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Smart Weather Monitoring and Forecasting System Using Machine Learning (ML)

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Abstract

The Smart Weather Monitoring System & Forecasting using Machine Learning (ML) represents an innovative approach to modern weather prediction and monitoring. This system combines the capabilities of machine learning algorithms with vast sets of weather data to provide accurate and timely weather forecasts. By collecting and analyzing data points like temperature, humidity, light intensity, rainfall, and atmospheric pressure, the system can generate precise predictions for a wide range of applications. Whether it's aiding in agriculture, improving transportation safety, enhancing disaster management, or simply helping individuals plan their daily activities, this ML-driven weather monitoring system offers a data-driven solution for reliable weather information. This abstract outline the core principles and benefits of this advanced system, highlighting its importance in today's data-driven world.

Keywords: Digital technology, machine learning, weather, data pre-processing, humidity, rainfall, internet of things (IoT).

INTRODUCTION

In this paper, the system lets you check the weather online without relying on a weather agency. It uses temperature, humidity, and rainfall sensors to give real-time weather info. The magic happens through the Internet of Things (IoT) and Cloud technologies, connecting devices and making data accessible online. It's like having a mini weather station that constantly watches temperature, humidity, and rain at different places. All this data is sent to the cloud through Wi-Fi, so you can check the weather from anywhere. The system involves a bunch of gadgets like a microcontroller board, temperature/humidity sensor, light intensity sensor, pressure sensor, rain sensor, and a Wi-Fi module. This setup lets you keep tabs on weather conditions worldwide. Live updates are provided by the information being generated that is transferred to an online server. You can even set alerts for specific situations. Key components of the system include the NODEMCU microcontroller board, DHT-11 temperature, and humidity sensor, LDR light intensity sensor, BMP180 pressure sensor, LM393 rain sensor, and a WIFI module for data transmission. These components collectively enable the capture, organization, and display of weather-related information. The WIFI module serves as a vital link, facilitating the transfer of data from the sensors to the web server. In conclusion, this innovative weather monitoring and reporting

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system showcases the potential of the Internet of Things and Cloud technologies in transforming how we access and utilize weather information.

LITERATURE SURVEY

Yashaswi Rahut, et al used several sensors to monitor many aspects of the weather and climate, including temperature, humidity, wind speed, wetness, light intensity, UV radiation, and even airborne carbon monoxide levels [1]. The development of embedded systems has proved to be a reliable solution in monitoring and controlling the environment monitoring system [2]. The data is transmitted to the control room by the proposed system of Khetmalis, et al using the VAISALA weather transmitter sensor WXT520. The temperature, the relative humidity, the process of precipitation, the direction of the wind and speed, and air pressure are only a few of the numerous environmental variables it measures. GSM is used to send this real-time data wirelessly across great distances [3]. A solar power panel is used in the suggested setup of Raste et al. Rain, humidity, wind direction, and temperature are all monitored by their system. The GSM module will receive the sensed data, which will then be transferred to the personal computer via the gateway. The database is linked to a server [4]. Along with forecasting analysis, Vamsi Krishna proposed a weather prediction model based on the temporal and geographical correlations among the climatic variables [5]. According to recent studies, machine learning approaches outperformed conventional statistical methods in terms of performance. Artificial intelligence's machine learning field has shown to be a reliable technique for evaluating and forecasting a given amount of data. In the domains of agriculture, industry, and logistics, where the weather forecast is a crucial factor, the module is essential [6]. The majority of these devices employ basic analogue technology, which is subsequently physically recorded and kept in a database [7]. Ladi et al. developed their own weather reporting system that provided data on the current humidity, temperature, and other variables. We could put this up in our house and receive periodic weather updates, which would make it easier for us to schedule our everyday tasks [8]. The system of Prasanna et al. was developed using the Internet of Things (IoT), a cutting-edge and effective way to connect sensors to the cloud that can store real-time sensor data and link everything in the world to a network [9].

BLOCK DIAGRAM

Figure 1 shows a block diagram of the Smart Weather Monitoring system**.** The Proposed system uses a NODEMCU Wi-Fi-based module to control and operate the system. The other components of the

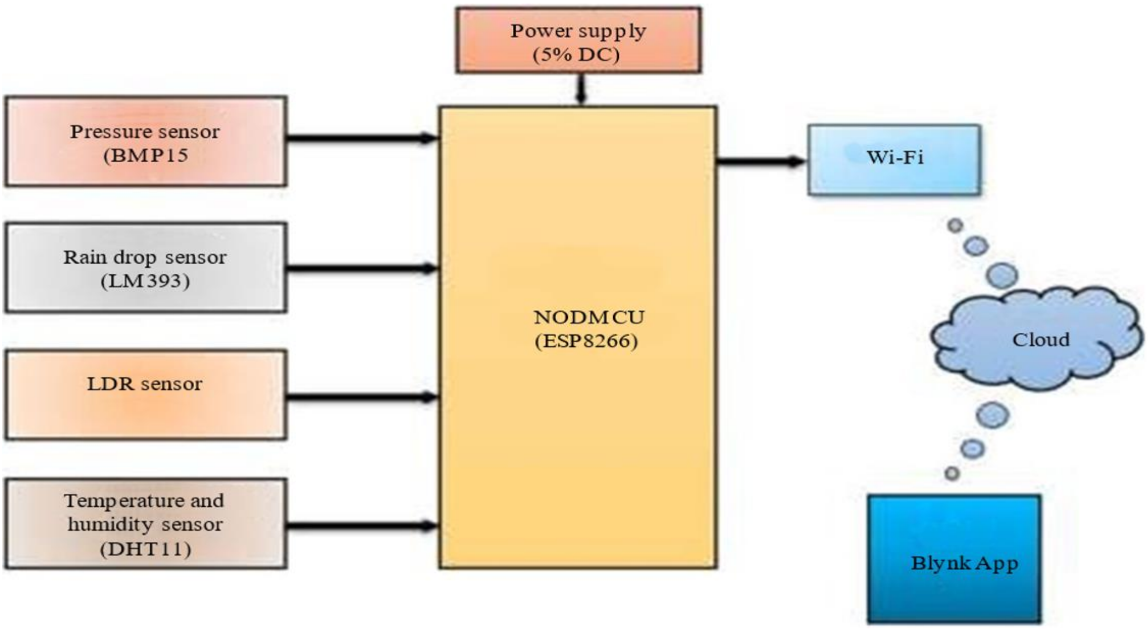

Figure 1. Block diagram of smart weather monitoring system.

system is the Temperature and Humidity sensor (DHT11), Rain Drop sensor (LM393), LDR sensor, Pressure sensor (BMP180), Blynk App (Console), and 5v DC power supply. The controller is an ESP8266 microcontroller board Vin pin is connected to a 5v DC power supply for the operation of the system. Other Components of a system like a Temperature and Humidity sensor are connected to digital pin D3 of the controller board and the VCC and GND of the DHT11 sensor are connected to the 3.3v and GND pin of the Board which gives the digital value of temperature and humidity presence in the environment to the board. The LDR sensor is connected to the controller's digital pin D0 and VCC, the Data pin is connected to 3.3v and the GND pin of the board this sensor gives light intensity present in the environment. The Rain sensor is connected to the board through analog pin A0, and other pins of the sensor are connected to boards 3.3v and GND pin. This sensor gives information about rainfall [9–11]. The BMP180 pressure sensor is connected through SCL and SDL pins to boards digital pins D1 and D2. This sensor gives atmospheric pressure strength. The whole system result is displayed on the Blynk app. It is an IoT-based cloud platform that is connected to the board through Wi-Fi. With the help of this IoT platform the system predicts and forecasts outputs for the user [12–13].

METHODOLOGY

The methodology for the Smart Weather Monitoring System & Forecasting using Machine Learning involves collecting extensive weather data, preprocessing it for analysis, selecting suitable machine learning algorithms, and training models with historical data. With real-time data integrating, the system can deliver precise and current weather forecasts. Over time, the model's predictions can be continuously improved by means of adaptive learning methods [14]. A user-friendly interface is developed for easy access to forecasts, and the system is deployed with a focus on ongoing maintenance and updates to ensure its reliability and effectiveness in providing precise weather information.

NODEMCU Board

As seen in Figure 2, the ESP8266 Wi-Fi Module is a self-contained SOC that can connect any microcontroller to the internet via Wi-Fi. It is enclosed with a standardized TCP/IP protocol stack. An application can either host itself on the ESP8266 or assign all Wi-Fi networking functions to a different application processor. Pre-programmed AT command set software is included with every ESP8266 module.

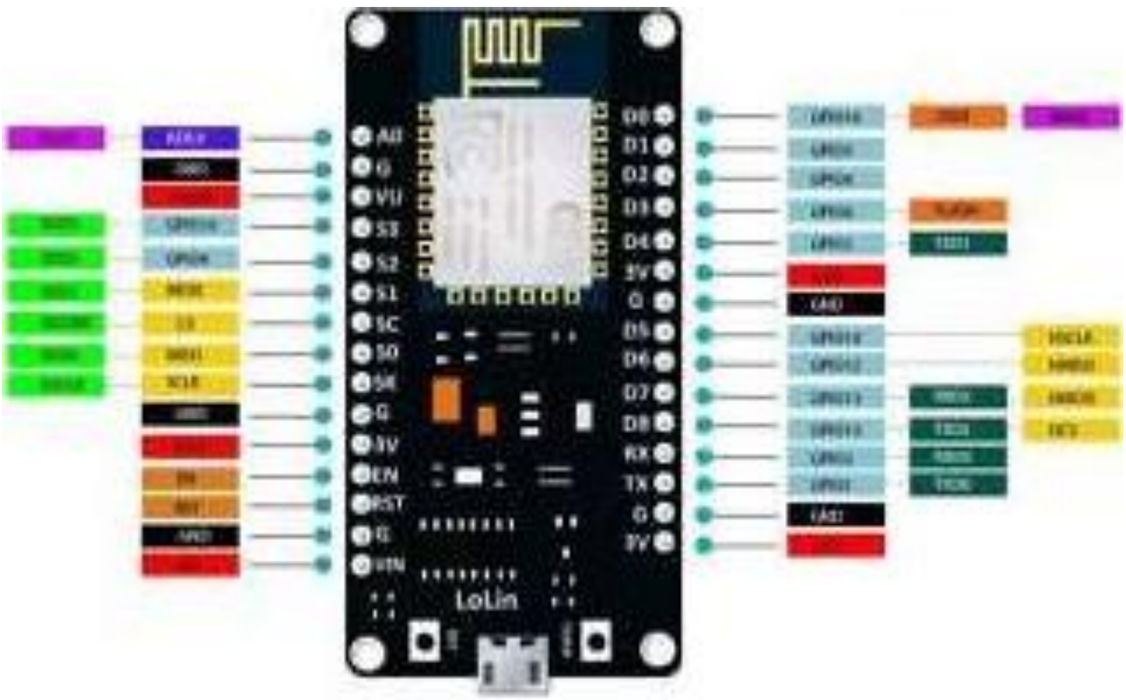

Figure 2. NODEMCU board.

Temperature & Humidity Sensor (DHT11)

Figure 3 shows the DHT-11 Digital Temperature and Humidity Sensor. A simple, incredibly affordable digital temperature and humidity sensor [15]. It uses a capacitive humidity sensor and thermistor to determine the air quality before sending a digital signal on the data pin (analogue input pins are not needed).

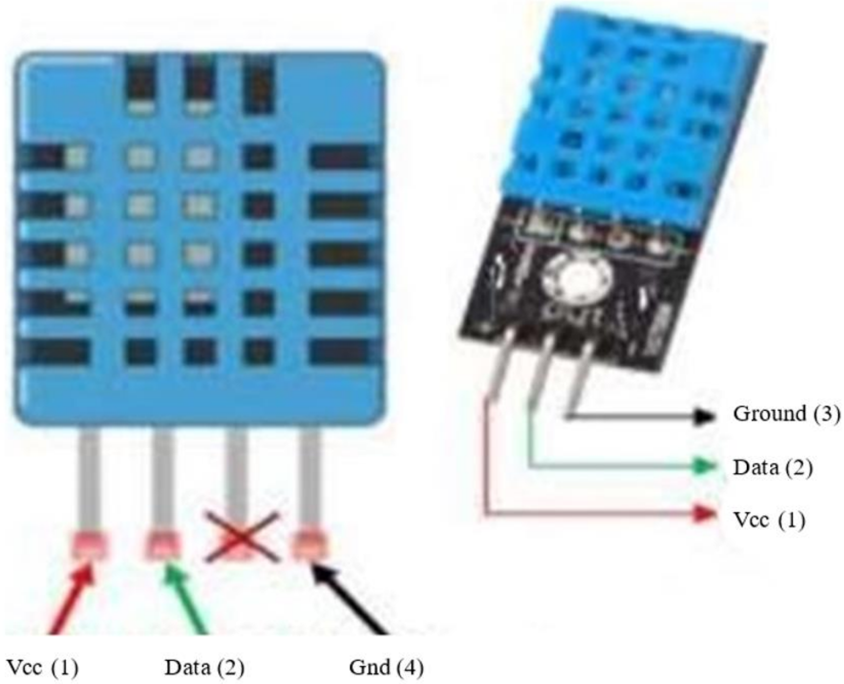

Figure 3. DHT11 Sensor.

LM393 Sensor

Figure 4 shows the LM393 rain sensor is one type of switching device that is used to identify rainfall. This sensor functions similarly to a switch, with the idea being that when it rains, the switch will generally be closed.

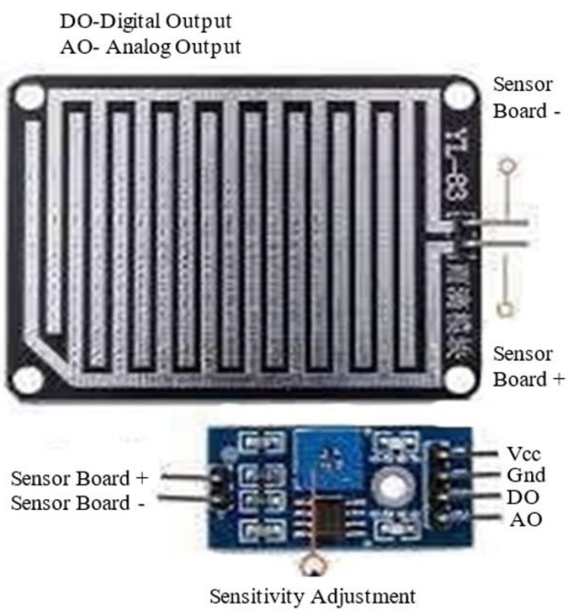

Figure 4. LM393 Sensor.

LDR Sensor

Figure 5 shows LDR (Light Dependent Resistor) sensor can be a useful component in a weather station system for measuring light levels, which can be relevant for several weather-related applications.

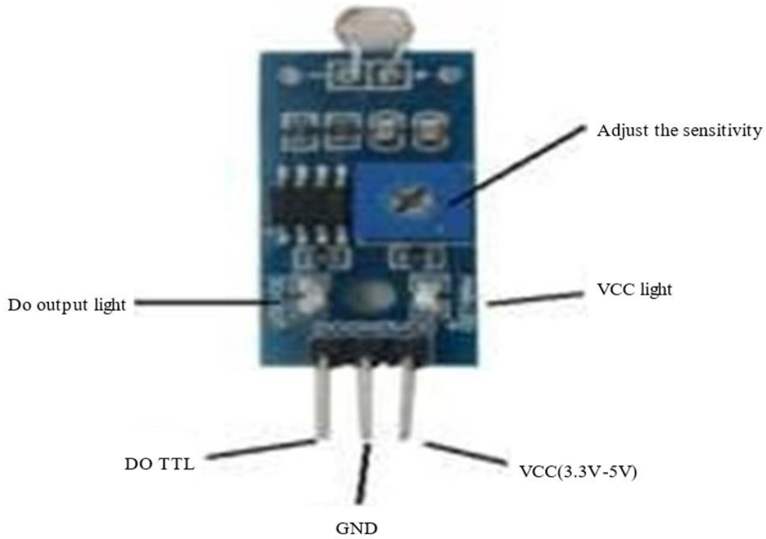

Figure 5. LDR Sensor.

Pressure Sensor (BMP180)

As seen in Figure 6 one of the sensors of the BMP XXX series is the BMP180. All of them are made to measure atmospheric or barometric pressure. A high-precision sensor designed for consumer items is the BMP180. Barometric pressure refers only to the weight of air applied to all objects. Everywhere there is air, there is pressure because air has weight. The BMP180 sensor detects that pressure and outputs the data digitally. Also requires temperature-compensated pressure readings because temperature has an impact on pressure. The BM180 comprises a high-quality temperature sensor as a balancing feature.

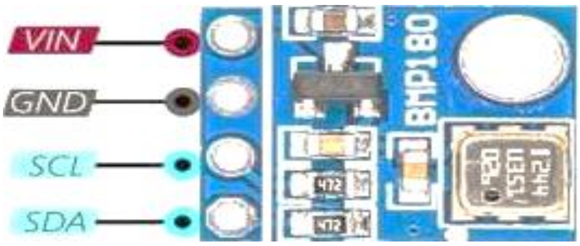

Figure 6. BMP180.

Power Supply

Figure 7 shows a 5v DC power supply to run the hardware system. The power supply gives input to the NODEMCU controller.

Figure 7. Power supply.

Jumper Wires

Figure 8 shows wires used for connecting all the components. It is used for wiring all the hardware components in this project.

Figure 8. Jumper wires.

EXPERIMENTATION

Flow Diagram

Figure 9 displays a system flowchart that demonstrates the operation of our proposed system. The intended system is designed to monitor the weather. This system just has three sensors, and it shows the outcome on the webpage.

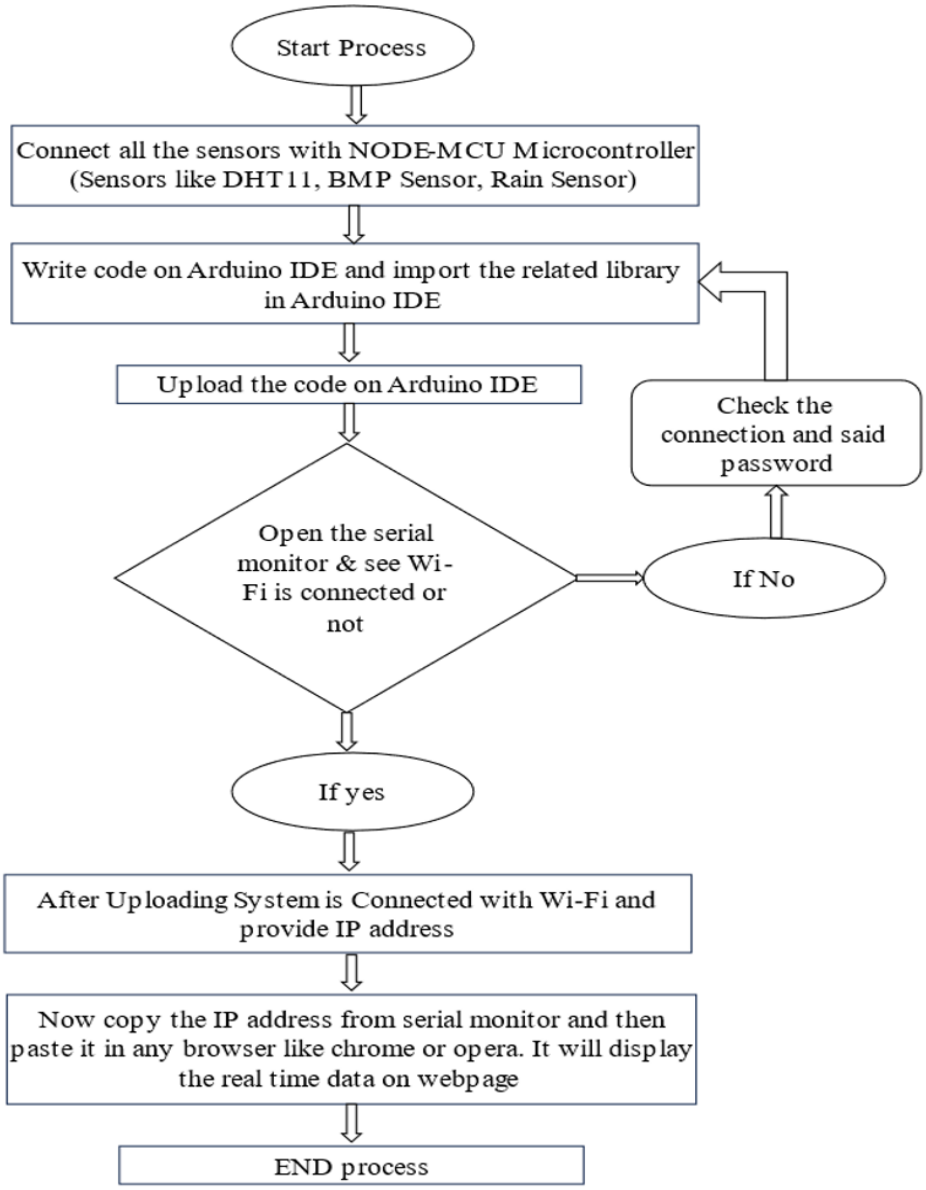

Figure 9. Flow chart.

Hardware Model

Figure 10 shows the hardware model of the project, which connects sensors to the Node MCU. In Figure 10, the system component diagram is displayed. The Node MCU is linked to the following sensors: pressure, rain, gas, temperature, and humidity. The client and the device are in a Wi-Fi connection. Temperature and Humidity (DHT11) sensors assess the percentage of moisture in the air compared to the maximum amount that can be held at the current temperature. The relative humidity varies with temperature because hotter air retains more moisture. CO_2 concentrations in the adjacent air are determined using the MQ135 gas sensor. The Rain sensor (FC-37) is used for identifying water above what a humidity sensor can.

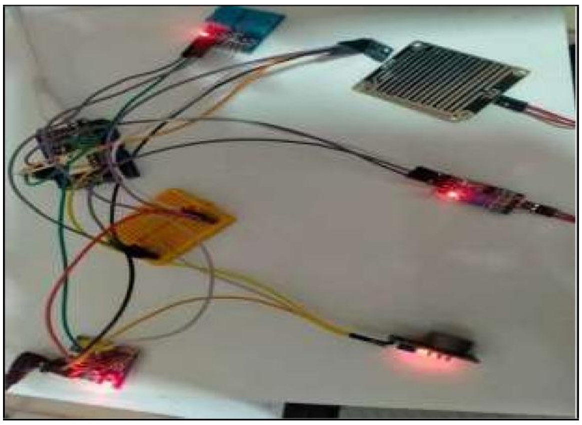

Figure 10. Hardware model.

RESULT AND DISCUSSION

To evaluate our proposed system, we have carried out a few experimental tests to assess our suggested system. Therefore, we checked each parameter independently after building the application code source and downloading it to the Node MCU board.

Humidity and Temperature Sensor Results

The humidity sensor findings are shown in Figure 11. The DHT11 sensor is the one utilized in the system to sense temperature and humidity. We carried out this simple test to keep an eye on the humidity in a particular zone: Once we positioned the DHT11 sensor in an exceptionally humid area, we observed that the system started to record different humidity levels. Figure 11 presents a graphic representation of the received values. The results of the investigation are considered proof that the sensor responds to humidity levels. It serves as additional evidence of the efficacy of our remote humidity monitoring system.

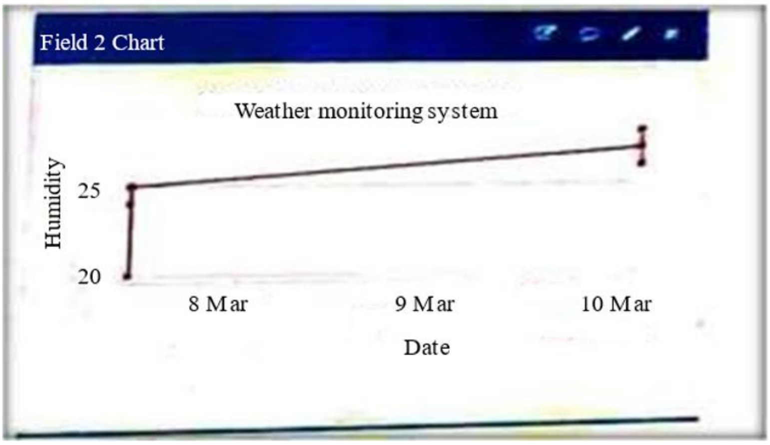

Figure 11. Humidity Results.

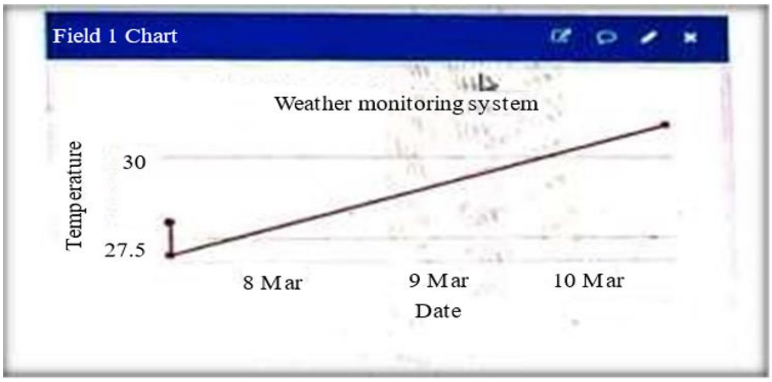

Figure 12. Temperature results.

We conducted a second quick test using the system to record the temperature readings. We adjusted the air temperature with a tiny flame during this inspection. The DHT11 sensor was then placed close to the flame to detect temperature changes in the air. The temperature measurement that was acquired is displayed as a graph in Figure 12. The temperature was raised from its initial value of roughly 32 _C to over 38 _C. This modification validates the system's capacity to detect different temperature values.

Rain Sensor Results

Figure 13 shows the result of the rain sensor tested in recent atmospheric conditions. The results show the presence of rainfall in the atmosphere is less than 1%.

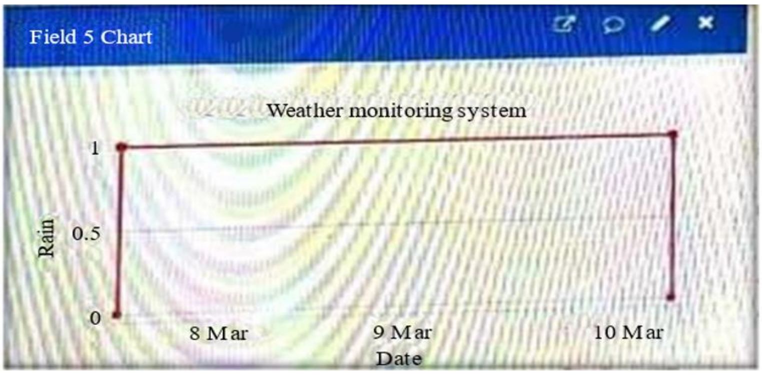

Figure 13. Rain sensor results.

Pressure Sensor Results

Figure 14 shows the result of the Pressure sensor tested in recent atmospheric conditions. The results show the presence of Pressure in the air.

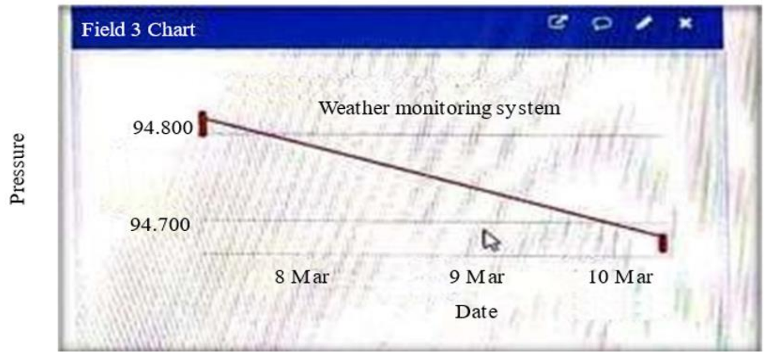

Figure 14. Pressure sensor results.

CONCLUSION

Systems for predicting and monitoring the weather are essential resources that have a big influence on our day-to-day activities. They provide essential information for agriculture, aviation, safety, and various other sectors. These systems help us make informed decisions and mitigate the effects of weather-related challenges. Their ongoing improvement ensures we can better prepare for and respond to changing weather conditions, enhancing our overall well-being and safety.

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