# Low Cost Weather Analyzer using IoT Platform


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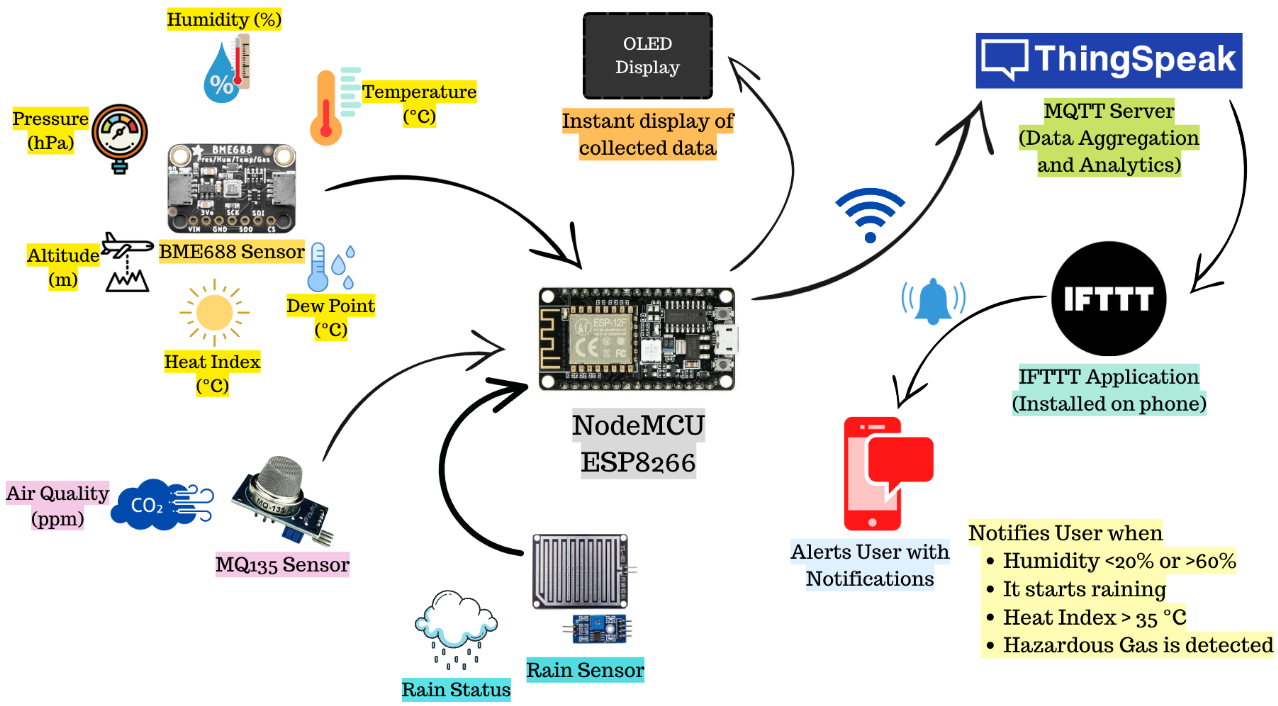
Graphical Abstract -





***Abstract*—This project uses open-source technologies to design and implement a low-cost IoT platform to track and record weather data in a residential area, including temperature, humidity, air pressure, and rain. Lung cancer, caused in around 1 in 10 people,[1] is brought on by outdoor air pollution [2] . Therefore, it is essential to constantly check the air quality in areas where older people and individuals with asthma reside. Viral transmission is facilitated by humidity levels greater [3] than 60%. Additionally, too little humidity might irritate the skin [4]. These days, heat strokes are also very common, so it's critical to keep an eye on a location's temperature and heat index. The Internet of Things (IoT)[5] device sends the data to a remote online server. In order to gather the data and log it into a database, a server application runs 24 x 7. If the heat index, humidity, or air quality crosses the threshold values, we receive a notification on our smartphones via the IFTTT application. It will also notify the user if it's raining outside. The entire system has been tested in real-time implementing IoT devices like the NodeMCU ESP 8266[6] with the appropriate sensors.**

## I. INTRODUCTION

The term "Internet of things" refers to tangible items with sensors, computing power, software, and other technologies that can connect to other systems and devices via the Internet or other communication networks and exchange data with them. In IoT Application ,NodeMCU ESP8266 collects sensors' data and sends it to the server database. Multiple sensors can be connected to one another to communicate real-time data. Using a straightforward user interface, you can easily keep an eye on them from anywhere. However, one may decide to deploy his own IoT platform using pre-existing technologies based on circumstances, such as privacy, security, and cost.

- **Motivation :** Using open-source platforms provides two significant advantages. First, open source is considerably less expensive than a proprietary solution[7]. In a commercial world, open source solutions are often far more affordable for equal or better capacity, and they also provide businesses with the flexibility to start small and scale. Exploring open-source alternatives makes good financial sense, considering businesses frequently face financial difficulties. Second, by utilizing open-source technology, the producer can ensure that none of the hardware or software contains any loopholes or back doors[8]. The low-level open-source codes for programmable IoT devices can be developed or improved upon by developers, increasing privacy and safety. The consumer product will become more accessible with high-volume production, which will benefit the manufacturer in terms of profit from higher sales.
- **Contribution :** Through this project, we explore how to deploy IoT devices to create a local weather analyzer that gives real-time measurements of temperature, humidity, pressure, altitude, heat index, dew point, air quality and rain status, stores and analyzes all the real-time data in cloud server and sends notification to the user smartphone in certain conditions.

In this project, the ThingSpeak[9] application has also been set up to display and store the incoming data from the IoT devices in a real-time dashboard, and the data can also be seen in an OLED display simultaneously.

## II. SYSTEM DESCRIPTION

The NodeMCU 8266 serves as the system's core controlling component and performs all three processing steps, i.e., receives sensor data, applies the calibration equation to the obtained sensor data and sends the data to a online server.

| Parameter | Sensor | Interface | Cost (rupees) |
|---|---|---|---|
| Temerature<br>Pressure<br>Humidity | BME688 | I2C | 800 |
| Rain | Rain sensor | Digital | 100 |
| Air Quality | MQ135 | Analog | 150 |

Having used the essential components and processing unit makes the system low-cost . The block diagram for the same is shown below in Fig. 1:

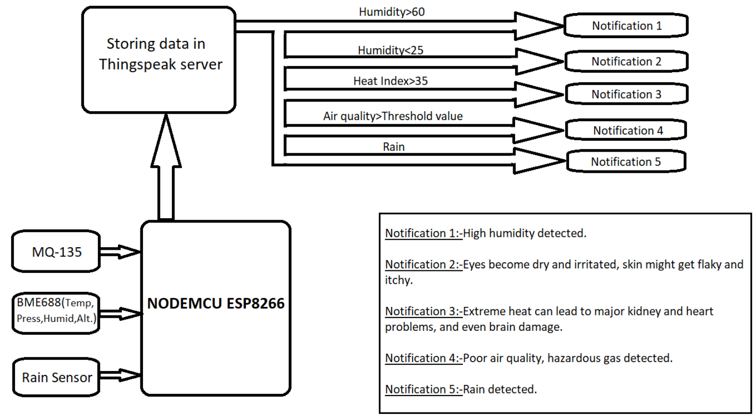



Fig. 1. Block Diagram

### A. BME 688 Sensor (Temperature + Humidity + Pressure)

The BME688 (produced by Bosch Sensortec) comes with high-accuracy humidity and temperature sensors. This sensor is connected to the ESP8266 in I2C connection. We get accurate temperature, humidity, pressure and altitude data from this sensor using AdafruitBME680 library in Arduino IDE.[10]

### B. MQ 135 sensor ( Gas sensor)

The sensing element is encased behind a steel exoskeleton that makes up the gas sensor module.Through connecting leads, current is applied to this sensing element. In this project, we are going to use an MQ-135 sensor to measure the air quality concentration in ppm(parts per million) and display it in the OLED.[11]

### C. Rain sensor

To check if it is raining, we use this module. The parallel resistance measured on the sensor board changes in value depending on how many water drops are present.[12]

### D. OLED display (128 x 64 )

In this project , we are using 0.96" I2C 128x64 OLED Display . We use this to display all the real time data.[13]

## III. Working Methodology

The steps in which our project works is described below :

- To start with, we create local variables - temperature, pressure, humidity, gasResistance, altitude, dewPoint, heatIndex, rain, airQuality.
- Then, the surrounding temperature (in °C), relative humidity (in %), pressure (in hPa), altitude (in m), and gas resistance (in K) is recorded with the help of the BME688 sensor, and the values are stored in the corresponding local variables.
- Now, using the current readings for temperature and relative humidity, the heat index (in °C) and dew point (in °C) are calculated using the below formulas and stored in the heatIndex and dewPoint variables respectively, and all the values above are now printed in the serial monitor.
  Formula of Heat Index[14]
  $HeatIndex(HI) = c_1 + c_2T + c_3R + c_4TR + c_5T2 + c_6R2 + c_7T2R + c_8TR^2 + c_9T^2R^2, \quad c_1 = -8.78469, c_2 = 1.6114, c_3 = 2.338, c_4 = -0.1461, c_5 = -1.231 * (10)^{-2}, c_6 = -1.6424 * (10)^{-2}, c_7 = 2.212 * (10)^{-3}, c_8 = 7.255 * (10)^{-4}, c_9 = -3.58 * (10)^{-6}$
  Formula of Dew Point [15]
  $x = (b * T)/(c + T) + log(RH * 0.01)$
  $DewPoint(DP) = (c * x)/(b - x), \quad b = 17.271, c = 237.7, T = temperatureRH = RelativeHumidity$
- A rain sensor is a device which is used to detect rainfall. If the digital value received from the D0 Port of NodeMCU ESP8266, is found to be high, then it confirms the rainfall and the variable is set to 1. Else it is set to zero.[16]
- In addition, an MQ135 sensor is used to get the air quality. In order to get an accurate ppm reading, the sensor needs to be calibrated. Therefore, in order to burn it in and stabilize it, it should be placed outside in adequate fresh air (preferably at 20°C  33% humidity), keeping it powered on for 12-24 hours. As a result, the air quality (in ppm) is recorded by using standard "MQ135.h" library functions and the obtained value is stored in the airQuality variable.
- Now, this stored data is sent to the Thingspeak server using the wifi client of ESP8266 and the data is stored in our Thingspeak server cloud. The live data can be observed and analyzed from the server. In addition to this, alerts are sent as notifications to mobile phone in the IFTTT app through Thingspeak server in case of
  - Humidity falls below 20% or crosses 60%
  - Starts Raining
  - Heat Index crosses 35 °C
  - Poor Air Quality and Hazardous gas detected.

  This helps User to take instant necessary actions and move the patients to a different place or a farmers can decide whether the place is good for a particular plant, or scientists can examine whether a new location is suitable for inhabitaion.
- The aforementioned variables' value is displayed in the OLED of our weather analyzer device. Four screens are being displayed at a delay of 3 seconds.

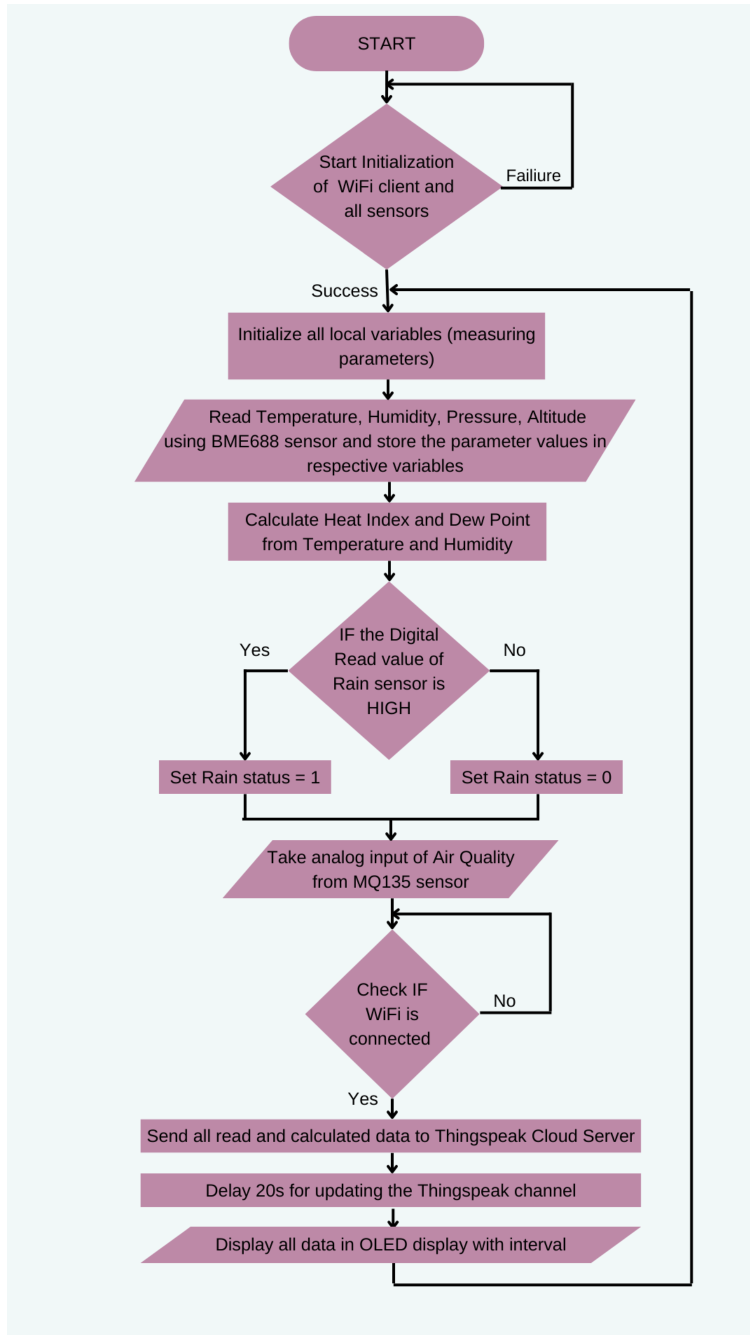



Fig. 2. Flowchart of working methodology

## IV. Electronic Connections

All electronic connections between ESP8266 and sensors are shown below -

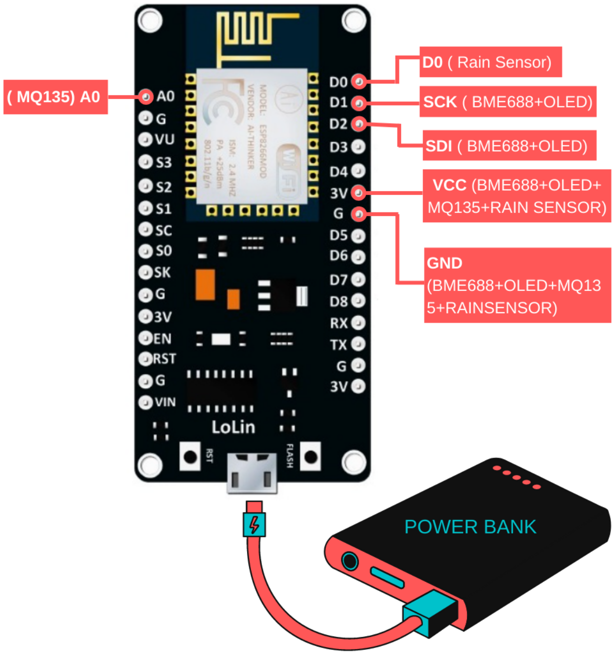
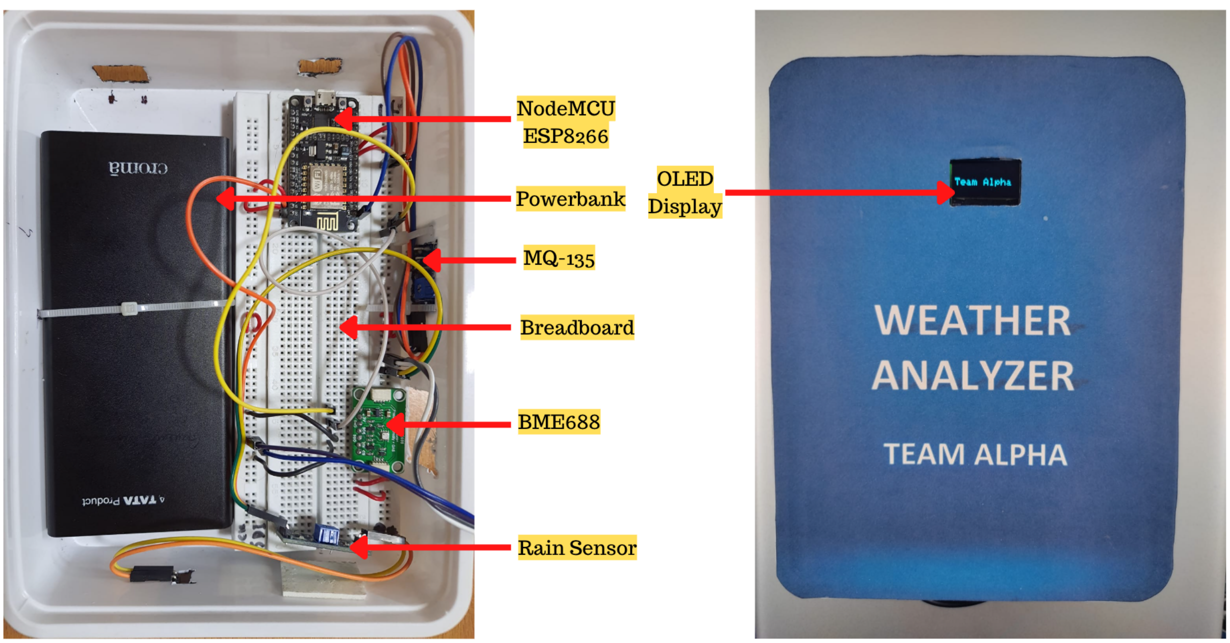



Fig. 3. Electronic circuit


Fig. 5. Temperature and Humidity in OLED display


Fig. 6. Air Quality and Rain in OLED display




Circuit Board of Weather Analyzer

Fig. 4. Image of our weather analyzer.

## V. Experimental Results and Discussions

### *A. Sample of Stored Data in Cloud*

| Date | Time | Temperature | Humidity | Pressure | Heat Index | Rain | Air Quality |
|---|---|---|---|---|---|---|---|
| 22-11-2022 | 12:32:02 | 26.8718 | 58.0355 | 1004 | 27 | NO | 25.82083 |
| 22-11-2022 | 12:32:40 | 26.97107 | 55.31606 | 1004 | 27 | NO | 11.6619 |
| 22-11-2022 | 12:33:18 | 27.07253 | 56.12502 | 1004 | 27 | NO | 29.16496 |
| 22-11-2022 | 12:33:56 | 27.12436 | 49.10882 | 1004 | 27 | NO | 38.11372 |
| 22-11-2022 | 12:34:35 | 27.12028 | 48.7098 | 1004 | 27 | NO | 35.38615 |
| 22-11-2022 | 12:35:13 | 27.08635 | 49.17145 | 1004 | 27 | NO | 29.16496 |
| 22-11-2022 | 12:35:51 | 27.02981 | 48.71661 | 1004 | 27 | NO | 35.38615 |
| 22-11-2022 | 12:36:29 | 26.95787 | 48.97702 | 1004 | 27 | NO | 28.01892 |
| 22-11-2022 | 12:37:08 | 26.87588 | 48.77044 | 1004 | 27 | NO | 28.01892 |
| 22-11-2022 | 12:37:46 | 26.78981 | 48.99841 | 1004 | 27 | NO | 28.01892 |
| 22-11-2022 | 12:38:24 | 26.71064 | 49.17841 | 1004 | 27 | NO | 28.01892 |
| 22-11-2022 | 12:39:03 | 26.63525 | 49.22397 | 1004 | 27 | NO | 26.90437 |
| 22-11-2022 | 12:39:41 | 26.56739 | 49.30734 | 1004 | 27 | NO | 26.90437 |
| 22-11-2022 | 12:40:23 | 26.49892 | 49.43365 | 1004 | 26 | NO | 25.82083 |
| 22-11-2022 | 12:42:15 | 26.35692 | 49.99979 | 1004 | 26 | NO | 25.82083 |
| 22-11-2022 | 12:42:53 | 26.33651 | 50.04028 | 1004 | 26 | NO | 25.82083 |
| 22-11-2022 | 12:43:31 | 26.32457 | 51.16376 | 1004 | 26 | NO | 23.74467 |
| 22-11-2022 | 12:44:10 | 26.31766 | 50.83453 | 1004 | 26 | NO | 30.34303 |
| 22-11-2022 | 12:44:58 | 26.31295 | 50.45675 | 1004 | 26 | NO | 30.34303 |
| 22-11-2022 | 12:45:27 | 26.30384 | 50.56677 | 1004 | 26 | NO | 30.34303 |
| 22-11-2022 | 12:46:05 | 26.2963 | 50.9122 | 1004 | 26 | NO | 30.34303 |
| 22-11-2022 | 12:46:43 | 26.2897 | 51.36388 | 1004 | 26 | NO | 30.34303 |
| 22-11-2022 | 12:47:21 | 26.28498 | 51.28878 | 1004 | 26 | NO | 30.34303 |
| 22-11-2022 | 12:47:59 | 26.27817 | 51.38013 | 1004 | 26 | NO | 18.20761 |
| 22-11-2022 | 12:48:38 | 26.27305 | 51.36788 | 1004 | 26 | NO | 22.75105 |
| 22-11-2022 | 12:49:16 | 26.26582 | 51.49731 | 1004 | 26 | NO | 22.75105 |
| 22-11-2022 | 12:49:54 | 26.25514 | 50.86964 | 1004 | 26 | NO | 22.75105 |
| 22-11-2022 | 12:50:33 | 26.24132 | 51.05981 | 1004 | 26 | NO | 22.75105 |
| 22-11-2022 | 12:51:11 | 26.22939 | 51.36831 | 1004 | 26 | NO | 22.75105 |
| 22-11-2022 | 12:52:26 | 26.21431 | 51.62716 | 1004 | 26 | NO | 30.34303 |
| 22-11-2022 | 12:53:04 | 26.20897 | 51.23533 | 1004 | 26 | NO | 22.75105 |
| 22-11-2022 | 12:53:42 | 26.203 | 50.94329 | 1004 | 26 | NO | 22.75105 |
| 22-11-2022 | 12:54:24 | 26.1942 | 50.63897 | 1004 | 26 | NO | 22.75105 |
| 22-11-2022 | 12:55:02 | 26.18321 | 50.8107 | 1004 | 26 | NO | 22.75105 |
| 22-11-2022 | 12:55:41 | 26.17504 | 51.08827 | 1004 | 26 | NO | 22.75105 |
| 22-11-2022 | 12:56:56 | 26.16467 | 50.74641 | 1004 | 26 | NO | 22.75105 |

### *B. Analysis of the data collected in an interval of 2 hours*

| Variables | Mean | Max | Min | Median | Standard Deviation | Variance |
|---|---|---|---|---|---|---|
| Temperature(in °C) | 26.416 | 27.434 | 26.046 | 26.279 | 0.332174 | 0.11034 |
| Humidity(in ) | 49.830 | 58.035 | 47.320 | 49.470 | 1.452708 | 2.11036 |
| Pressure (in hPa) | 1002.505 | 1004 | 1002 | 1002.0 | 0.60536 | 0.36646 |
| Heat Index(in °C) | 32.4636 | 35.2 | 31.79 | 32.21 | 0.6661 | 0.443774 |

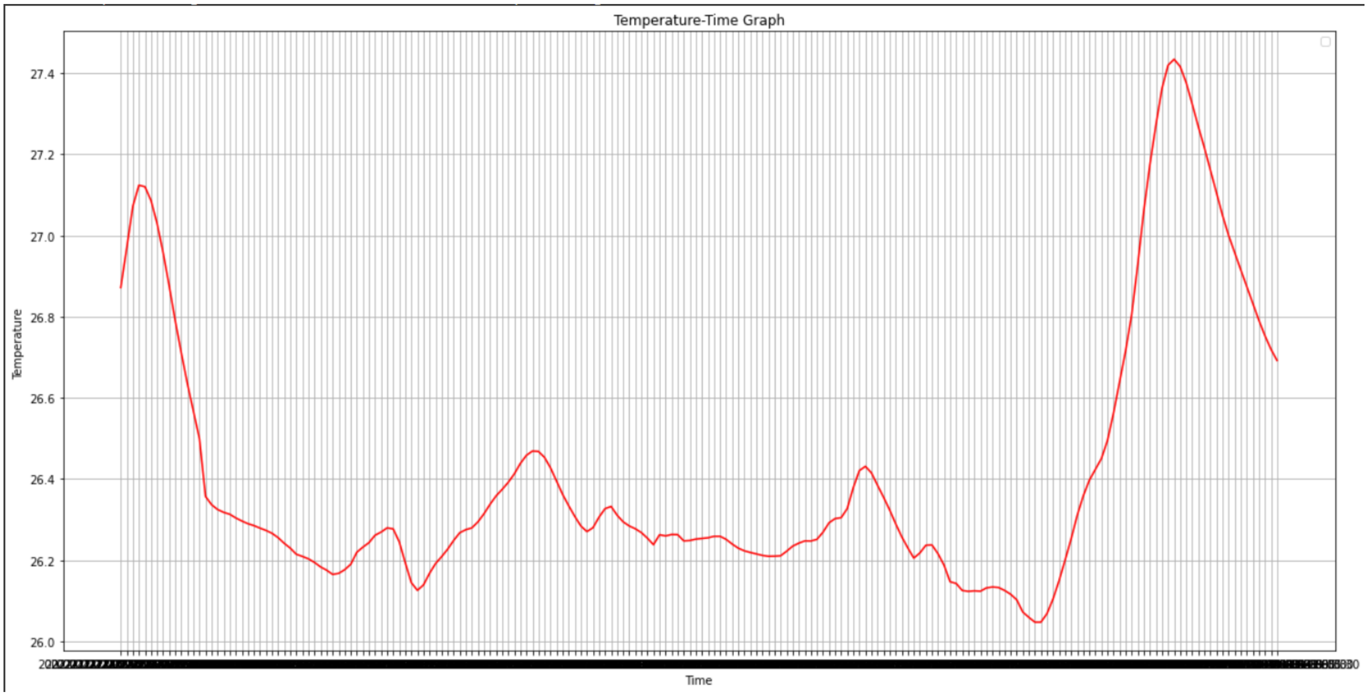



Fig. 7. Temperature-Time Graph

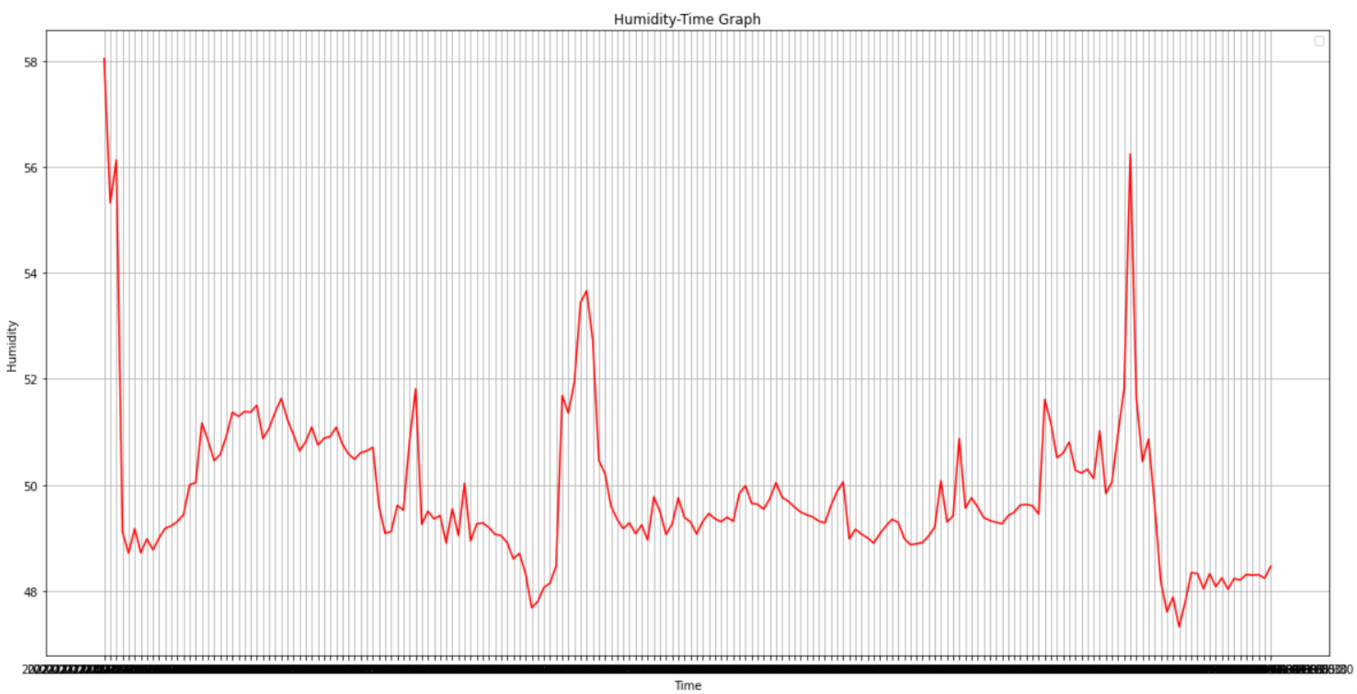



Fig. 8. Humidity-Time Graph


Fig. 9. Pressure-Time Graph

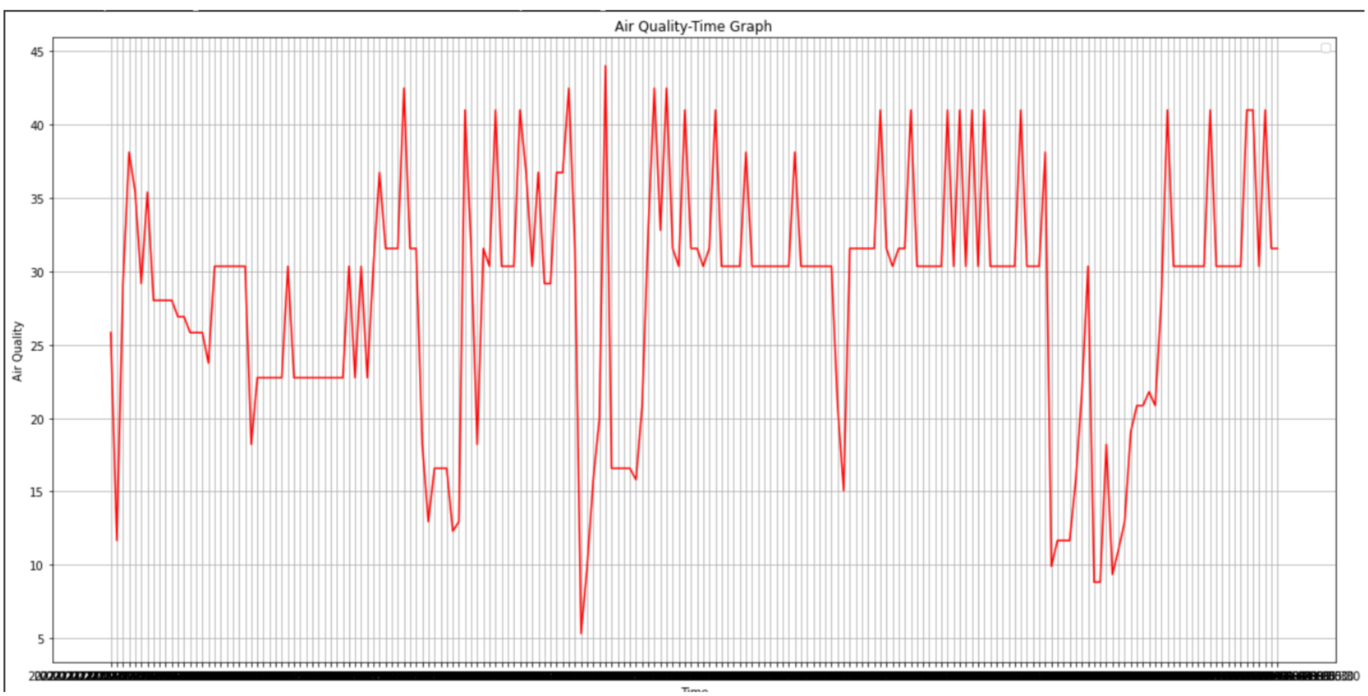



Fig. 10. Air Quality-Time Graph

## VI. Sample Notifications and Alerts


Fig. 11. Image of rain notification


Fig. 12. Image of Poor Air Quality notification

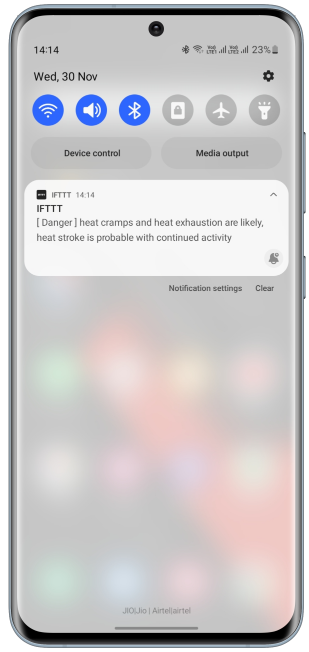



Fig. 13. Image of Heat Index notification

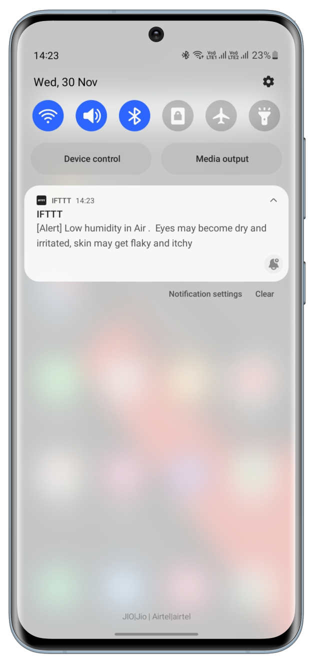



Fig. 14. Image of humidity notification

## VII. Conclusion and Future Scope

A weather analyser system was created that includes BME688 sensor, MQ135 sensor, OLED display and Rain sensor using embedded IoT devices.[17]The Message Queuing Telemetry Transport (MQTT) protocol was set up to operate the IoT server software "ThingSpeak" on a Virtual Private Server (VPS).[18]

The main feature of this hardware is that it will instantly notify you via the IFTTT application on your smart phone and alert you about the abnormal heat index, humidity, temperature, and rain, and the user can act accordingly.

The study can be expanded further by including machine learning in the suggested system, which should enable it to predict weather conditions in advance that may be valuable for the service sector, the industrial sector, or the agricultural sector to take precautionary measures. [19]

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