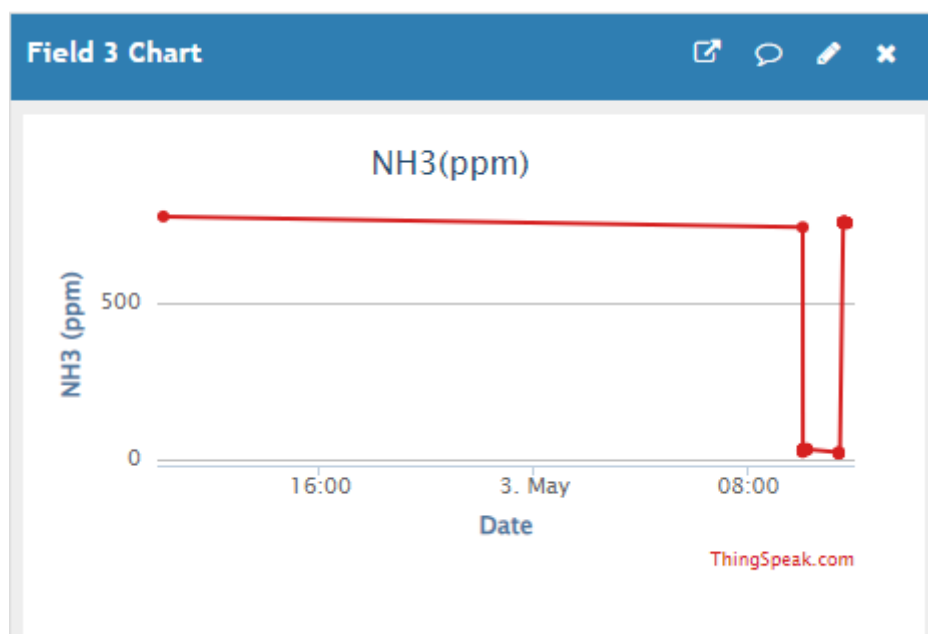


Figure 5.10 NH₃ (ppm) Data Visualization Chart

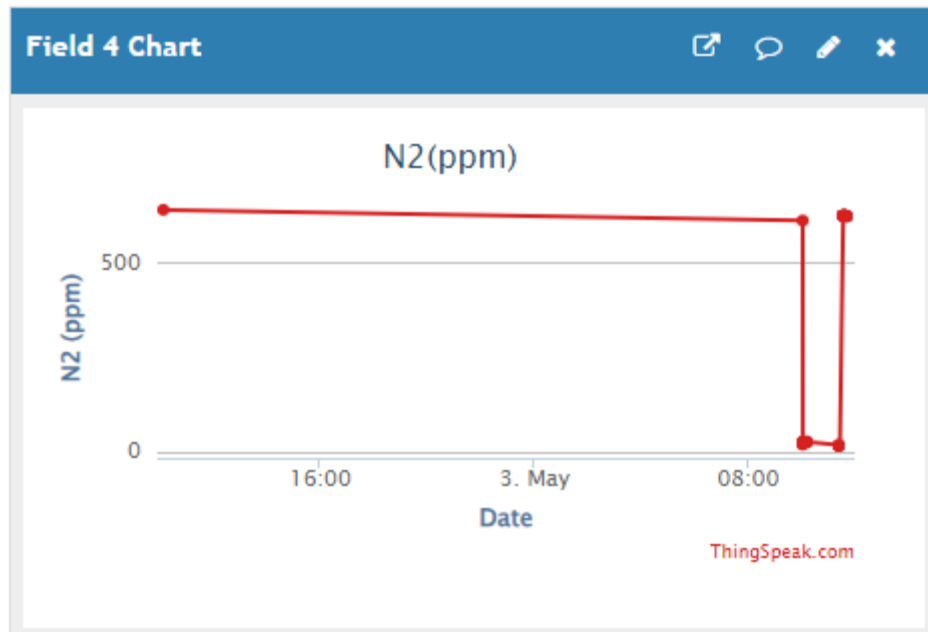


Figure 5.11 N₂ Data Visualization Chart

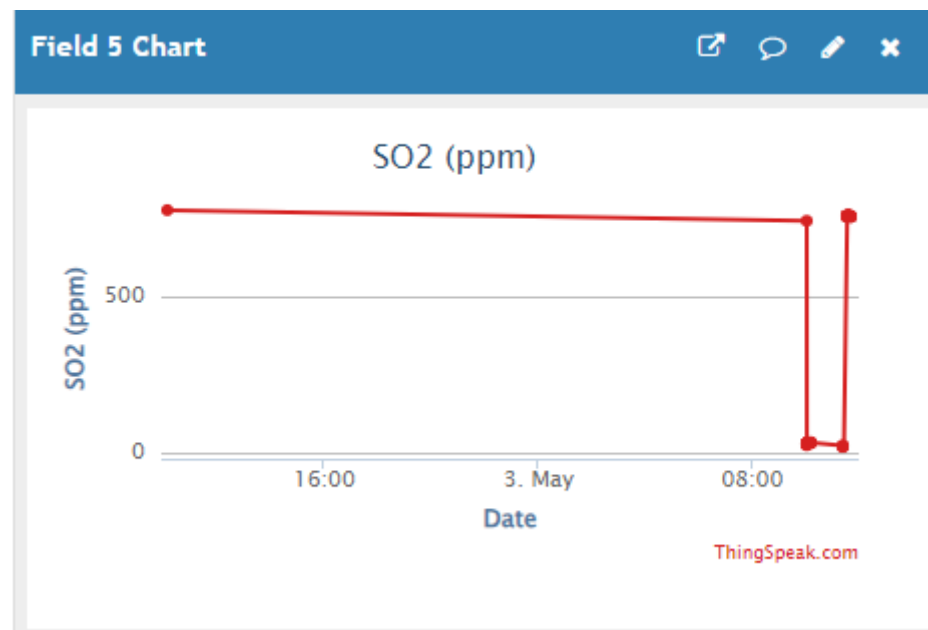


Figure 5.12 SO₂ (ppm) Data Visualization Chart

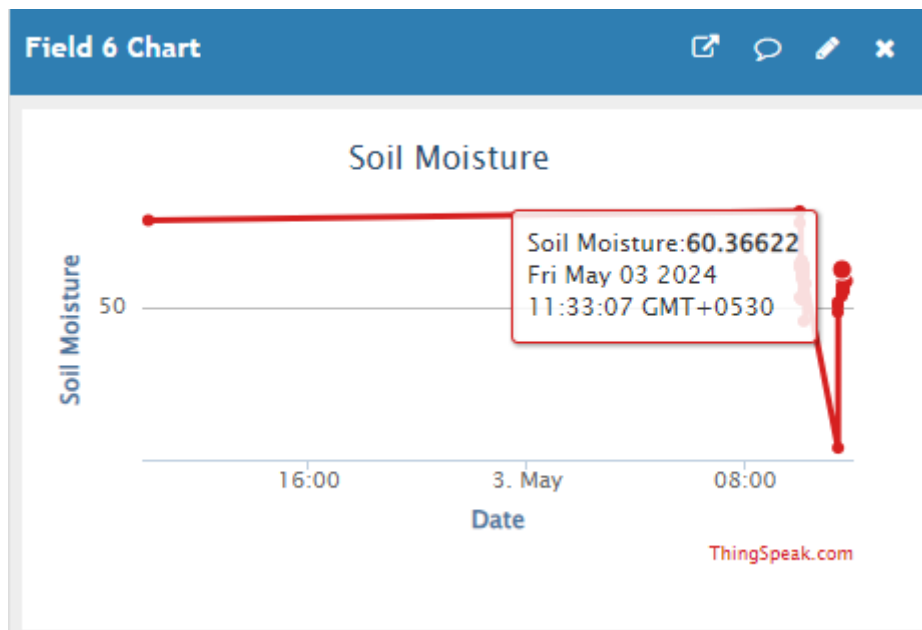


Figure 5.13 Soil Moisture (%) Data Visualization Chart

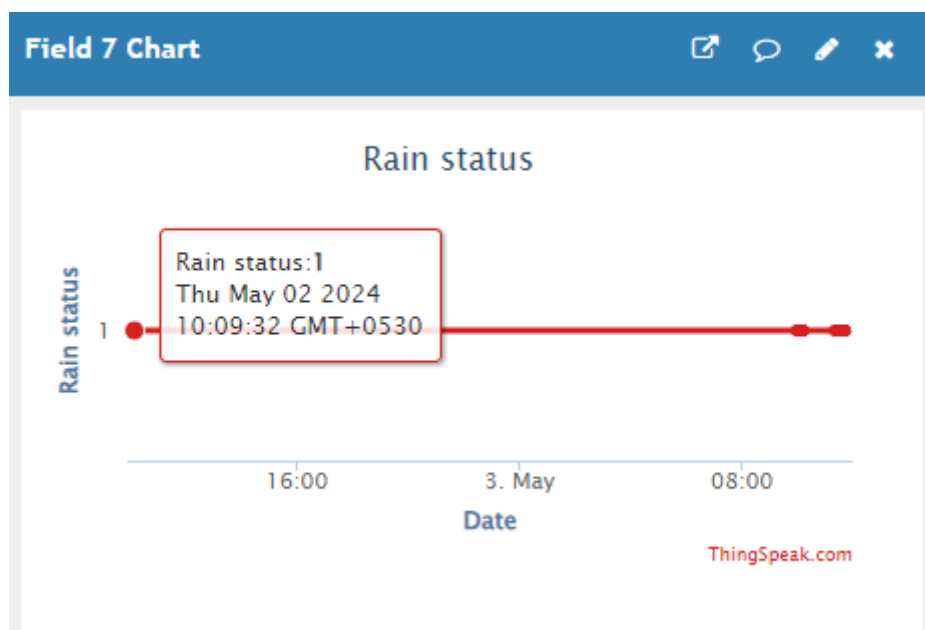


Figure 5.14 Rain Status Data Visualization Chart (1 or 0) – 1: not raining

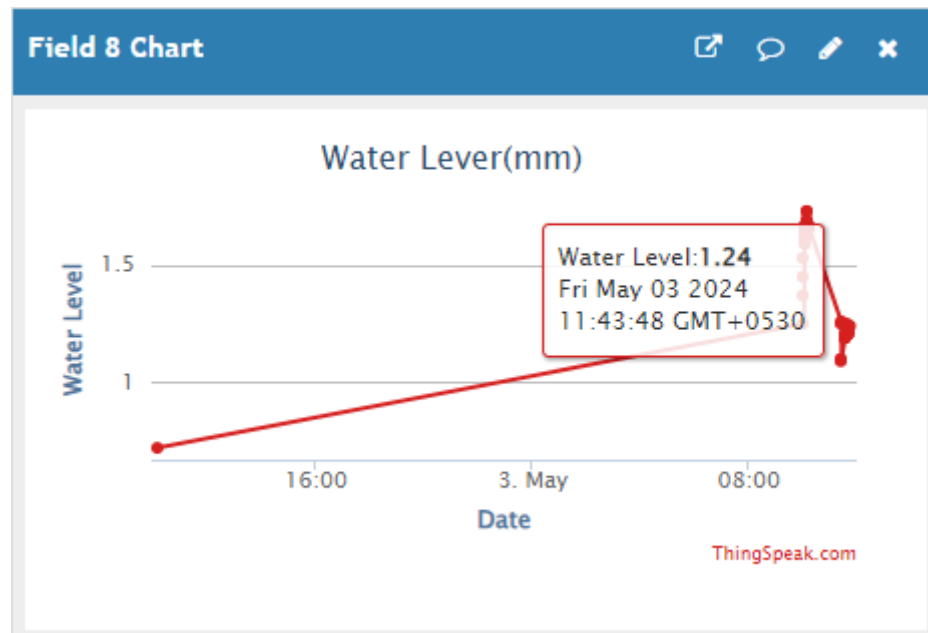
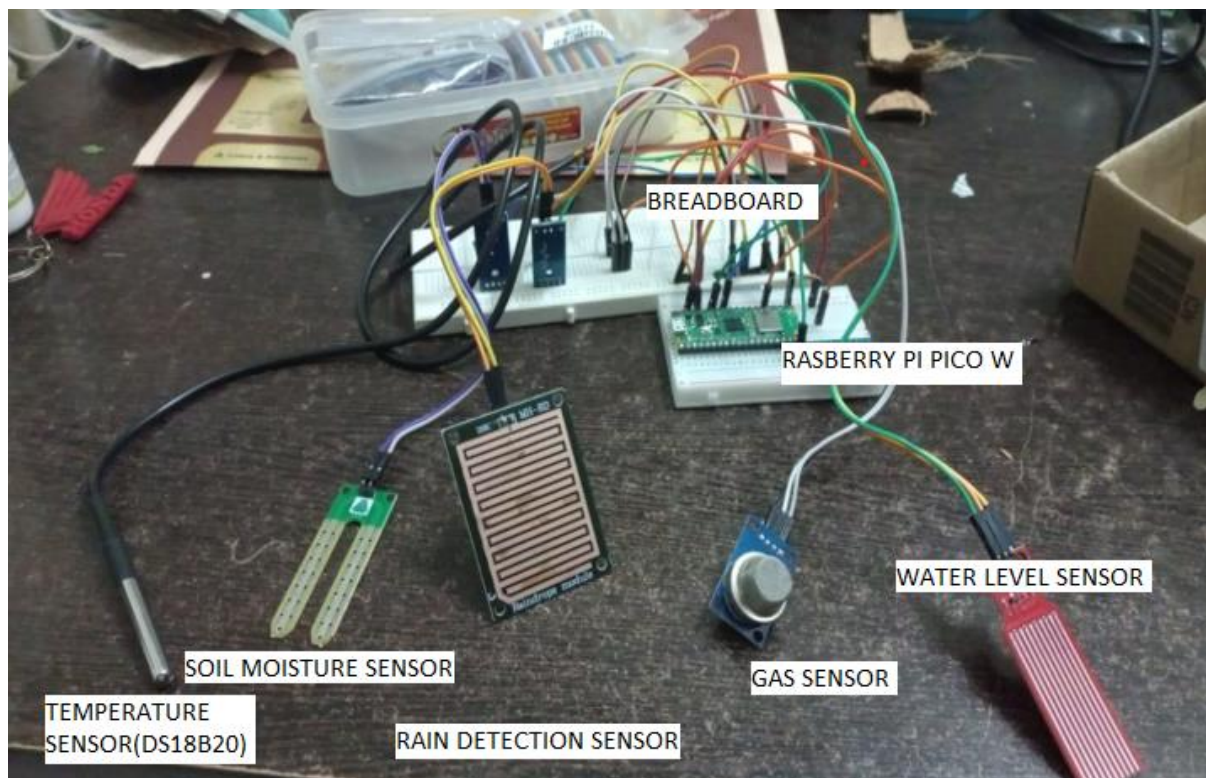


Figure 5.15 Water level (mm) Data Visualization Chart



5.16 Our model setup

CHAPTER 6

SUMMARY AND CONCLUSION

The implementation of our smart agriculture system has yielded comprehensive results, providing real-time monitoring and analysis of crucial environmental parameters essential for optimal crop management. Leveraging the capabilities of the ThingSpeak platform, our system offers accessible and informative visualizations that can be accessed remotely with network connectivity. The rain status widget offers immediate insight into precipitation events on the agricultural farm, signified by distinct colours. Similarly, the temperature widget provides up-to-date temperature readings, enabling farmers to monitor ambient conditions effectively. The soil moisture sensor, with its color-coded indication, alerts users to moisture levels below the threshold of 55 ml per 10 square area, aiding in irrigation decision-making. The water level indicator widget illuminates when water levels exceed 30 mm-cm, ensuring proper water management. Furthermore, the graphical representations of temperature, carbon monoxide, NH₃, N₂, and SO₂ levels over the past 1-2 weeks offer valuable historical data for trend analysis and anomaly detection. The inclusion of soil moisture, rain status, and water level graphs enhances the system's capabilities, providing a comprehensive overview of environmental conditions over time. Additionally, the moisture level indicator widget offers a precise percentage representation of water moisture content, further assisting in irrigation planning and crop health management. Overall, these results demonstrate the effectiveness and versatility of our smart agriculture system in facilitating informed decision-making and optimizing agricultural operations.

Our project leverages the web-based IoT platform, ThingSpeak, for remote monitoring of sensor data, accessible globally. Data analysis is simplified with a LAMP widget, providing real-time alerts for value deviations. Users can access all data in an Excel sheet, facilitating historical data tracking and trend analysis. Seasonal data availability aids farmers in optimizing fertilizer and pesticide usage through data-driven decisions. The system's sensors are scalable, versatile, user-friendly, and easy to maintain, ensuring smooth operation across various settings.

The future prospects for our smart agriculture system entail a series of strategic enhancements aimed at elevating its efficacy and impact in the agricultural landscape:

- **Implementation of Advanced Microprocessors:** Transitioning from microcontrollers to advanced microprocessors will empower our system with greater processing power, scalability, and versatility, enabling more sophisticated data analytics and algorithmic processing capabilities.
- **IoT Integration for Seamless Operation:** Enabling IoT connectivity will facilitate seamless operation and management of the system, allowing for remote monitoring, real-time data transmission, and automated control functionalities. This integration promises enhanced efficiency, productivity, and adaptability in agricultural operations.
- **Implementation of Smart Irrigation Systems:** Deploying smart irrigation systems equipped with soil moisture sensors, weather forecasts, and automated control mechanisms will revolutionize water management in agriculture. By enabling precise irrigation scheduling based on real-time environmental conditions, these systems will optimize water usage, conserve resources, and mitigate the environmental impact of agricultural practices.

In conclusion, our smart agriculture system represents a paradigm shift in farming practices, driven by the convergence of advanced technologies, data analytics, and sustainability principles. By embracing the above ideas, we are poised to revolutionize agriculture, enhance food security, and foster sustainable agricultural development for generations to come.

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