SMART FARMING

Explore how to farm smarter using sensors and actuators

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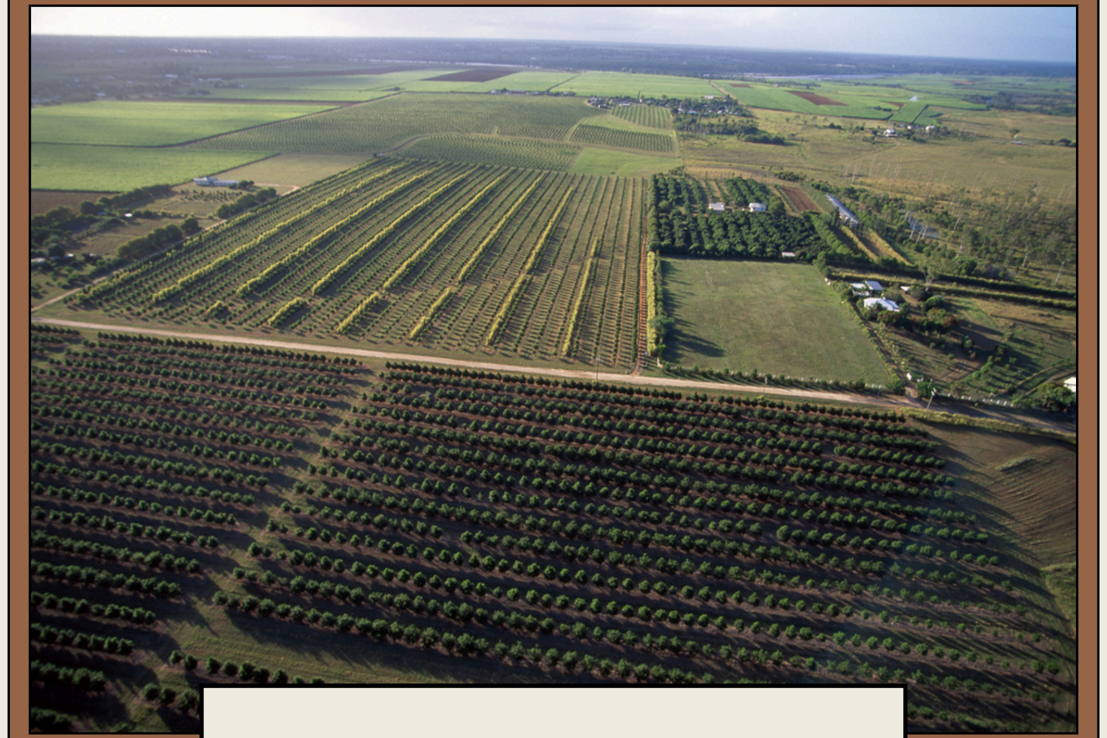
Factors Influencing Farming Decisions



Climate

Farmers should select crops and animals suited to their region's typical weather.

Soil Composition

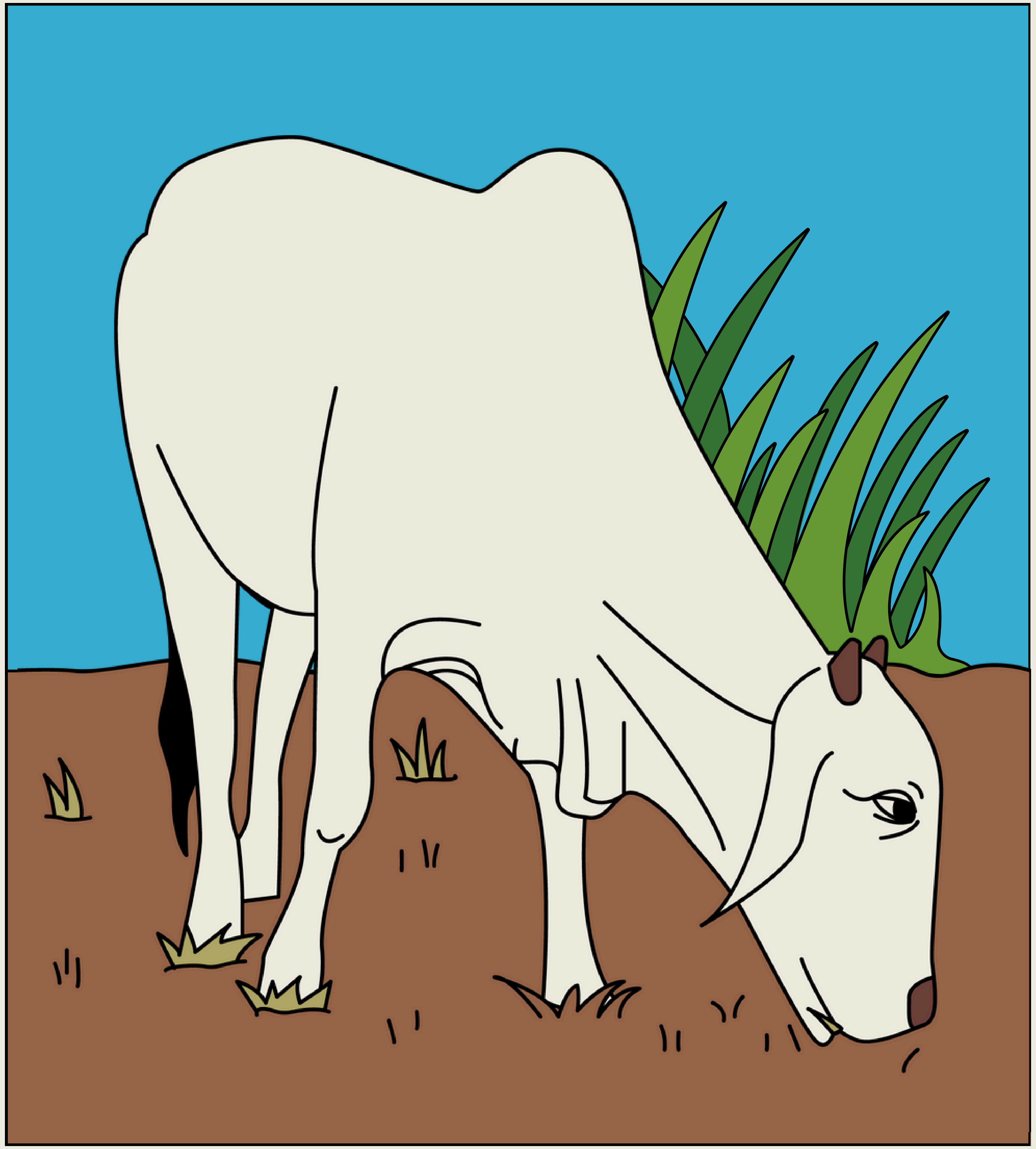
They must know how soil fertility, drainage and nutrient availability affect crops and livestock growth.

Water Availability

Farmers must also consider how much water is available for irrigation and livestock.

How can farmers learn more about what might work best in their local area?

SMART-FARMING!

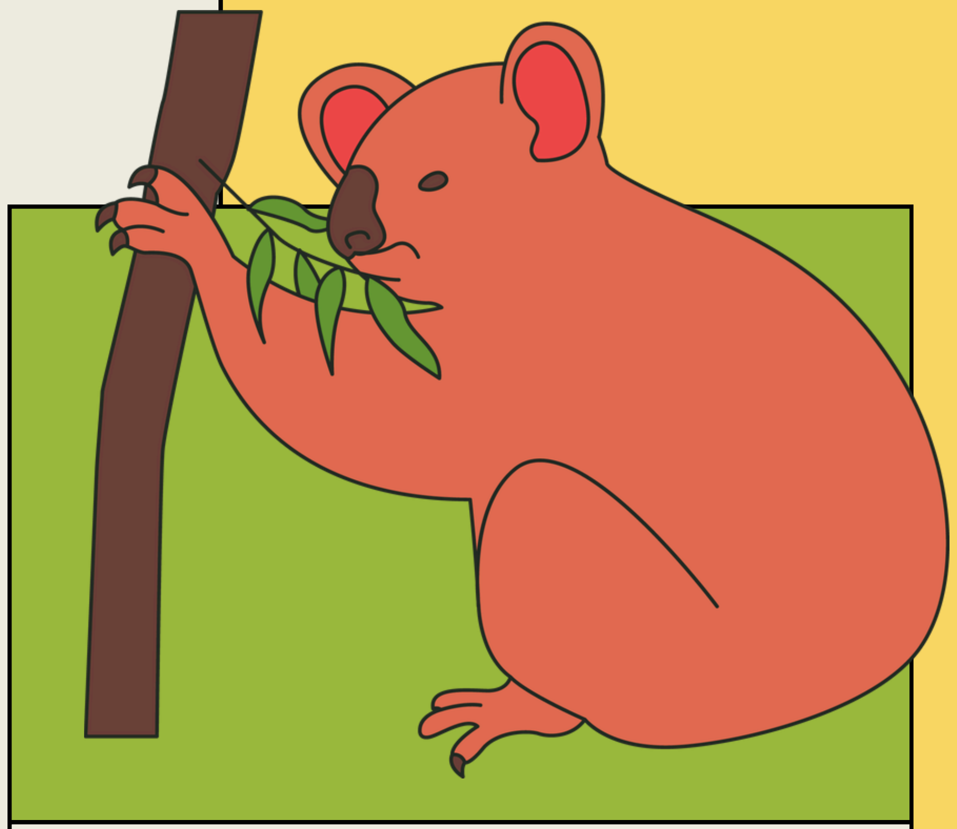


Motivation

- Smart farming refers to an upcoming concept that combines conventional farms with new technologies such as IoT.
- The purpose of Smart farms is to increase the quality of agricultural products whilst optimising human intervention.
- To address the challenges of farmers, efforts and research are in place to improve the quality and quantity of agriculture products by making them ‘connected’ and ‘intelligent’ through “smart farming”.
- The IoT technology uses a data-driven approach and enables farm managers to keep a detailed check on their crops. It helps the farmers take appropriate actions against unwanted pests and protect their crops from various diseases.
- The smart farming solution keeps an eye on every activity of crop production, which triggers instant alerts about its health, condition, and temperature requirement, and displays all the details on the interconnected smart gadgets.

COMPONENTS USED

- ESP-32
- SGP30
- DHT-22
- LDR
- Soil Moisture Sensors (Capacitive and Resistive)
- Solenoid Valve



ADAPTATION

The process of adjusting or modifying something to better suit a new or different environment

ESP-32

It is the microncontroller that we used for our project. It is responsible for receiving, interpreting and sending data received from the sensors and also act as an inteface for the automatic solenoid valve system we have in place for irrigation.

Advantages

- Its operating voltage range is 3.3-5V which is ideal for our use case.
- It has integrated Wi-fi and Bluetooth which is useful in maintaining and storing data to a public platform (ThingSpeak)

SGP30

Gas Sensor that measures CO_2 level (in ppm) and TVOC (in ppb) in the surrounding environment

CO_2 and TVOC is measured using changes in conductivity of the metal oxide of the sensing element

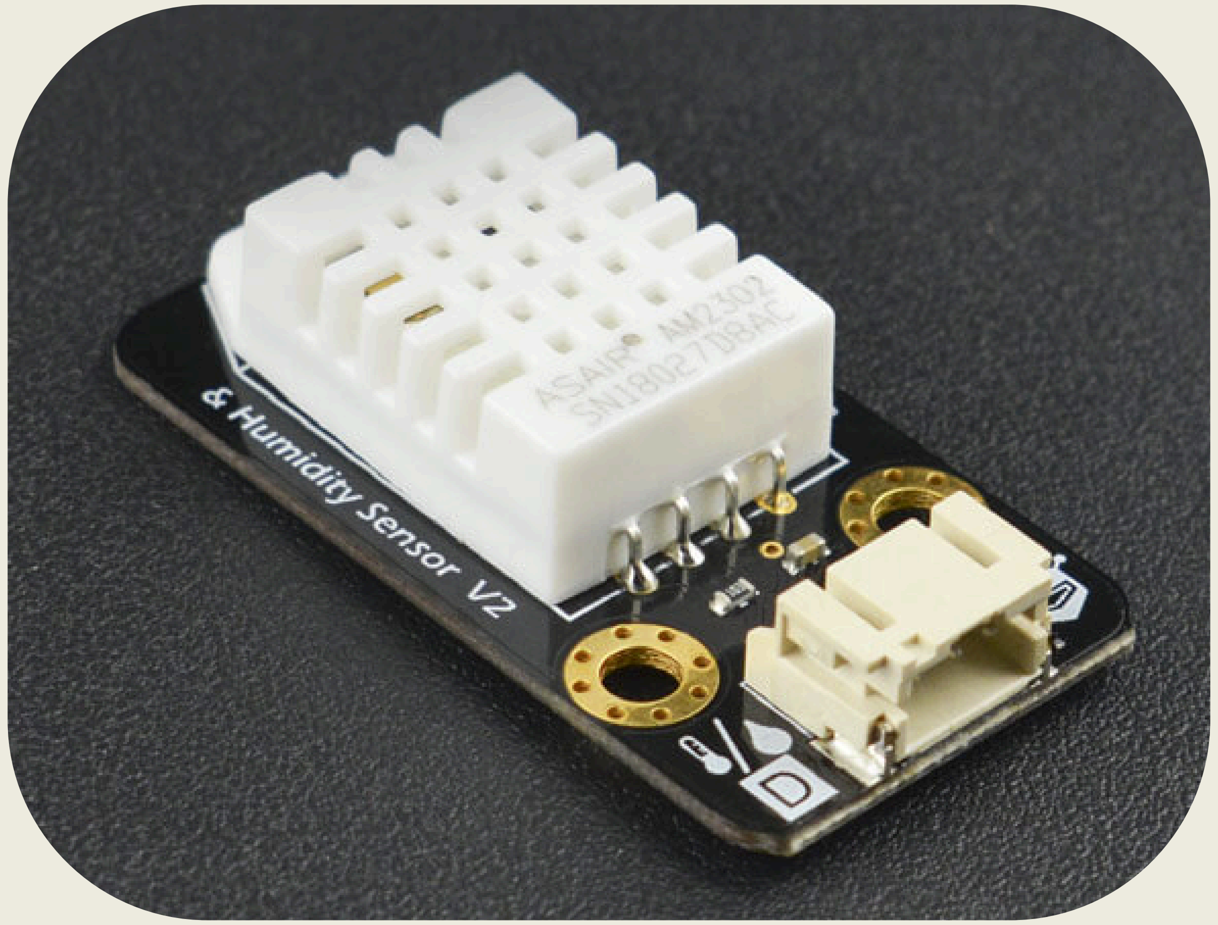
Both levels of CO_2 and TVOC are crucial for monitoring plant growth.

Calibration

The SGP30 has an integrated baseline compensation algorithm, which means it automatically calibrates itself over time to adjust for environmental factors and sensor drift.
However, this self-calibration process requires the sensor to be exposed to fresh air regularly to maintain accuracy.

DHT-22

It is used to measure ambient temperature and humidity.



Working

Consists of 2 different components:

- NTC thermistor for measuring temperature
- Capacitive humidity sensing element measures humidity- has dielectric moisture holding substance between two electrodes

Use Case

Monitoring temperature and humdity to ensure they are within suitable thresholds

Calibration

The DHT22 is factory-calibrated, meaning it does not require any user calibration under normal circumstances.
Calibration data is stored in the sensor's onboard memory, ensuring accurate readings out of the box.

Accuracy: Humidity: ±2–5% RH Temperature: ±0.5°C.

LDR

It is used to measure light intensity of the environment.

Working

LDR is a light-dependent resistor that changes its resistance when different amounts of light fall on it. They work on the principle of photo conductivity where it gives less resistance in high light intensity and high resistance in low light intensity

Use Case

It is used to measure intensity of sunlight which affects photosynthesis of plants.

Calibration

The analog values were adjusted as needed by switching out the resistor in series with it (12 kΩ) as part of the voltage divider.

SOIL MOISTURE SENSORS

CAPACITIVE

Working

A capacitance sensor uses the soil as a capacitor element and use the soil charge storing capacity to calibrate to water content.

Use Case

It is used to measure soil moisture.

SOIL MOISTURE SENSORS

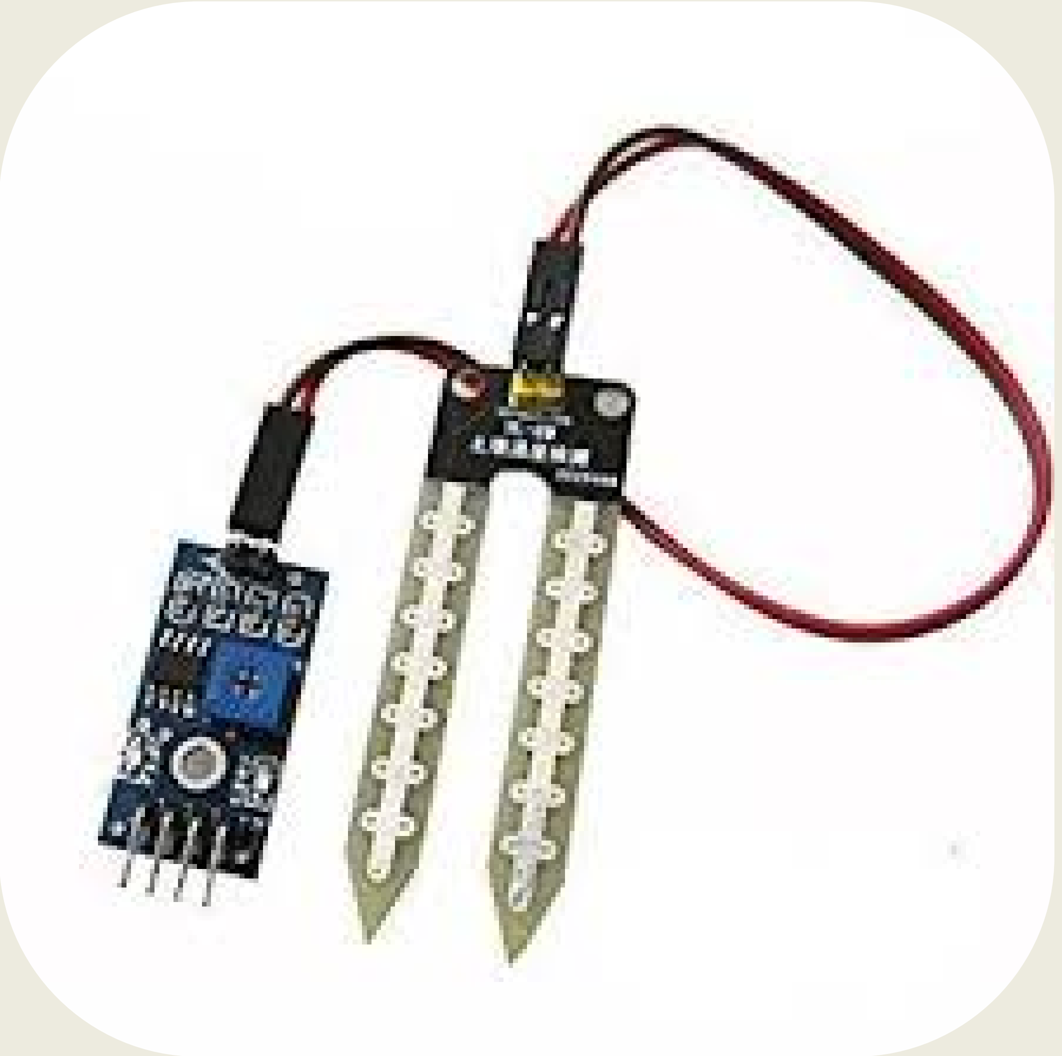
RESISTIVE

Working

The Soil Moisture Sensor Module (Resistance) consists of two probes which are used to measure the volumetric content of water. The two probes allow the current to pass through and then it gets the resistance value to measure the moisture value.

Use Case

It is used to measure soil moisture.



SOIL MOISTURE SENSORS

Calibration - Capacitive

Threshold and baseline values

```
int dryValue_capacitive = 2500;
int wetValue_capacitive = 400;
```

Calculation

Our capacitive soil moisture sensor was calibrated using readings from dry (2500) and wet (400) soil samples. Curve fitting tests with advanced models showed minimal improvement over a linear approach, which accurately described the data. Studies suggest that with proper calibration, capacitive sensor

The applied formula is:

moisture=100−(analogRead−wetValue)×100/dryValue-wetValue

This allows consistent and efficient mapping of sensor outputs to soil moisture percentages.

Ref Nagahage, E. A. A. D., Nagahage, I. S. P., & Fujino, T. (2019). Calibration and Validation of a Low-Cost Capacitive Moisture Sensor to Integrate the Automated Soil Moisture Monitoring System. Agriculture, 9(7), 141.

SOIL MOISTURE SENSORS

Calibration - Resisitive

Threshold and baseline values

```
int dryValue_resistive = 4095;
int wetValue_resistive = 1500;
```

Calculation

We calibrated the resistive soil moisture sensor using multiple readings across dry (4095) and wet (1500) soil conditions. Initially, curve fitting was explored with polynomial and exponential models; however, a simple linear representation aligned best with the data. Research supports that resistive sensors exhibit near-linear behavior under controlled conditions, simplifying the calibration process.

moisture=100−(analogRead−wetValue)×100/dryValue-wetValue

This ensures reliable performance across various soil conditions with minimal complexity.

Ref [Chowdhury, S., Sen, S., & Janardhanan, S. (2022, October 6). Comparative Analysis and Calibration of Low Cost Resistive and Capacitive Soil Moisture Sensor.]

SOLENOID VALVE

It is used as smart-irrigation system. It can be used control water flow to plants, likely allows water when amount below fixed point.

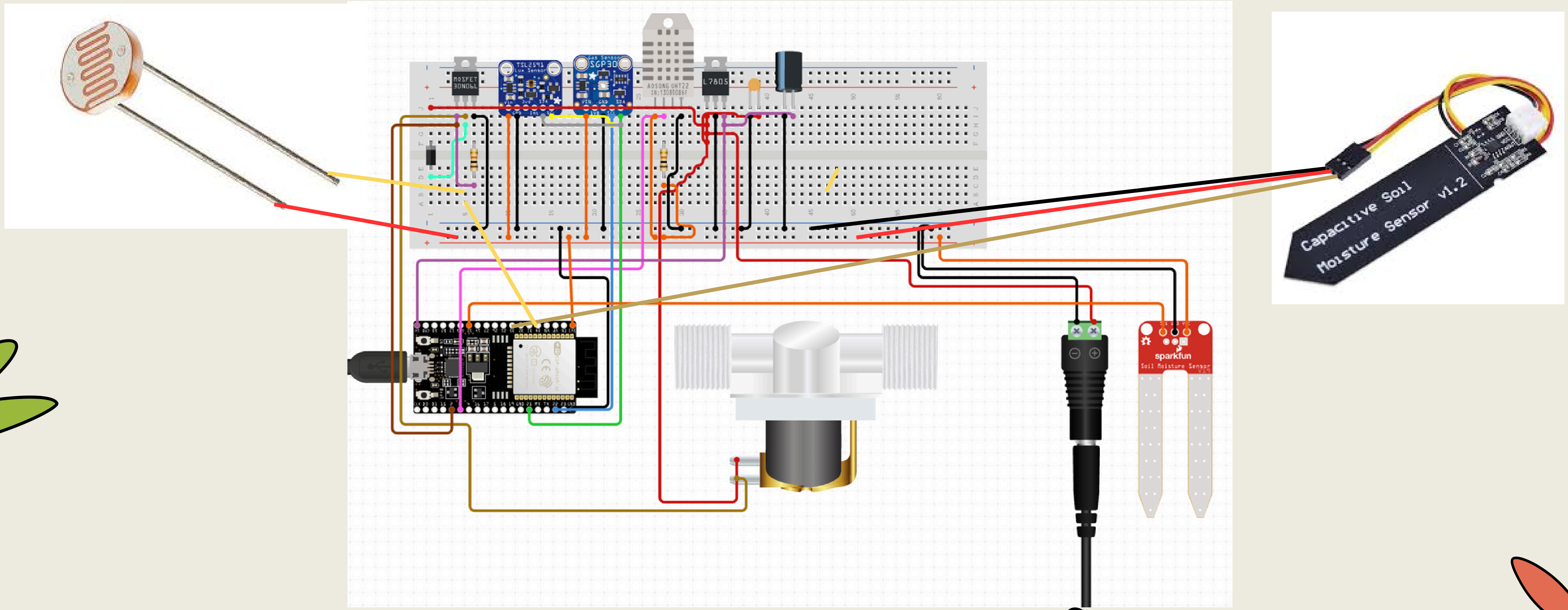
Working

Solenoid valves are control units which, when electrically energized or de-energized, either shut off or allow fluid flow. The actuator takes the form of an electromagnet. When energized, a magnetic field builds up which pulls a plunger or pivoted armature against the action of a spring.

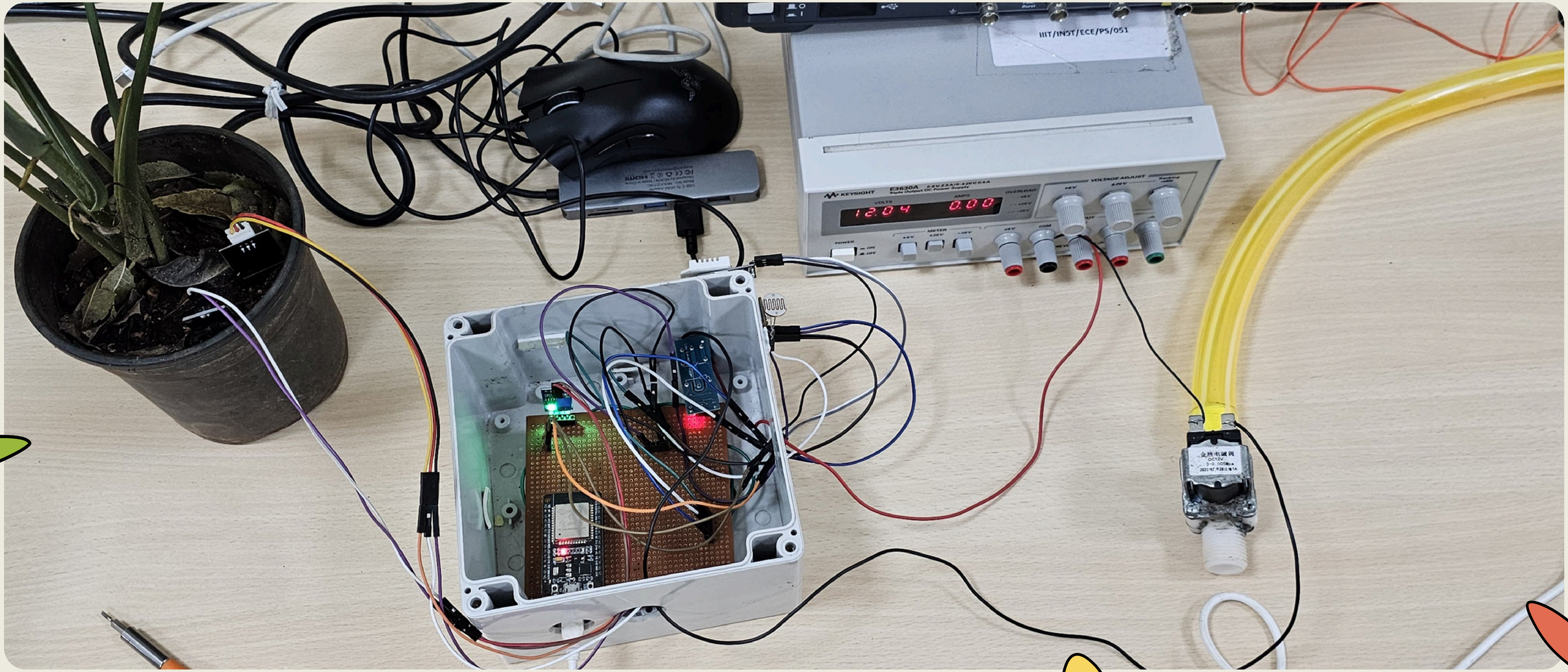
Use Case

It can be used control water flow to plants to ensure soil moisture is within specified thersholds

CIRCUIT DIAGRAM

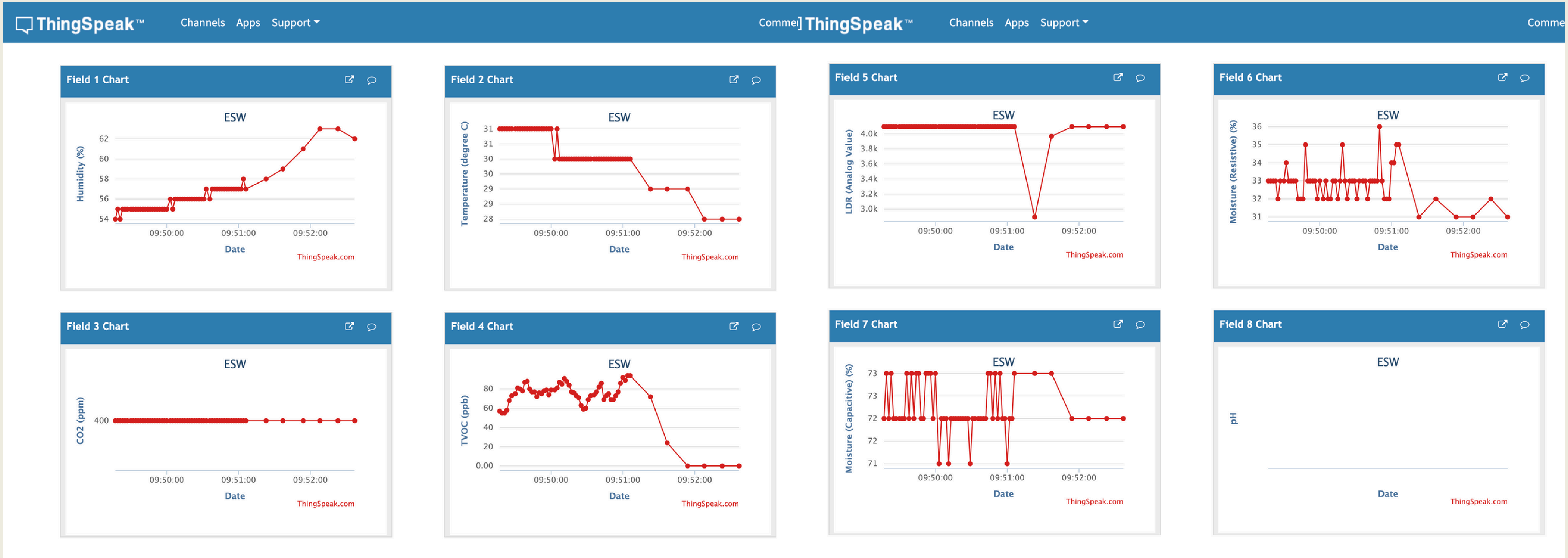


HARDWARE IMPLEMENTATION

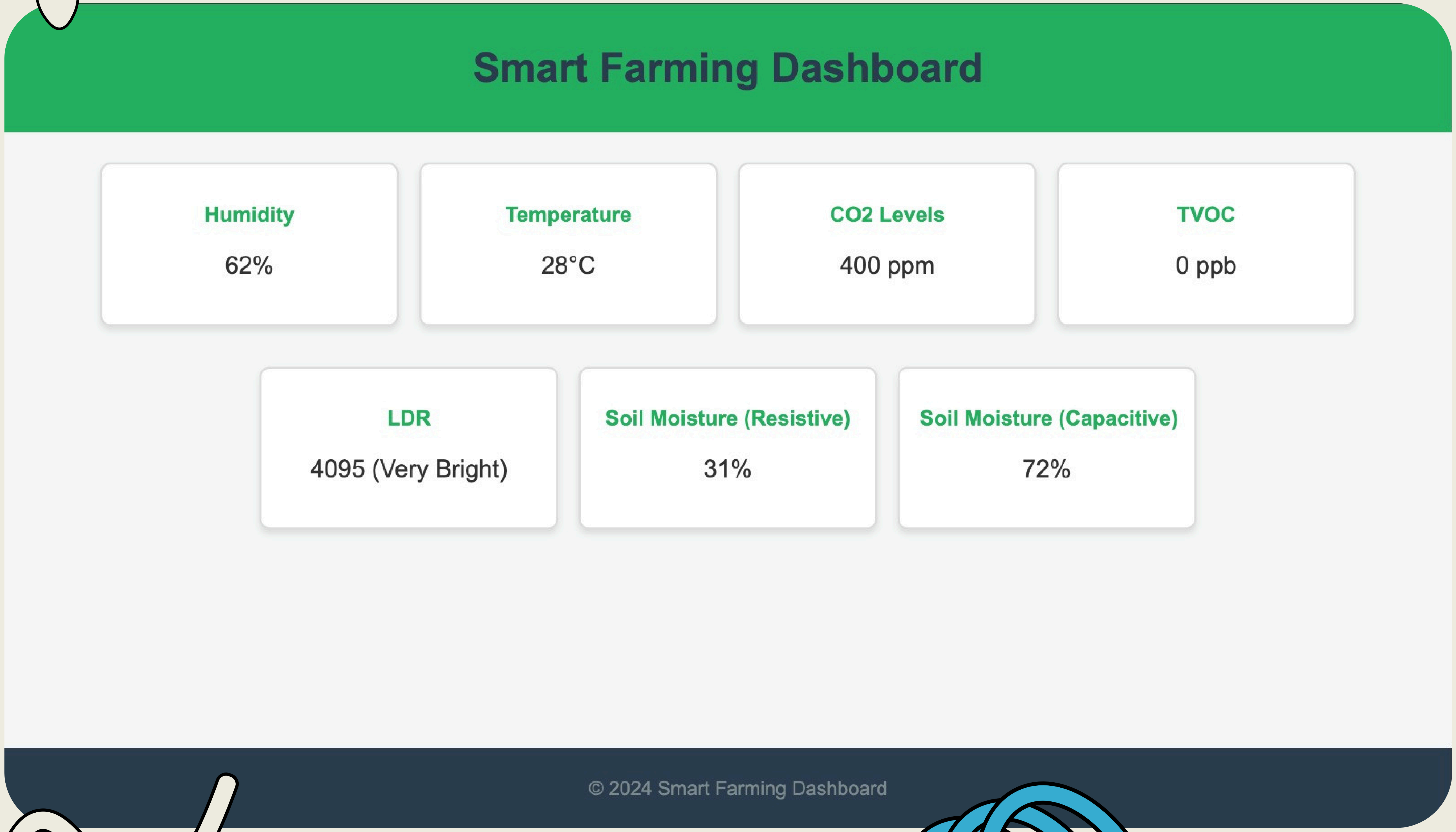


HARDWARE IMPLEMENTATION

Thingspeak View



Website



Working

The website is using HTTP fetch APIs to get current reading of sensors from the ThingSpeak server.

The website is also mainitaining a .csv file to store the data collected over previous 7 days.

DATA ANALYSIS

Plant Profile

Species

The plant monitored throughout the project was the Syngonium podophyllum (commonly known as the arrowhead) plant. It is a species of aroid that is a popular houseplant.

Favourable conditions

20°C - 30°C

Medium Indirect (3000-3700)

40-80% humidity
40-70% moisture

Indoor (0-500 ppm)
TVOC (<400ppb)

DATA ANALYSIS

Temperature values from DHT22

For the chunk of data analysed, the temperature of the surroundings stayed around the range 27-30°C. For the particular plant, this is an optimum temperature range.

Moisture values from soil moisture sensors (Resistive and Capacitive)

This showed more variation in the range depending on the soil moisture. Ideally for the plant, the values should be in the range 20-70% and 30-80% respectively. This measurement allows us to regulate the moisture content as needed by actuating the solenoid valve.

Light intensity values for LDR

The LDR value did not have a huge range shift in the day.
The optimum range was achieved during day by keeping the plant indoors in indirect sunlight.

DATA ANALYSIS

C02 values from SGP30

The CO2 values measured were in the range 400 - 550 ppm. The environment in which the plant was kept in an ideal concentration (indoor > 400 ppm but < 500 ppm), which could encourage plant growth. The sudden peaks were user induced for testing.

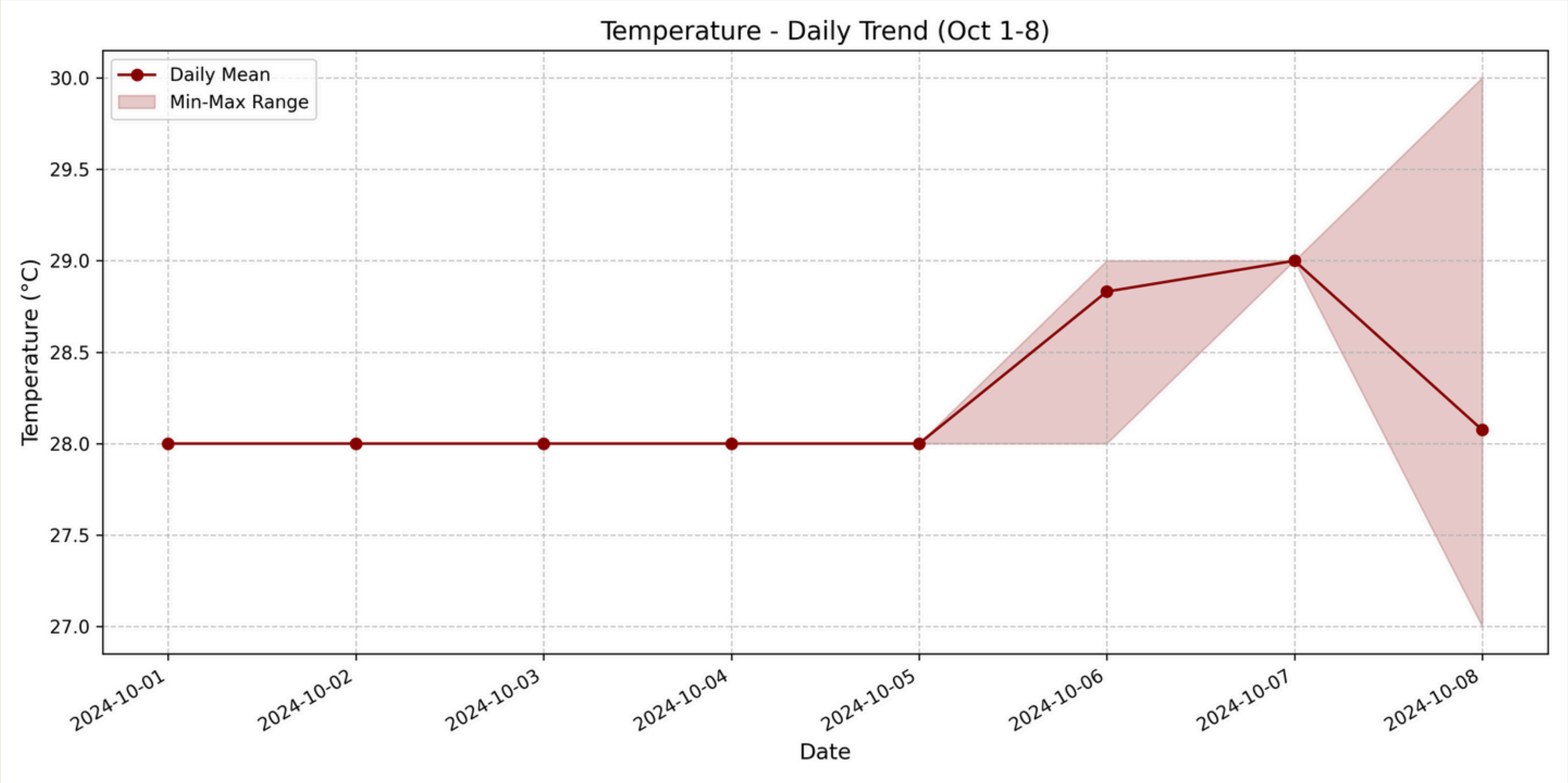
TVOC values from SGP30

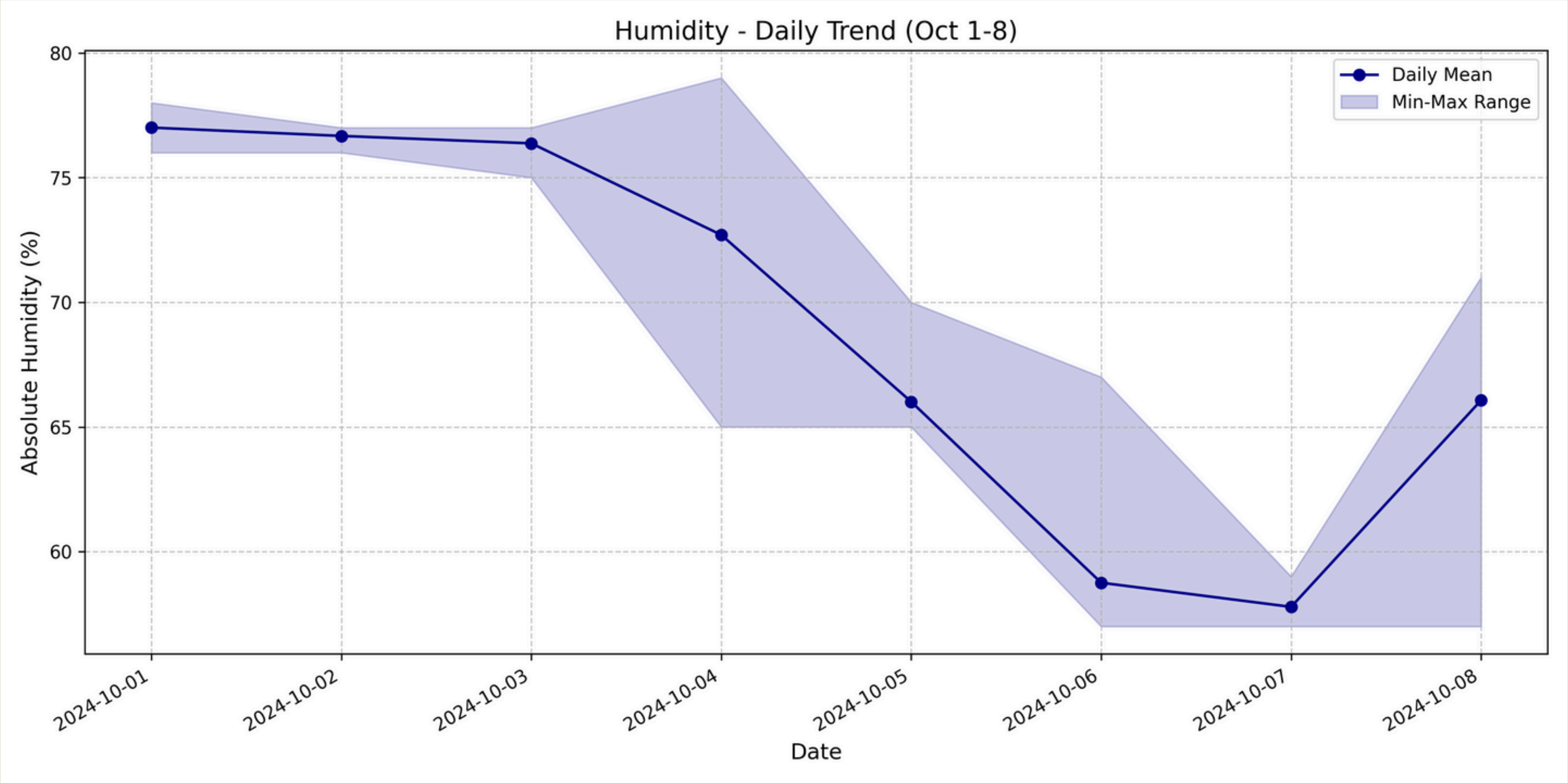
The range VOCs measured was from 0-250 ppb. (Sudden peaks were user induced). These are relatively low values and allow us to indicate an increase in VOCs near plants apart from ambient values could be indicative of a problem such as release in response to a pest infestation.

Humidity from DHT22

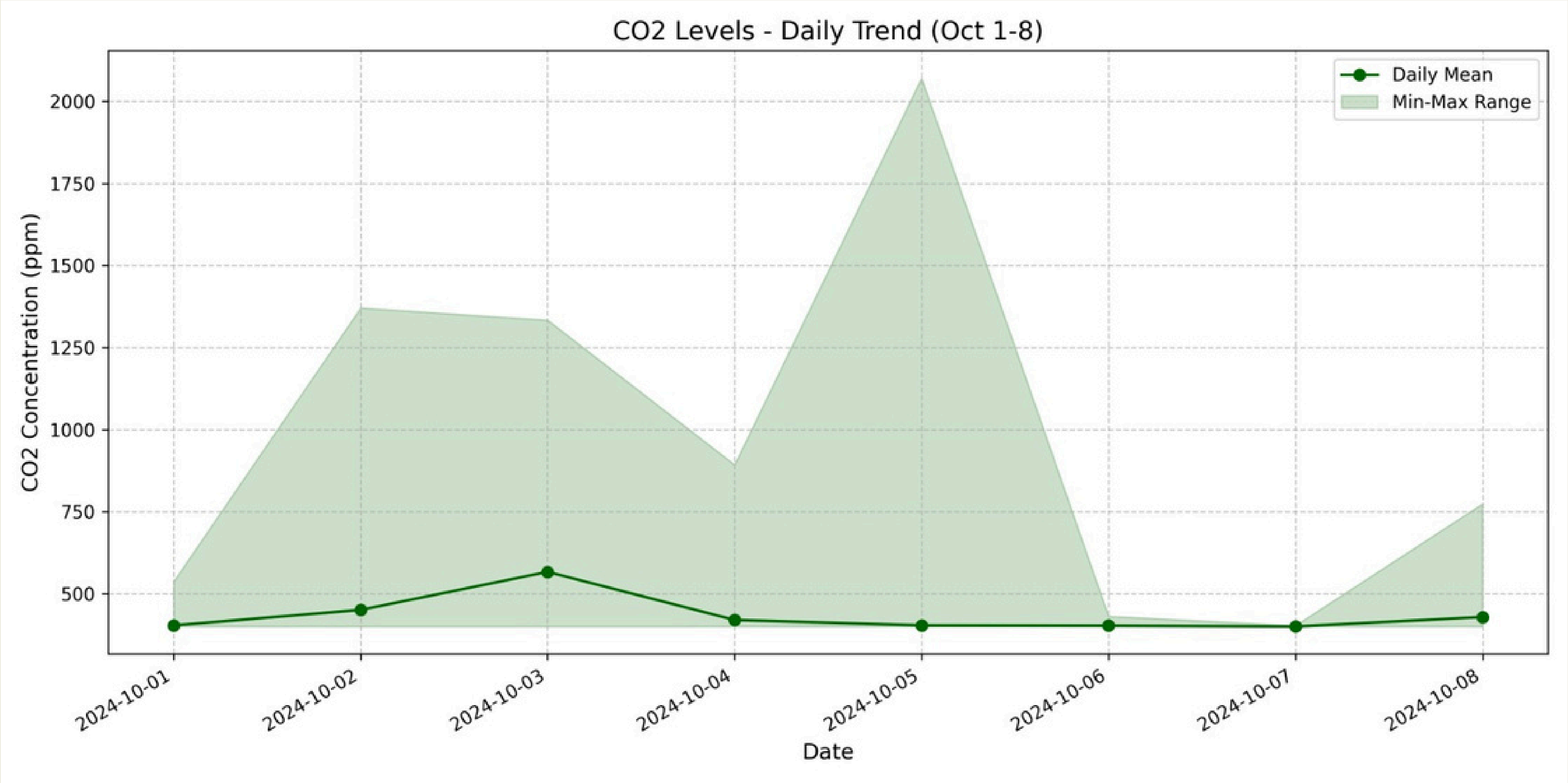
Humidity values ranged from 55-80%. (High variance was attributed to the sudden change in weather). This is also in the optimal range for the plant, as it is within 40-80%.

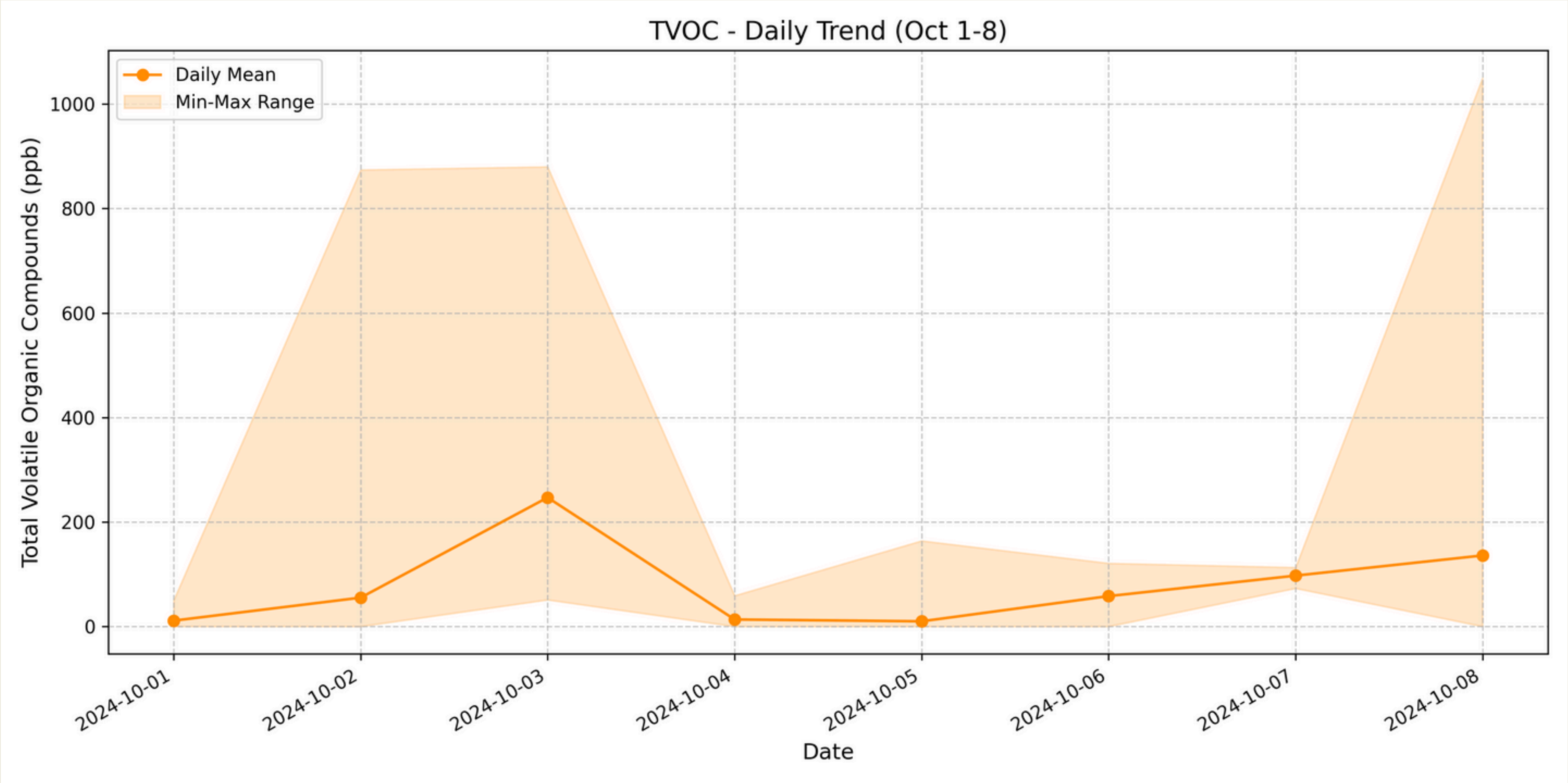
DATA ANALYSIS





DATA ANALYSIS





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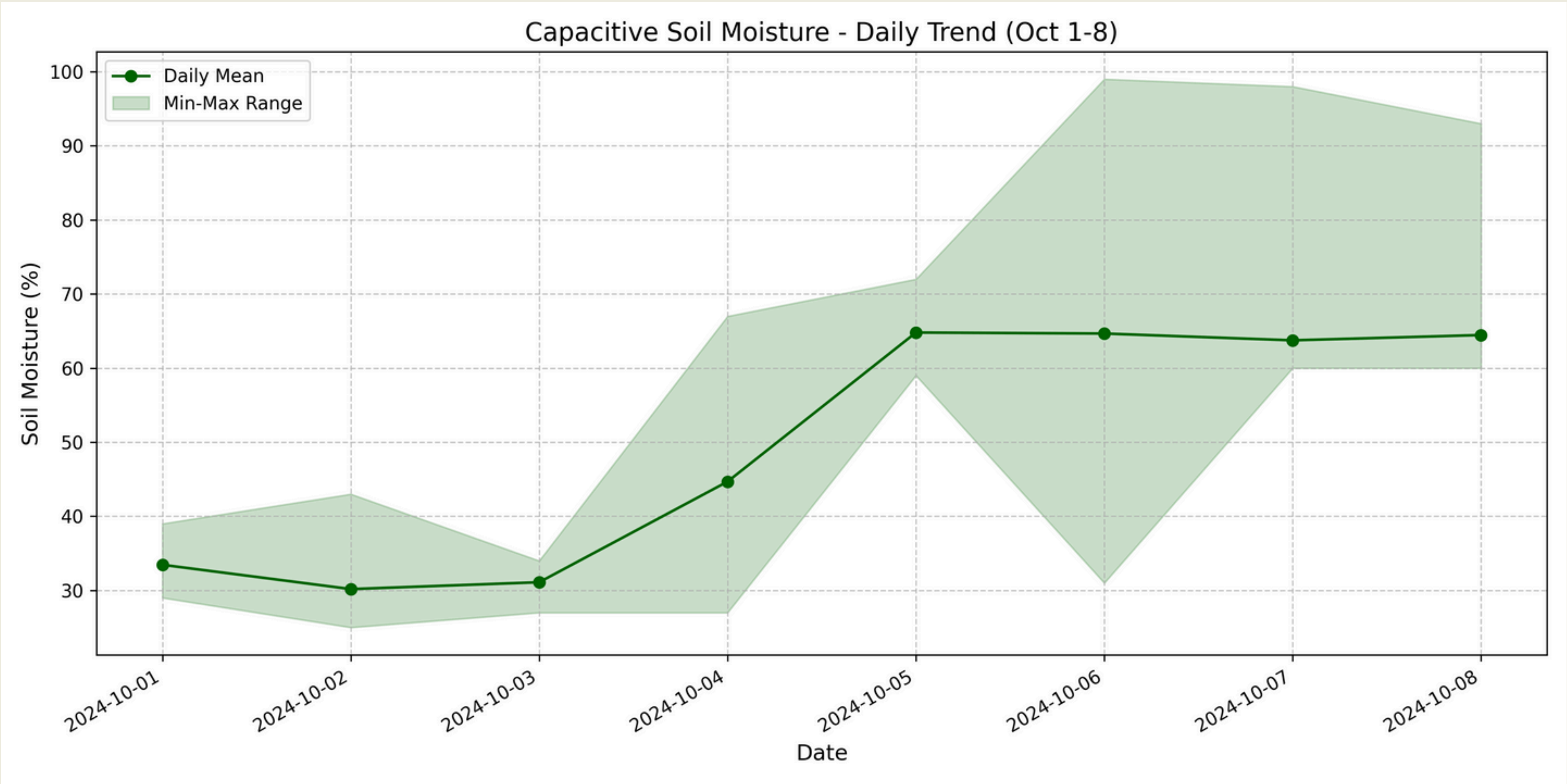
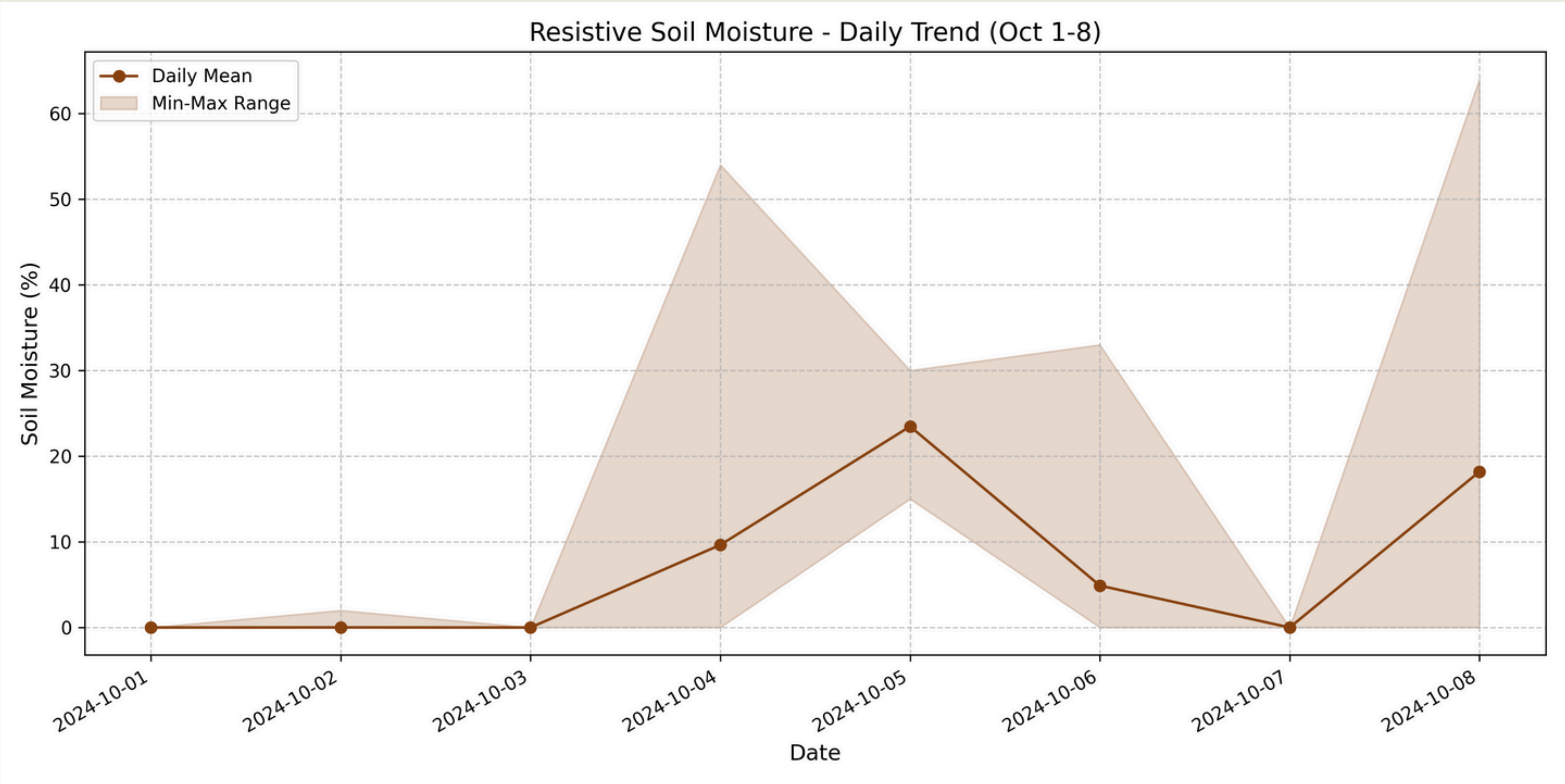
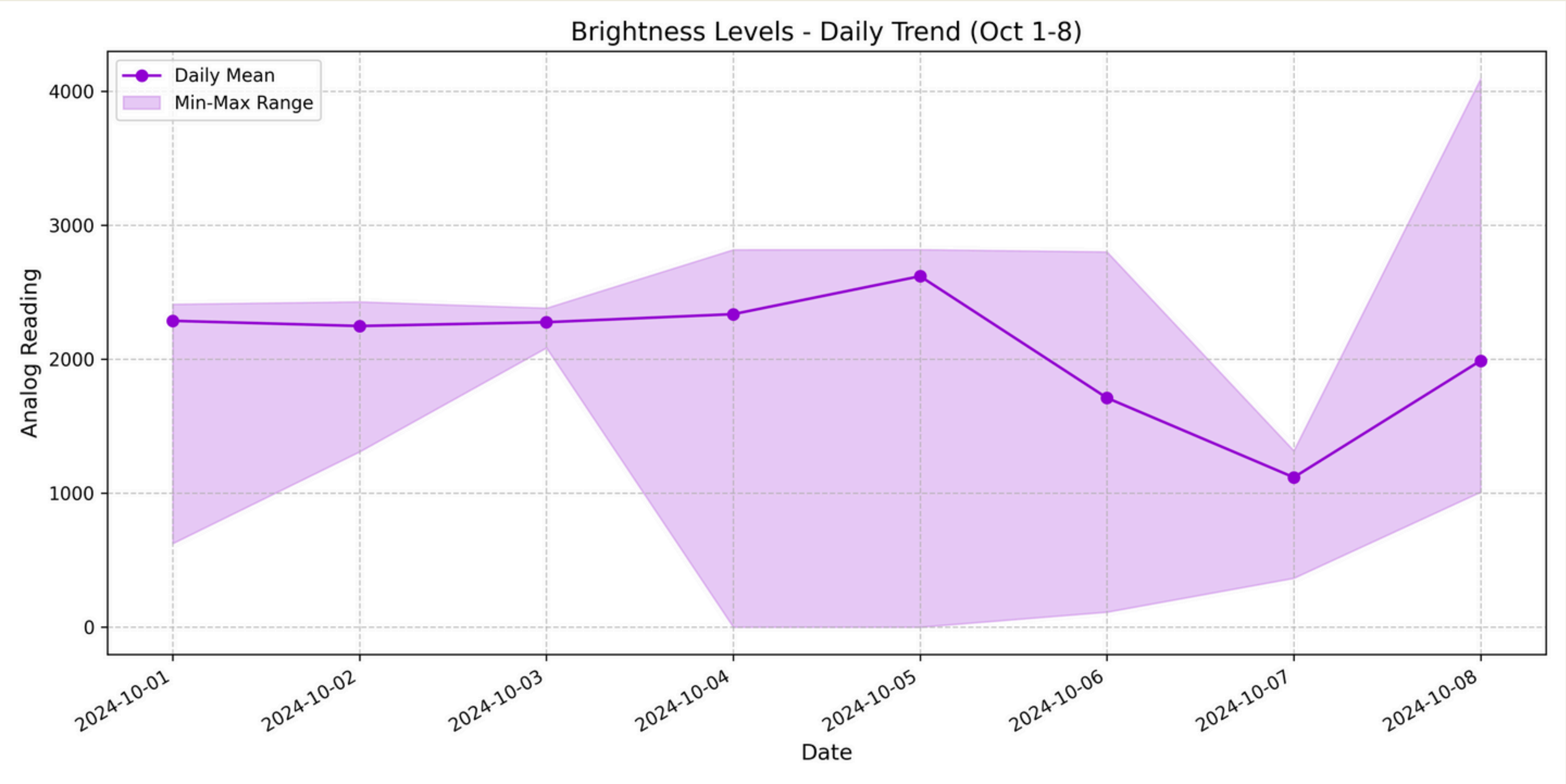




DATA ANALYSIS



Summary

Factors Influencing Farming Decisions

These include climate,
soil composition,
water availability,
local market demand and
farming infrastructure.

Our Solution

IoT-based approaches that make farming more controlled and accurate. In simple words, plants get precisely the treatment they need, determined by machines with superhuman accuracy. The biggest difference from classical approach is that each plant gets "special treatment" from these machines . By precisely measuring variations within a field, farmers can boost the effectiveness of pesticides and fertilizers, or use them selectively.

Decision-Making Strategies

Various
sensors are deployed to measure the environmental parameters according to the specific requirements of the crop. That data is stored in a cloud- based platform for further processing and control with minimal manual intervention. It is also later used to control the irrigation system using a solenoid valve.

Thank you!

TVOC Results

VOC Conc increase due to Plant Stress

High levels of volatile organic compounds (VOCs) released by plants are often associated with pathogen attacks. When a plant is under stress from a pathogen, it releases a specific profile of VOCs that serves multiple functions. These VOCs act as distress signals not only to the affected plant but also to neighboring plants, signaling them to activate their own defense mechanisms. This communication between plants is part of their natural defense strategy to prepare for potential threats, such as disease or herbivory.[1][2]

Can indicate pathogen attack

For example, when a plant is attacked, it releases higher concentrations of specific VOCs that can trigger defensive responses in nearby plants, making them more resistant to the pathogen or pest. In addition to plant-plant communication, these VOCs can also attract beneficial organisms, like natural predators, which help mitigate the pathogen's effects.[3]

Decision-Making Strategies

Thus, higher levels of VOCs could indicate that a plant is under pathogen attack, and this release of VOCs could be used to predict the onset of such attacks, as part of a broader defense response across the plant community. This aligns with the concept that VOC profiles change based on the type of stress the plant is undergoing, particularly in response to pathogens.[4]

With the results of these studies in mind, we can conclude that high TVOC levels indicate an onset of pathogen attack. A sudden and high increase in TVOC levels is thus monitored and alerted by our IoT system (>500 ppb).