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Development of Low-Cost Weather Station

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Abstract: *Floods are among the most devastating natural disasters, leading to significant loss of life, property damage, and disruption of daily life. The unpredictability of flood events makes real-time monitoring and early warning systems crucial for minimizing their impact. This project presents the design and development of an IoT-based flood monitoring system using the ESP8266 NodeMCU microcontroller integrated with the Blynk IoT cloud platform. The system aims to continuously monitor key environmental parameters such as river water level, rainfall intensity, and temperature and humidity to detect early signs of potential flooding. An ultrasonic sensor is employed to measure the water level of a river or water body, while a rain sensor detects precipitation. A DHT11 sensor provides real-time data on ambient temperature and humidity, contributing to a comprehensive understanding of the surrounding environmental conditions. The ESP8266 controller processes the data from all connected sensors and sends it to the Blynk IoT mobile application, where users can view live readings from remote locations. Alerts can be sent to the users' smartphones if critical thresholds are exceeded, allowing timely action. This system is designed to be low-cost, scalable, and energy-efficient, making it ideal for rural and urban deployments alike. Its real-time functionality and remote accessibility enhance the readiness and responsiveness of flood management authorities and communities. Additionally, the cloud connectivity ensures historical data logging, which can be valuable for analysis and future prediction models. By leveraging the Internet of Things, this project provides a proactive approach to disaster management, aiming to save lives, protect infrastructure, and promote environmental resilience.*

Keywords: IoT, ESP8266, Flood Monitoring, Ultrasonic Sensor, Blynk IoT, Rain Sensor, DHT11, Real-time Monitoring, Early Warning System, Environmental Monitoring

I. INTRODUCTION

Floods are one of the most frequent and destructive natural disasters globally, often resulting in severe damage to infrastructure, displacement of populations, and significant economic losses. As climate change accelerates, the intensity and unpredictability of rainfall patterns and water levels in rivers and reservoirs have increased, making traditional flood prediction and monitoring systems insufficient for early response and disaster preparedness. In this context, Internet of Things (IoT) technology offers a modern and intelligent solution to enhance flood monitoring and early warning systems. IoT enables the real-time collection, transmission, and analysis of environmental data using smart sensors and cloud platforms. By integrating sensors with microcontrollers and wireless connectivity, real-time environmental conditions such as water level, rainfall, temperature, and humidity can be monitored remotely, allowing for quicker response and mitigation actions. This project introduces a low-cost, scalable IoT-based flood monitoring system using the ESP8266 NodeMCU, a Wi-Fi-enabled microcontroller, along with various sensors including an ultrasonic sensor for water level detection, a rain sensor for precipitation monitoring, and a DHT11 sensor for temperature and humidity tracking. The data collected is transmitted via Wi-Fi to the Blynk IoT cloud platform, where it can be accessed through a mobile application. The primary goal of this system is to assist authorities and communities in making informed decisions by providing real-time alerts and visual data dashboards. The portability, affordability, and cloud integration of this system make it highly suitable for deployment in both urban and rural flood-prone areas. Through the effective use of IoT, this system aims to reduce the risks associated with floods, protect lives and property, and support the development of smarter and more resilient communities.

II. LITERATURE SURVEY

The increasing need for accurate and accessible weather data has driven the development of innovative weather monitoring systems, particularly in remote and rural areas. Traditional weather stations, often reliant on wired connections, present challenges in installation, maintenance, and real-time data transmission. The integration of Internet of Things (IoT) technology offers a promising solution to these challenges by enabling wireless data collection and transmission**.**

The challenge of obtaining real-time weather data is compounded by the labor-intensive installation and maintenance of wired sensors, necessitating frequent adjustments. To counter this, this study introduces a portable weather data collection station tailored for efficient data collection in rural settings. Using advanced wireless technologies, the station instantly transmits data to predetermined destinations or securely stores it on an online server, eliminating the limitations of wired connections. The project employs the DHT_11 and BMP_180 sensors for precise temperature, humidity, and pressure measurements. The NodeMCU V3 seamlessly transmits the collected data over Wi-Fi to a Google Sheet, ensuring secure data storage. Integration of the MQTT protocol enables efficient communication between the NodeMCU V3 and the designated server, ensuring reliable data transmission. Moreover, the system integrates Google Maps for location tracking and utilizes MATLAB for comprehensive data analysis, enhancing its capabilities for indepth weather monitoring. This portable weather data collection station streamlines the acquisition of real-time weather information and offers a sustainable solution for monitoring weather conditions, especially in remote regions. By integrating cutting-edge wireless technologies and advanced data management tools, the system meets the escalating demand for accessible and comprehensive weather data, addressing the limitations of traditional wired weather monitoring systems.[1]

The system that Snehashish Mandal and Ravi Kishore Kodali proposed is intended to measure temperature, humidity, pressure, and light intensity. We are able to compute additional data factors, including the dew point, by using temperature and humidity. Apart from the aforementioned features, we have the ability to keep an eye on the location's light intensity. We have also made it possible to keep an eye on the room's air pressure. Moreover, we can keep an eye on the rain value. The Nodemcu (12E) Wi-fi module, based on the ESP8266, is the brains of the prototype. The NodeMCU is connected to four sensors: a light dependent resistor (LDR), a pressure sensor (BMP180), a raindrop module, and a temperature and humidity sensor (DHT11). [2]

According to the system designed by Chen Jianyun and Sun Yunfan a method of data acquisition and transmission based on NBiot communication mode is proposed, Introduction of Internet of things technology, Sensor digital and independent power supply as the technical basis, In the construction of Automatic To realize the intelligent interconnection of the automatic weather station, and then to form an automatic weather station based on the Internet of things. [3]

Weather forecast these days is unpredictable too be exact because of the climate changes drastically over weather. In cause of that, Weather Reporting System is mostly used to monitor the continuously changing climatic and weather conditions over controlled areas likes house, industry, agriculture and etc. in real time monitoring. Internet of Things (IoT) platform use is Thing Speak it's should be able displaying the weather parameters and the information will visible wherever in the world and it's also displaying on the OLED with two-way microcontroller communication via Wi-Fi hotspots. The condition of some particular place that be reported by satellite weather report system does not give the exact condition. However, the problem occurs when needed the accurate weather report for current time. With weather reporting system all weather parameters sensor will be controlled by ESP32 microcontroller as the server that will send all the data collected by sensors to the database by Thing Speak and will visible anywhere in the world and also display on OLED that use Wemos D1 mini as its microcontroller and a client. This data then will be compared with the weather forecast data and statistics made by forecast station. All data collected will be also saved in google sheet format by IFTT tool for easier to analyses the data. This system will monitor the changes of weather condition happening over the environment and then provides the users fastest way to access the information from anywhere. [4]

This research is based on the need to have a measurement tool to carry out different studies that require meteorological information in high mountain areas, therefore, a low-cost weather station based on open source is designed and implemented. The design process considered the inclusion of the directives of the World Meteorological Organization

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and the place of installation. Then we continued with the assembly and installations in conjunction with a Campbell Scientific station (3800 m) and a HOBO station (5000 m), in order to compare their records. The Arduino Mega 2560 controller used as a datalogger responded adequately, the data captured when compared are very similar to those of the stations. The average difference between the low-cost station and the other two is in temperature 0.193 °C, humidity 1.3% RH, atmospheric pressure 0.14 mbar, solar radiation 5.8%, soil temperature 0.127 °C, wind speed 0.485 m/s and wind direction 1.33°. The cost benefit is 4 to 18 times compared to purchasing a commercial station and certified instrumentation.[5]

Monitoring respectively. While the error of air pressure and PWV were 0.092% and Precipitable water vapor 2.61%, respectively. The PWV value is higher when the sun is very active or during a thunderstorm. The developed weather system is also capable of measuring altitude on pressure measurements and automatically stores daily data. With a total cost below 50 dollars, all major and support systems developed are fully functional and stable for long-term measurements.[6]

These works underline that IoT-based flood systems are feasible, reliable, and essential in modern disaster management. They also highlight the increasing preference for using cloud platforms like Blynk, Thingspeak, and Firebase for real-time data visualization.

III. METHODOLOGY

This project introduces an Internet of Things (IoT)-based environmental monitoring system that uses a variety of sensors to gather and send real-time environmental data using the NodeMCU ESP8266 microcontroller. The system is made to keep an eye on important environmental factors like humidity, gas concentration, rainfall intensity, and distance (for detecting water levels). The central controller is the NodeMCU ESP8266, which has integrated Wi-Fi capabilities. Four essential sensors are interfaced with it: a humidity sensor, a MQ6 gas sensor, an ultrasonic sensor, and a rainfall sensor. When tracking rising water levels in flood-prone locations, the ultrasonic sensor's ability to calculate distance to a surface is especially helpful. The rainfall sensor provides early warning of shifting weather conditions by detecting the amount and intensity of precipitation. The MQ6 gas sensor's ability to identify dangerous gases including methane, propane, and LPG is crucial for safety and air quality monitoring. The measurement of air humidity, which is essential for climate analysis and weather forecasting, is done by the humidity sensor (such the DHT11 or DHT22). Every sensor is linked to the NodeMCU input pins. To guarantee steady functioning, the NodeMCU is powered by a controlled power source. The NodeMCU Wi-Fi module processes and sends the gathered sensor data to the Blynk Cloud platform. The Blynk mobile application improves accessibility and user engagement by enabling users to remotely check real-time data on their smartphones. This method is appropriate for use in smart agriculture, flood detection, pollution monitoring, and general environmental awareness since it guarantees ongoing, economical, and energy-efficient environmental condition monitoring. Scalable deployment across several geographic areas is made possible by the incorporation of cloud connection.

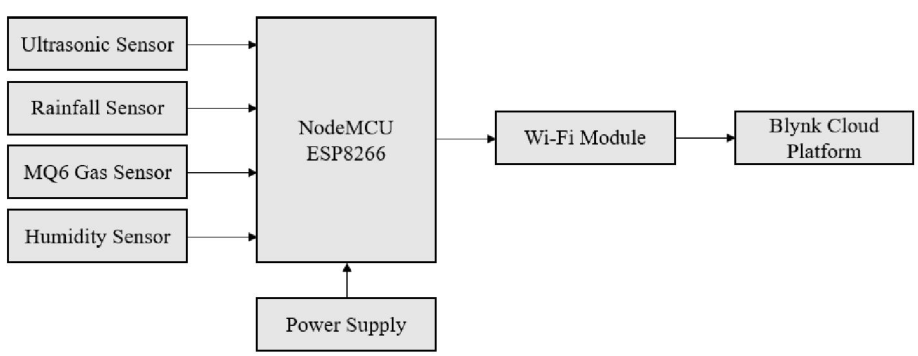

Fig. 1. Block Diagram of development of low-cost weather station

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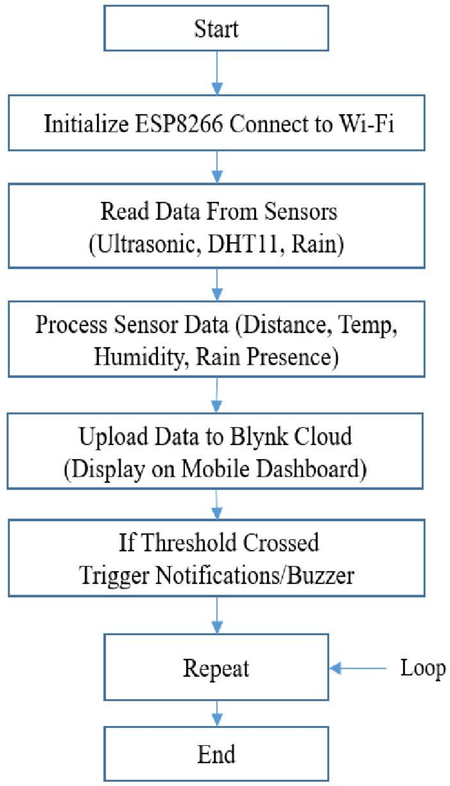

Fig. 1. Flow chart of proposed module

IV. RESULTS

The IoT-based Weather Monitoring System demonstrated reliable performance in monitoring key environmental parameters including temperature, humidity, rainfall, gas concentration, and water level. Real-time data was collected using sensors such as DHT11, MQ6, Rain Sensor, and Ultrasonic Sensor, all interfaced with NodeMCU ESP8266. The system transmitted sensor readings to the Blynk Cloud platform with a real-time response time of under 2 seconds and a transmission success rate of approximately 98% under stable Wi-Fi conditions. Temperature and humidity readings showed accuracy within ±2% when compared to standard meteorological instruments, while the MQ6 gas sensor reliably detected LPG and methane levels, contributing to enhanced environmental safety. Mobile alerts and dashboard visualizations through the Blynk app allowed users to monitor and receive notifications when thresholds were exceeded. These features proved useful in applications such as agriculture, disaster preparedness, and smart city development. The rainfall sensor efficiently detected precipitation levels, and the ultrasonic sensor accurately monitored water levels, though slight variations occurred under turbulent conditions. Power consumption tests confirmed that the system operates efficiently, suitable for deployment in low-power or solar-powered environments. Simulations in Proteus validated the hardware integration, while MATLAB-based data analysis confirmed the consistency and reliability of sensor readings under varying environmental conditions. Discussions highlighted the need for periodic calibration of sensors, particularly the MQ6, to maintain accuracy. The modular design enables future enhancements, including integration of AI for predictive weather modelling and the use of alternative communication protocols for rural deployment. Overall, the system proves to be a cost-effective, scalable, and practical solution for real-time environmental monitoring with significant potential in various sectors.

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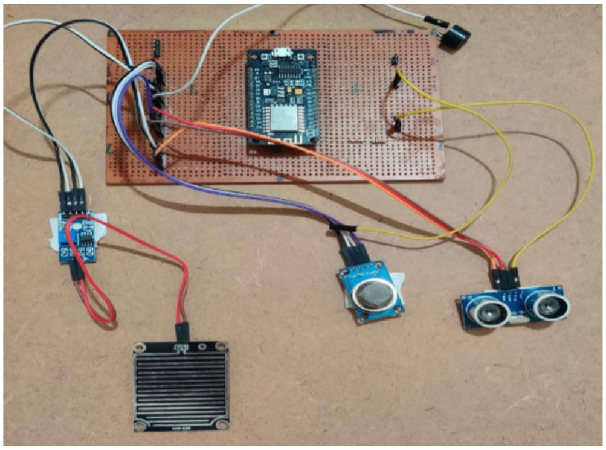

Fig. 1. Arrangement of Components on circuit board

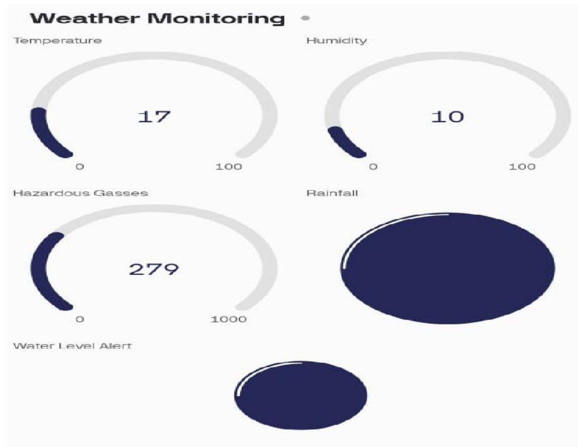

Fig. 1. Output on mobile Interface in Blynk IOT

V. CONCLUSION

Based on the experimental outcomes and simulation results, the IoT-based Weather Monitoring System has proven to be a reliable, accurate, and responsive solution for real-time environmental data collection. The system successfully measured temperature and humidity with ±2% accuracy, detected rainfall intensity effectively, and identified harmful gas levels using the MQ6 sensor. The ultrasonic sensor consistently measured water levels, with minor deviations only in turbulent conditions. Real-time data was transmitted to the Blynk cloud platform with a response time of less than 2 seconds and a data success rate of approximately 98%.Mobile alerts were triggered instantly upon threshold breaches, providing users with timely updates for effective decision-making. The system's low power consumption and stable operation confirmed its suitability for continuous, long-term deployment—even in remote areas with solar or battery power. Proteus simulations validated circuit functionality, while MATLAB-based analysis confirmed the accuracy and robustness of sensor outputs under different environmental conditions.

Overall, the results confirm that the system meets its objectives in terms of precision, energy efficiency, and practical usability. It is well-suited for applications in agriculture, flood monitoring, pollution control, and smart city infrastructure. These outcomes strongly support the feasibility of deploying this IoT-based solution in real-world environments.

VI. ACKNOWLEDGMENT

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1. Saurabh Mahajan
2. Aditya Nikam
3. Parth Shelar

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