# IoT-enabled Automated Greenhouse Monitoring System


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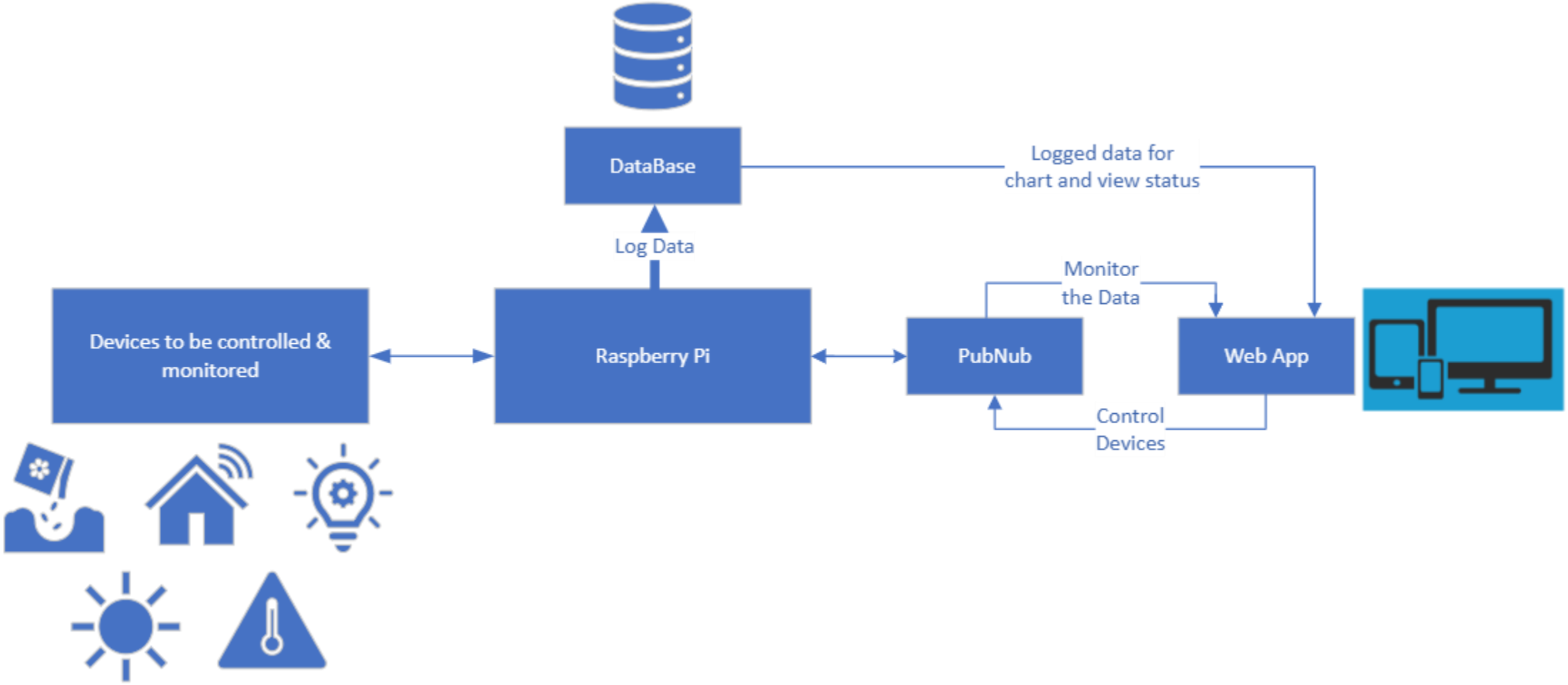
# Introduction

- An IoT-enabled Automated Greenhouse Monitoring System is like a high-tech house.
- It uses a network of smart devices and sensors to keep an eye on everything we need like the right temperature, humidity, and light levels.
- Imagine a device that not only monitors the conditions within a greenhouse but also communicates in real-time (and eventually learns and adapts) to create the optimal environment for plant growth. Today, we're going to take you through the exciting features of our IoT greenhouse device, and how we've integrated PubNub and database capabilities to enhance its functionality.

# Greenhouse Operation Automation

- Greenhouse environment conditions to be monitored through the web page:
  - Air temperature and humidity
  - Soil moisture
  - Light intensity
  - Rain sensing
- Greenhouse operation control:
  - Ventilator fan: Control the ambient temperature by the user decision while observing the actual temperature
  - Heater: Control the humidity by the user decision while observing the actual humidity
  - Light bulb: Control the lighting status by the user decision while observing the actual light intensity.
  - Watering pump: Control the soil water by the user decision while observing the actual soil saturation.
  - Drainage servo: Control the drainage servo pump in case there is a flooding or watering.

# System Architecture



# Components

- Input devices:

1. DHT11 sensor is used to measure the temperature & humidity.
2. Soil moisture sensor
3. Photo resistor sensor that is connected to A2D MCP3008 converter to measure the light intensity
4. Raindrop sensor module.

- Output devices:

1. Ventilator fan: we used DC motor with external power supply by a battery 9 VDC.
2. Heater: we used LED light for demonstration.
3. Light bulb: we used LED light for demonstration.
4. Watering pump: DC submersible water pump.
5. Drainage servo: DC Servo Motor.

- IOT Device: Raspberry Pi 4 8Gb

# Communication and Database

- Pubnub is used as gateway to collect data from the raspberry pi and send it to the web page to be monitored & controlled.
- MySQL is hosted on AWS and is collecting the data directly from the raspberry pi to be logged. In addition, the historical data can be monitored through the web page trends.

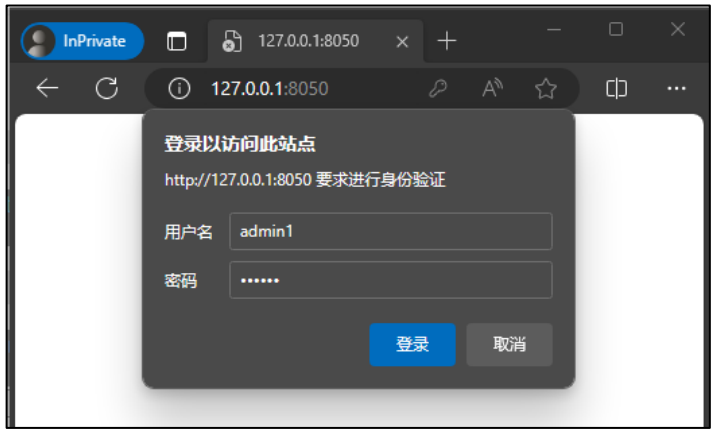
iot_data | Enter a SQL expression to filter results (use Ctrl+Space)

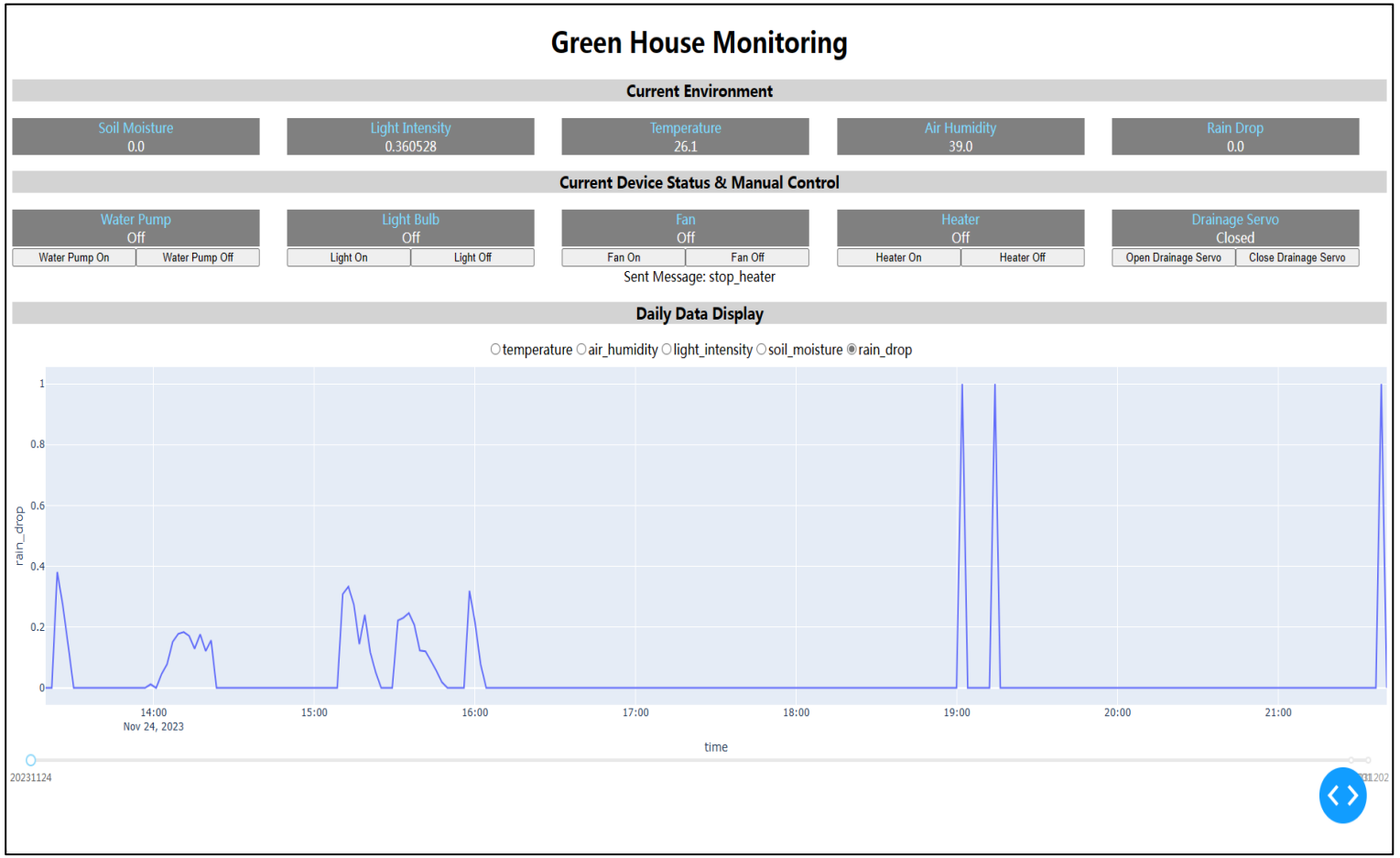
| | sensor_id | sensor_type | value | time |
|---|---|---|---|---|
| 1 | temp_1 | temperature | 26.6 | 2023-11-24 13:19:43 |
| 2 | humidity_1 | air_humidity | 18 | 2023-11-24 13:19:43 |
| 3 | light_1 | light_intensity | 0.670249 | 2023-11-24 13:19:43 |
| 4 | soil_1 | soil_moisture | 0 | 2023-11-24 13:19:43 |
| 5 | raindrop_1 | rain_drop | 0 | 2023-11-24 13:19:43 |
| 6 | temp_1 | temperature | 24 | 2023-11-24 13:19:58 |
| 7 | humidity_1 | air_humidity | 17 | 2023-11-24 13:19:58 |
| 8 | light_1 | light_intensity | 0.709331 | 2023-11-24 13:19:58 |
| 9 | soil_1 | soil_moisture | 0 | 2023-11-24 13:19:58 |
| 10 | raindrop_1 | rain_drop | 0 | 2023-11-24 13:19:58 |
| 11 | temp_1 | temperature | 24.8 | 2023-11-24 13:22:00 |
| 12 | humidity_1 | air_humidity | 17 | 2023-11-24 13:22:00 |
| 13 | light_1 | light_intensity | 0.766976 | 2023-11-24 13:22:00 |
| 14 | soil_1 | soil_moisture | 0.319492 | 2023-11-24 13:22:00 |
| 15 | raindrop_1 | rain_drop | 0 | 2023-11-24 13:22:00 |
| 16 | temp_1 | temperature | 24.5 | 2023-11-24 13:24:03 |
| 17 | humidity_1 | air_humidity | 17 | 2023-11-24 13:24:03 |
| 18 | light_1 | light_intensity | 0 | 2023-11-24 13:24:03 |
| 19 | soil_1 | soil_moisture | 0.354665 | 2023-11-24 13:24:03 |
| 20 | raindrop_1 | rain_drop | 0.381045 | 2023-11-24 13:24:03 |

iot_device_status | Enter a SQL expression to filter results (use Ctrl+Space)

| | device_id | device_class | device_type | status | time |
|---|---|---|---|---|---|
| 1 | fan_1 | actuator | fan | 0 | 2023-12-02 13:10:48 |
| 2 | humidity_1 | sensor | humidity | 0 | 2023-11-24 13:24:03 |
| 3 | light_1 | sensor | light_intensity | 0 | 2023-11-24 13:24:03 |
| 4 | light_bulb_1 | actuator | light_bulb | 0 | 2023-12-02 13:10:51 |
| 5 | raindrop_1 | sensor | rain_drop | 0 | 2023-11-24 13:24:03 |
| 6 | soil_1 | sensor | soil_moisture | 0 | 2023-11-24 13:24:03 |
| 7 | temp_1 | sensor | temperature | 0 | 2023-11-24 13:24:03 |
| 8 | heater_1 | actuator | heater | 0 | 2023-12-02 13:10:44 |
| 9 | pump_1 | actuator | pump | 0 | 2023-12-02 13:10:54 |
| 10 | drainage_servo_1 | actuator | drainage_servo | 0 | 2023-12-02 13:10:42 |

# Webpage



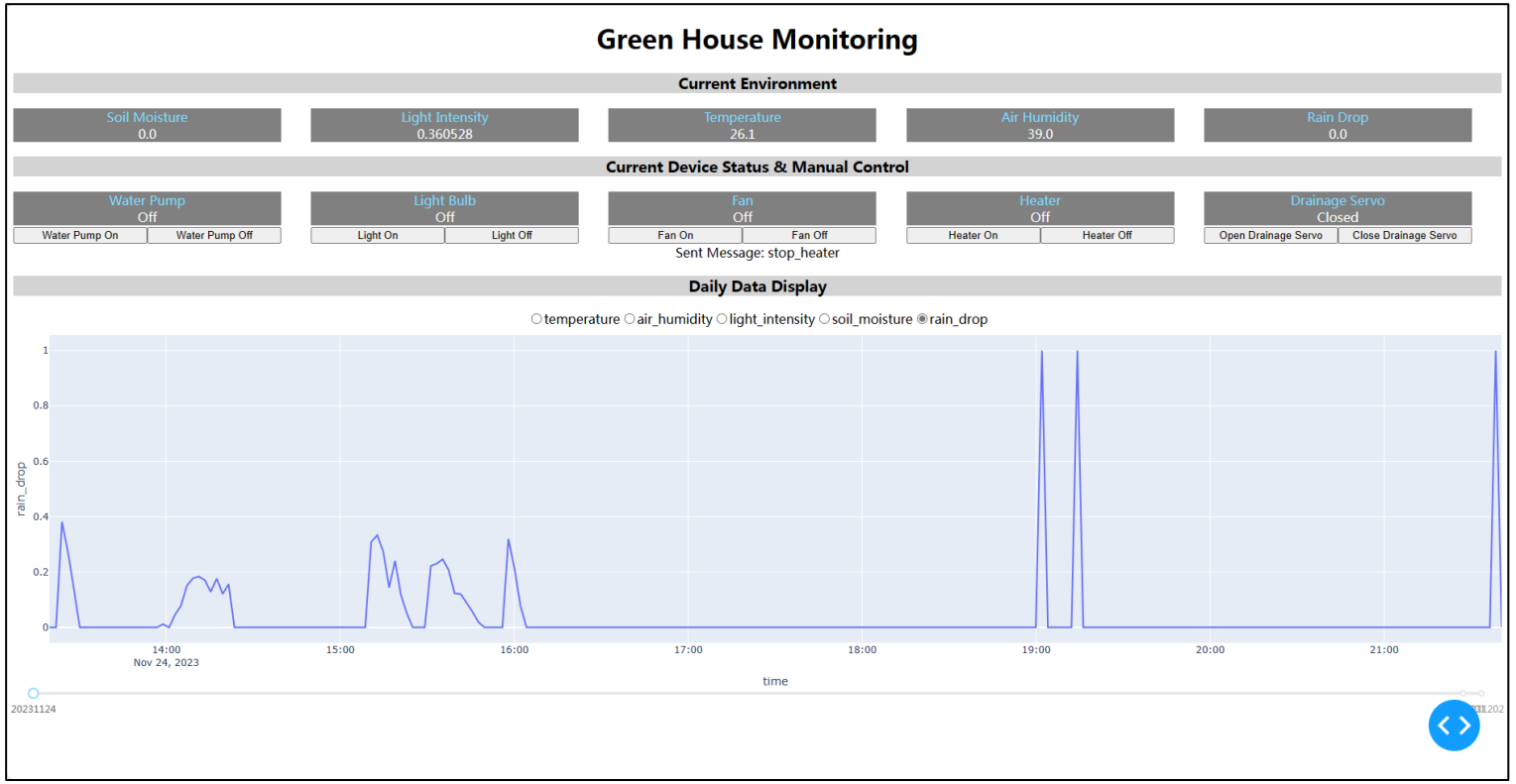

**Functions**

1. Authentication
2. Show the real-time environment and device status, which can change as the data change.
3. Allow the user to click buttons to publish messages on Pubnub.
4. Show the daily data figure of the environment status. It allows the user to choose the features of environment and the date.

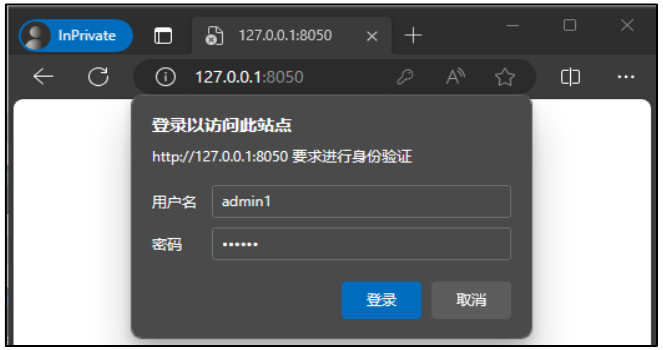
# Webpage

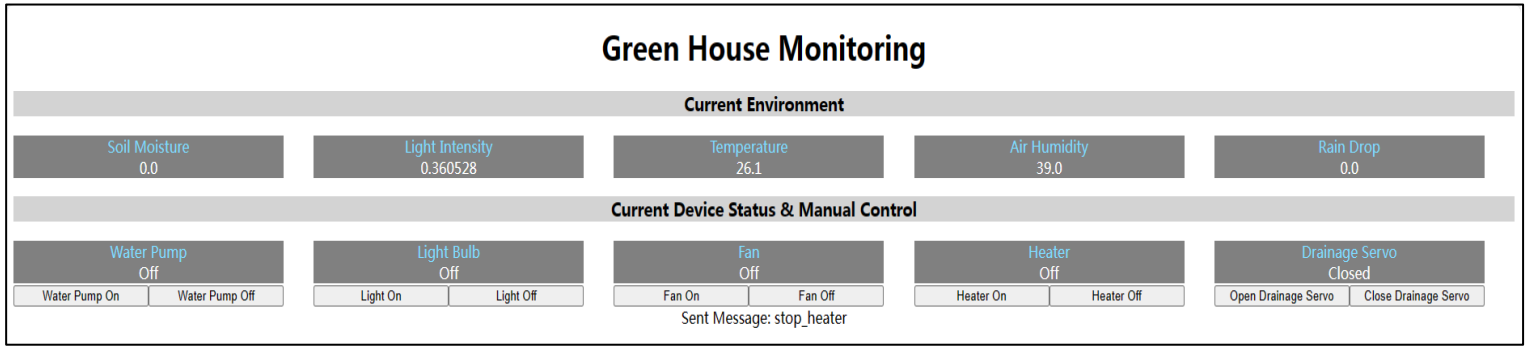
**Python Library Dash**

- Webpage layout: CSS style
- Real-time data display:
  - Callback function
    Input: Updating intervals
    Ouput: Environment/device status
  - Retrieve from MySQL every second
- Daily data figure:
  - Callback function
    Input: Users' clicks of features and dates, Updating intervals
    Output: Line figure
  - Retrieve from MySQL every second



# Webpage




## Python Library dash_auth

- Authentication Function:

  user_pass_map = {"admin1": "666666"}

  auth = dash_auth.BasicAuth(app, user_pass_map)

## Python Library Dash

- Buttons
  - Callback function

    Input: Users' click

    Output: Publish message to Pubnub and remotely control the devices

# Video Link

- https://drive.google.com/drive/folders/1Tp5sQKiH5E7eiwnrnTUcWSaZWBEOiCrC?usp=sharing

# Future Work

- Min-Max range limits to enable auto pilot
- ML model to better control plant health
- Additional sensors to monitor:
  - Soil nutritional content (NPK)

# Citation


- [1] “Dash Documentation & User Guide | Plotly,” *dash.plotly.com*. https://dash.plotly.com/

# Any Questions?
# Thank You!