Weather Monitoring Station

Group Name: ZHU Squad

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1. Project Overview

A. Introduction

The **Smart Weather Monitoring Station** is an ESP32-powered IoT system designed for real-time environmental data acquisition and predictive analysis. It integrates multiple sensors to track air quality, pressure, and precipitation, pushing live data to the **Blynk IoT Cloud** while providing automated emergency alerts via **Gmail SMTP**.

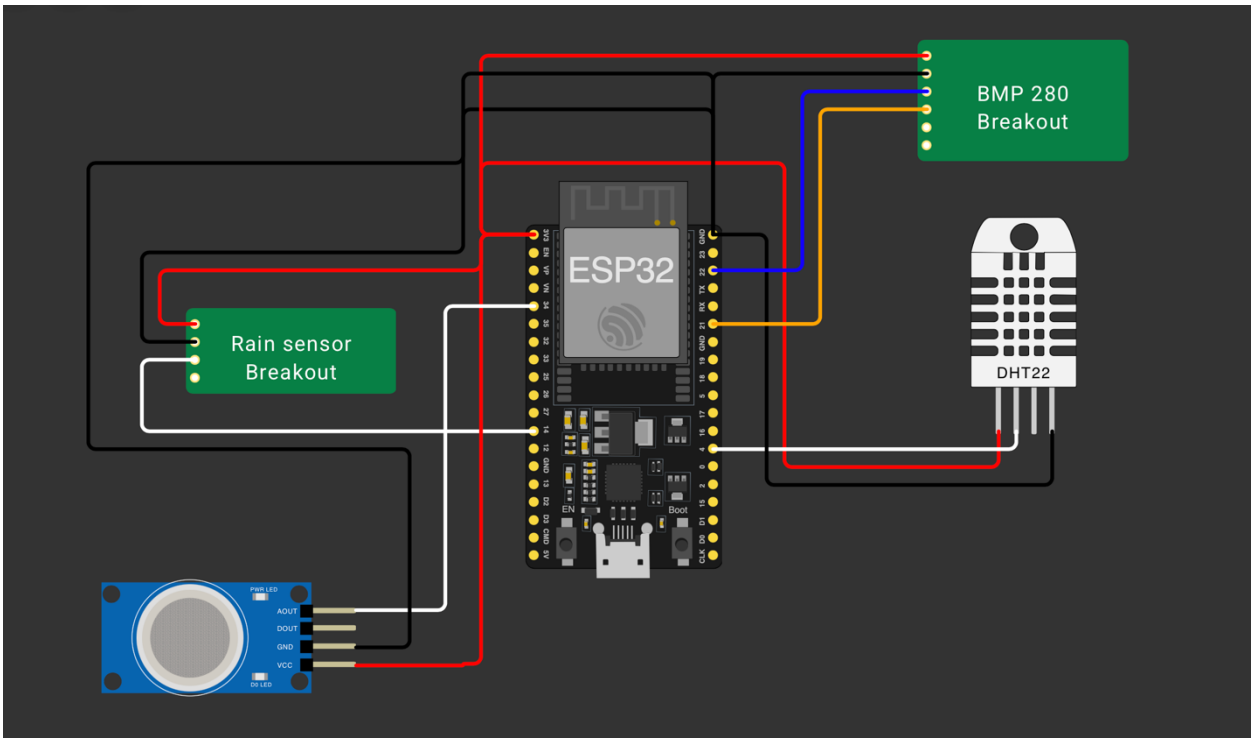
B. Problem Statement

There is a need for a **cost-effective**, **real-time IoT weather station** that monitors local environmental conditions, provides remote access, and automatically alerts users to critical weather events like storms or poor air quality.

C. Objectives

- **Multi-Sensor Integration:** Develop an ESP32-based system to monitor Temperature, Humidity, Pressure, Rain, and Air Quality in real-time.
- **Local Visualization:** Display live sensor readings on an OLED screen for immediate on-site access.
- **Remote IoT Monitoring:** Transmit data to the Blynk platform for remote tracking via a mobile dashboard.
- **Weather Prediction:** Implement algorithms to forecast weather changes based on atmospheric pressure trends.
- **Automated Alerting:** Enable direct Email notifications for critical conditions such as rain, extreme heat, or hazardous air quality.

2. Block Diagram:



Block Diagram

3. Hardware and Software Description

A. Hardware Description

- **DHT11:** This is your primary climate sensor; it tracks how hot it is and how much moisture is in the air.
- **BMP280:** A precision instrument that measures atmospheric pressure—essential for "feeling" changes in the weather before they actually happen.
- **MQ-5:** This acts as a safety guard, sniffing the air for combustible gases or smoke to ensure the environment is safe.
- **Rain Sensor:** A simple but effective pad that detects the very first drop of rain, letting you know the moment the weather turns wet.

B. Software Description

a) Blynk IoT Configuration

The system uses the Blynk IoT platform for remote monitoring and data visualization.

- **Template ID/Name:** Used to identify the project on the Blynk server.
- **Auth Token:** The unique key used by the ESP32 to securely connect to your specific Blynk dashboard.
- **Data Mapping:**

  - **V0 (Double):** For Temperature.
  - **V1 (Double):** For Humidity.
  - **V2 (Double):** For Pressure.
  - **V3 (Integer):** For Rain (0 for dry, 255 for rain).
  - **V4 (Integer):** For Air Quality %.
  - **V5 (String):** For the Weather Prediction text.
  - **V6 (Double):** For the Heat Index ("Feels Like").

b) SMTP Service (Gmail)

The **ESP_Mail_Client** library facilitates automated email alerts.

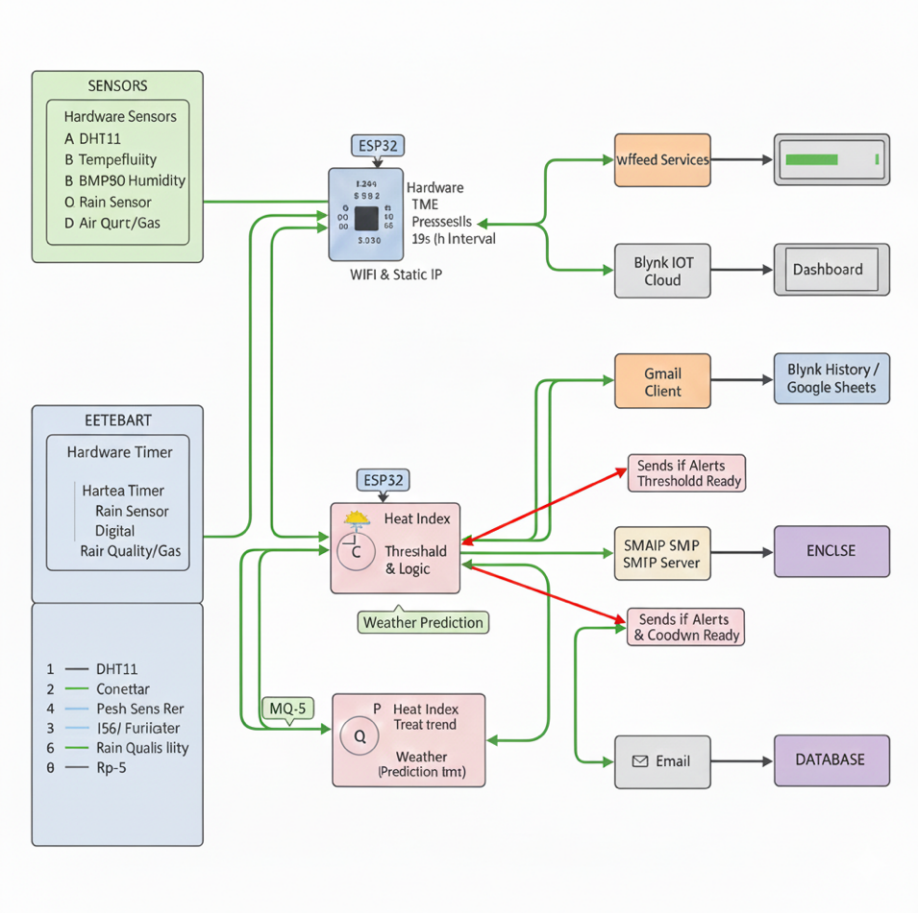
- **SMTP Host:** smtp.gmail.com (Port 465 for SSL).
- **Authentication:** Uses a **Google App Password**, bypassing standard login requirements for higher security.
- **Rate Limiting:** A 5-minute cooldown (managed by an ESP32 hardware timer) prevents the system from spamming the recipient during a persistent critical event.

4. Methodology and Flow Chart

A. Working

1. **The Loop:** Every 1 second, a hardware timer triggers the sendSensorData function.
2. **Processing:**
   - **Heat Index:** Calculated using a complex polynomial formula to determine the "Feels Like" temperature.
   - **Forecasting:** The system compares the current pressure against the value from 10 minutes ago; a sharp drop predicts a storm, while rising pressure indicates clearing skies.
3. **Transmission:**

- Data is written to **Blynk Virtual Pins** for real-time mobile/web dashboard updates.
- **Alert Verification:** If any sensor crosses a "**Critical Threshold**" (e.g., Temp > 40°C or Rain Detected), the system checks the **canSendEmail** flag.
- If the flag is **true**, an email is dispatched and the flag is locked for **5 minutes**.



Flow Chart

5. Network Configuration

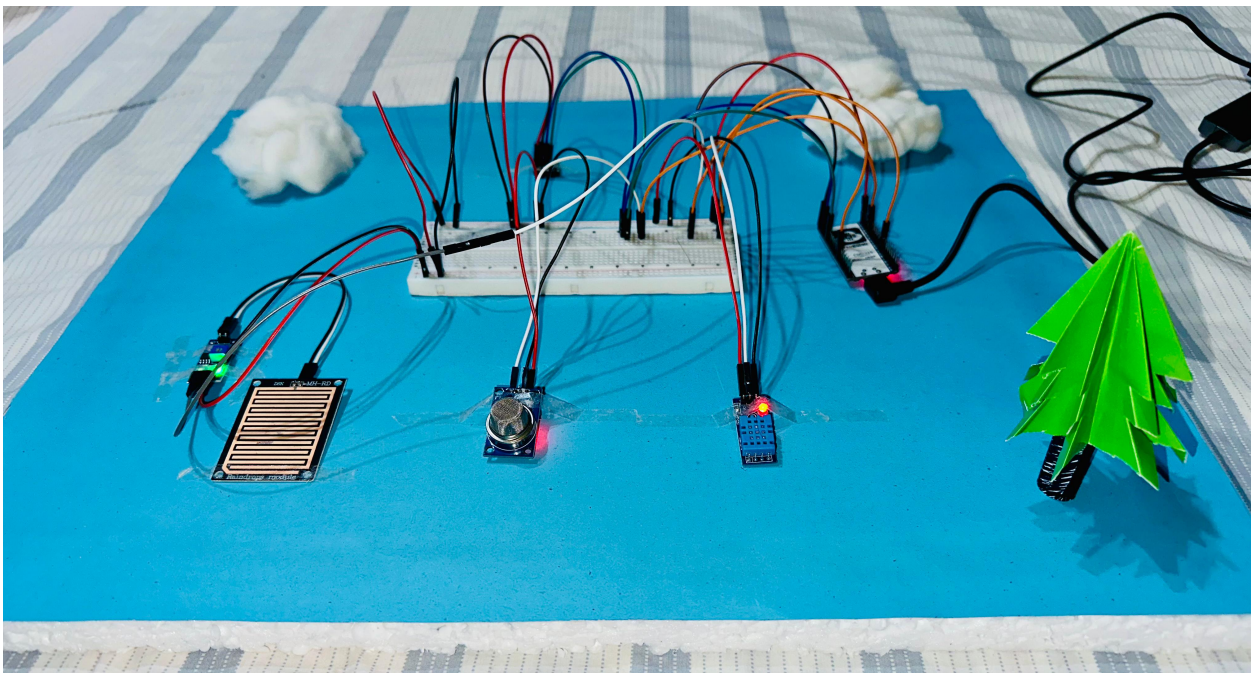
The device uses a **Static IP Configuration** (10.153.74.17). This ensures that the weather station maintains a fixed address within the local network, which is critical for stability and troubleshooting in industrial or home automation environments.

6. Pin Diagram:

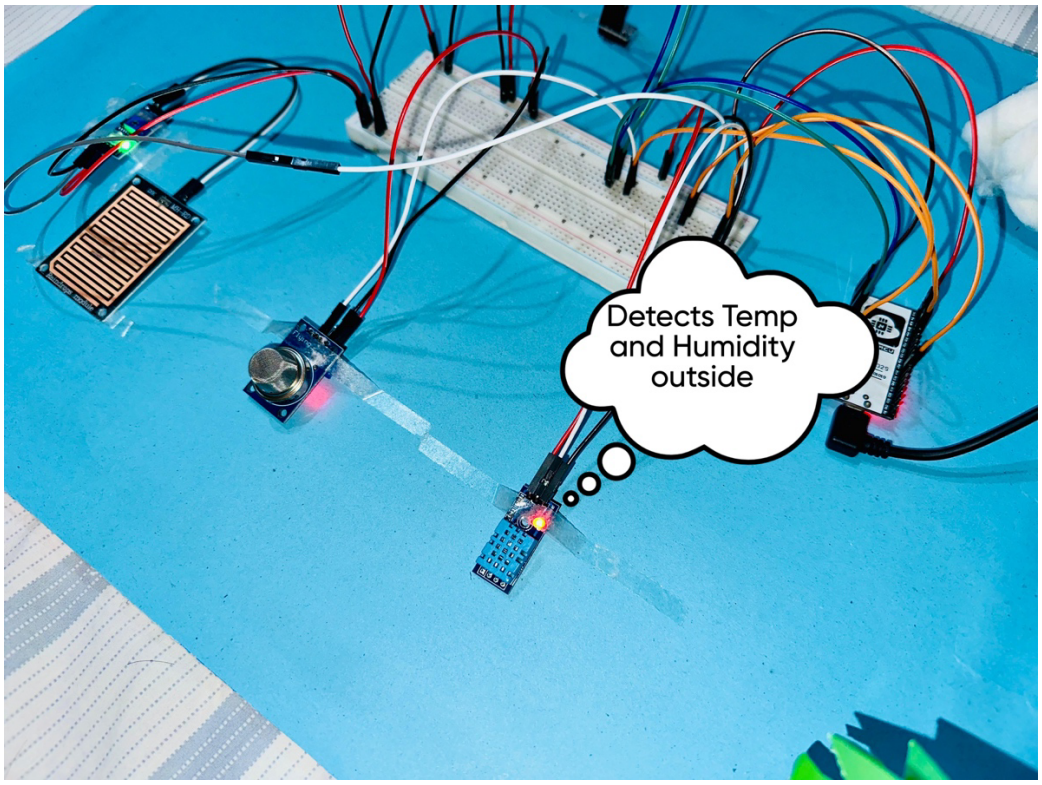
Components	ESP32 Pin	Signal Type
DHT11	GPIO **4**	Digital Input
Rain Sensor	GPIO 14	Digital Input
MQ-5 Gas Sensor	GPIO 34	Analogue Input
BMP280 (SDA)	GPIO 21	I2C Data
BMP280 (SCL)	GPIO 22	I2C Clock
Power (VCC)	VCC 3.3/5	Power
Ground (GND)	GND	Ground

Pin-Map Diagram

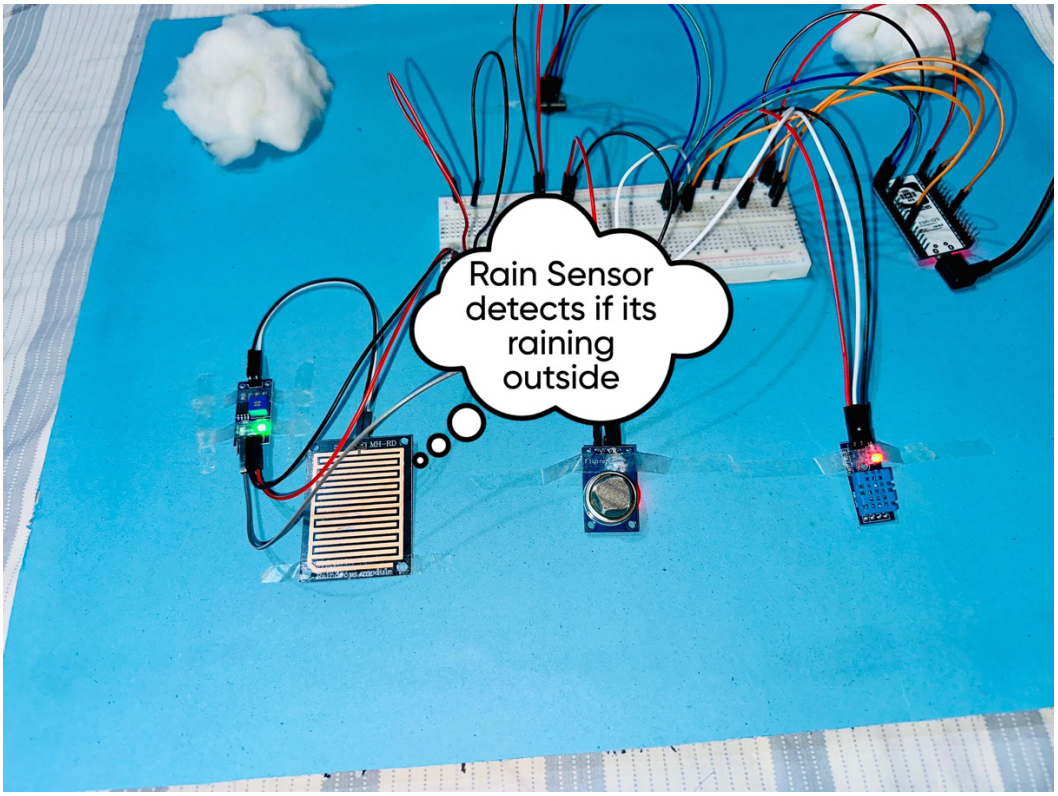
7. Screenshots



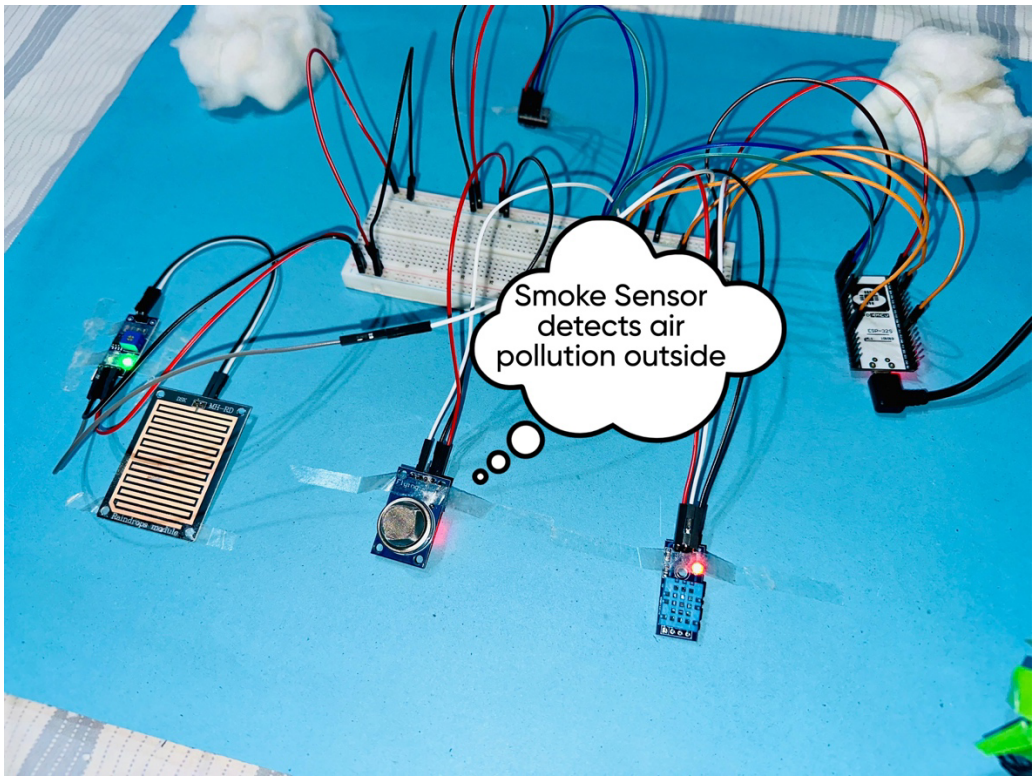
Project Prototype



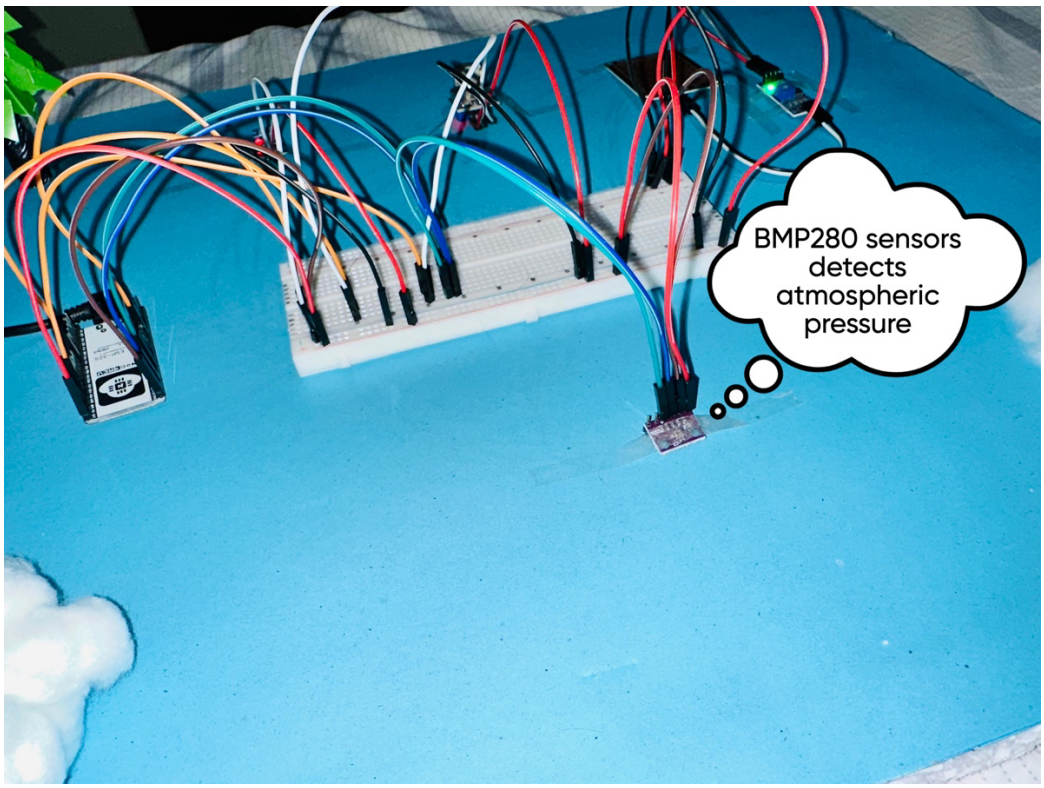
DHT Sensor detects temperature and humidity



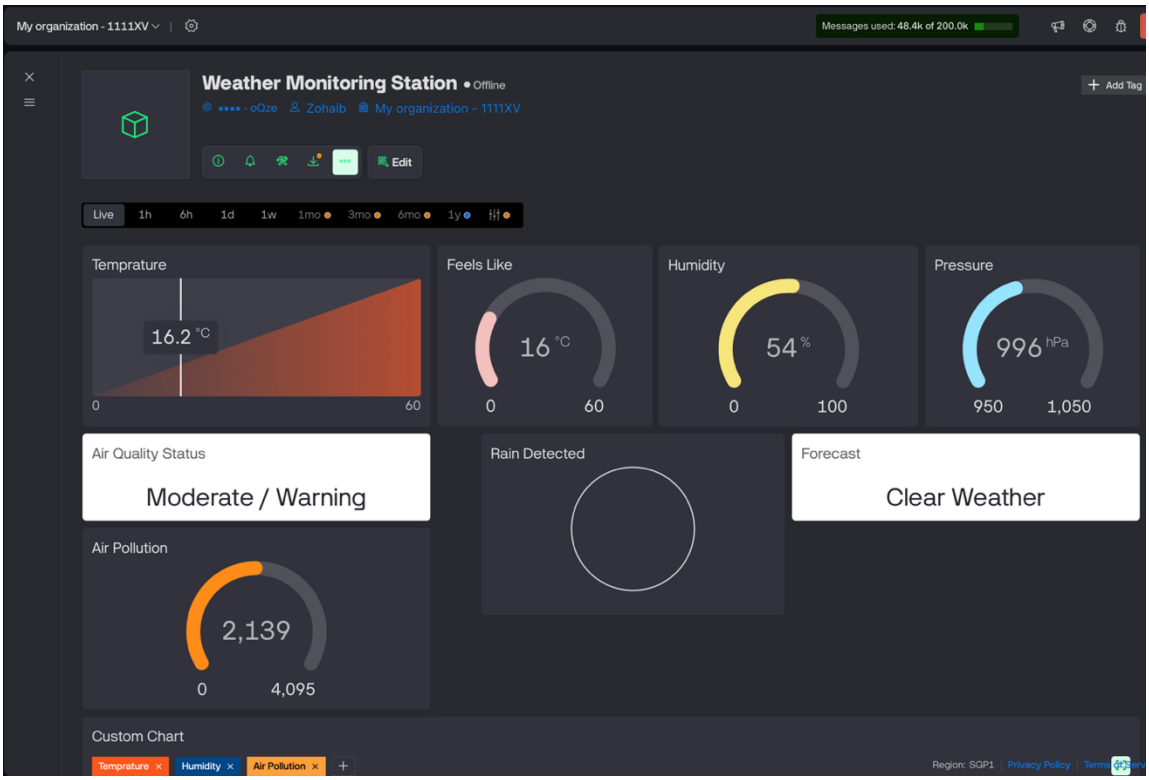
Rain sensor detects if it's raining outside



Smoke sensor detetcs air pollution outside



BMP 280 sensor measure atmospheric pressure



Blynk Cloud Dashboard

8. Result, Conclusion and Future Scope

A. Result

The system successfully **monitored** Temperature, Humidity, Pressure, Rain, and Air Quality in **real-time**. Data was **accurately** transmitted stably to the Blynk dashboard. The automated email alert system triggered correctly when critical environmental thresholds were exceeded.

B. Conclusion

This project successfully validated a **low-cost**, hybrid weather monitoring station. It combines immediate local feedback with remote IoT tracking and automated component-level alerts **(Email)**. The system proves effective for personal or agricultural safety monitoring, ensuring users are informed of **critical conditions** instantly.

C. Future Scope

- **Solar Power:** Implementing solar charging for off-grid autonomy.

- **Data Logging:** Adding SD card or cloud storage for historical trend analysis.
- **Sensor Upgrades:** Using higher-precision sensors (e.g., BME280) and adding wind monitoring.
- **Push Notifications:** Replacing emails with direct mobile app notifications for faster alerts.