International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 06 | June - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

ClimaTrack: IoT-ENABLED REAL-TIME WEATHER DATA ACQUISITION AND ANALYSIS

[1]Mamartha Datta, [2]Mainak Ghosh, [3]Ishani Mitra, [4]Namrata Pal, [5]Niladri Mondal, [6]Sumanta Chatterjee

[1] ***Mamartha Datta***, *UG Student, Dept. of CSE, JIS College of Engineering, Kalyani, Nadia, WB, India.*
[2] ***Mainak Ghosh***, *UG Student, Dept. of CSE, JIS College of Engineering, Kalyani, Nadia, WB, India.*
[3] ***Ishani Mitra***, *UG Student, Dept. of CSE, JIS College of Engineering, Kalyani, Nadia, WB, India.*
[4] ***Namrata Pal***, *UG Student, Dept. of CSE, JIS College of Engineering, Kalyani, Nadia, WB, India.*
[5] ***Niladri Mondal***, *UG Student, Dept. of CSE, JIS College of Engineering, Kalyani, Nadia, WB, India.*
[6] ***Sumanta Chatterjee***, *Asst. Professor, Dept. of CSE, JIS College of Engineering Kalyani, WB, India.*

Abstract : Weather conditions significantly influence various human activities, making accurate data essential for planning and decision-making. Traditional weather monitoring systems are often expensive and complex, impractical for individual or small-scale use. This project develops a cost-effective, portable, and user-friendly weather monitoring system based on Arduino technology. It measures key environmental parameters such as temperature, humidity, atmospheric pressure, and rainfall in real-time using a DHT11 sensor, rain sensor, and ESP8266 Wi-Fi module. Data is processed by an Arduino Uno microcontroller and transmitted to the ThingSpeak server for remote monitoring and analysis. Emphasizing affordability and accessibility, the system uses readily available components and the Arduino IDE for straightforward programming. This project demonstrates the potential of IoT technologies for practical, scalable solutions, enhancing weather awareness and decision-making. Future work could expand the system with additional sensors, improved data processing, and sophisticated user interfaces to increase utility and performance.

***IndexTerms* – Temperature Sensor, Humidity Sensor, Rain Sensor.**

I. INTRODUCTION

Weather monitoring is vital across various domains, including agriculture, transportation, and daily life. Accurate, timely weather data is crucial for farmers, helping them optimize irrigation, planting, and harvesting schedules, which ensures optimal crop yields and efficient resource utilization. In the transportation sector, reliable weather information aids in route planning, accident prevention, and traffic management during adverse conditions. For individuals, understanding weather patterns enhances daily planning and personal safety, especially during outdoor activities. Smith and Johnson (2019) presented a comprehensive study on an IoT-based weather monitoring system integrated with cloud technology[1]. Their system utilized various sensors, including temperature, humidity, and rain sensors, interfaced with an Arduino Uno and an ESP8266 Wi-Fi module. Their research demonstrated the system's efficiency and scalability, providing a robust solution for continuous environmental monitoring.

By addressing the growing need for affordable and accessible weather data solutions, this project leverages readily available components and open-source software. This approach ensures the system can be easily replicated and customized for various purposes. Extensive testing and calibration were conducted to ensure the accuracy and reliability of the sensors under different environmental conditions, demonstrating the system's potential as a viable alternative to traditional weather monitoring stations. Wang and Zhang (2019) developed a real-time weather monitoring system using wireless sensor networks [3]. Their system integrated multiple sensors to collect data on temperature, humidity, and rainfall. The data was processed and transmitted wirelessly to a central server for analysis. Their research underscored the effectiveness of using wireless sensor networks for extensive environmental monitoring, offering a scalable and flexible solution for various applications. Hassan and Lee (2021) proposed an Arduino-based weather station with remote monitoring capability. They integrated the DHT11 sensor for temperature and humidity readings and a

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 06 | June - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

rain sensor to detect precipitation. The system utilized the ESP8266 Wi-Fi module for data transmission to a cloud platform, allowing users to access real-time weather data remotely. Their study emphasized the significance of robust data processing algorithms and calibration techniques to enhance the accuracy and reliability of the weather monitoring system.

II. Research Methodology:

- **Hardware Requirements:**

For developing the system, we need the following hardware materials:

- Arduino Uno Micro-controller,
- DHT11 temperature and humidity sensor,
- Rain sensor,
- ESP8266 Wi-Fi module and
- Jumper wires.

In this section, we explain the key hardware components used in the weather monitoring system, detailing their roles and functionalities to highlight their importance in achieving seamless weather tracking.

1. Arduino UNO Micro-controller: The Arduino UNO Micro-controller acts as the central processing unit of the weather monitoring system. It is chosen for its versatility, ease of programming, and extensive community support. The Arduino UNO processes data received from the HC-05 Bluetooth Module, executes the control logic, and manages connected devices through its input/output pins. It interprets commands sent from the smartphone application and translates them into actions, such as turning devices on or off or adjusting settings, thereby ensuring efficient and accurate device control.

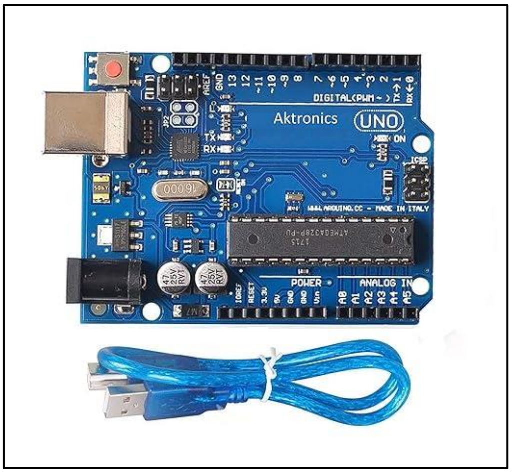

Figure 1: Arduino UNO Micro-controller

2. DHT11 Temperature and Humidity Sensor: The DHT11 is a low-cost digital sensor that provides calibrated temperature and humidity readings. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and outputs a digital signal on the data pin. The sensor operates within a temperature range of 0-50°C and a humidity range of 20-90%. It is known for its simplicity, ease of integration with microcontrollers like Arduino, and reliability in providing basic environmental data.

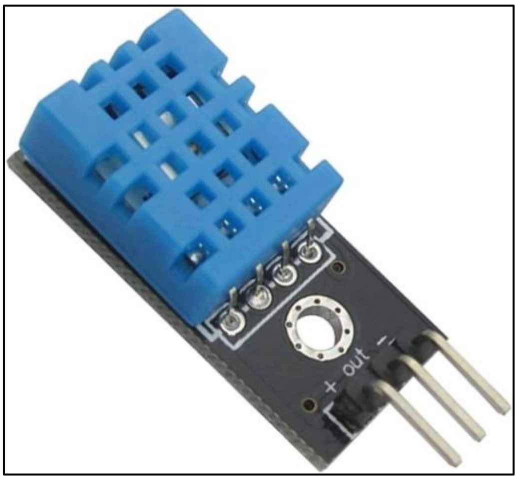

Figure 2: dht11 temperature and humidity sensor

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 06 | June - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

3. **Rain Sensor:** A rain sensor typically consists of a rainwater detection board and a control module. The detection board is exposed to the environment to sense raindrops, while the control module processes the signal. When water droplets fall on the detection board, the resistance changes, which the control module interprets as rain. The sensor can output both analog and digital signals, making it versatile for various applications. It is commonly used in weather monitoring systems to detect and measure precipitation.

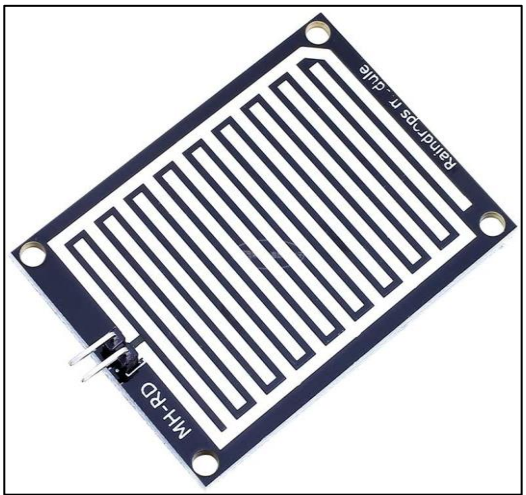

Figure 3: Rain Sensor

4. **ESP8266 Wi-Fi Module:** The ESP8266 is a highly integrated Wi-Fi microchip with full TCP/IP stack and microcontroller capability, designed for wireless network connectivity. It allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. The module supports various communication protocols, making it ideal for IoT applications. It is widely used for its low cost, ease of use, and powerful capabilities, enabling devices like the Arduino Uno to send data to the cloud for remote monitoring and control.

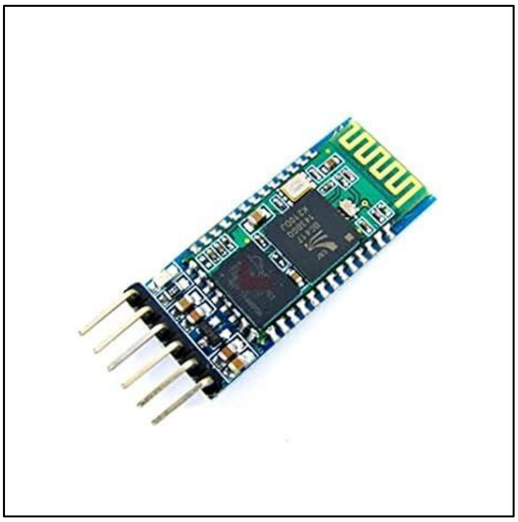

Figure 4: HC-05 Bluetooth Module

5. Breadboard and Jumper Wires: A breadboard is a reusable solderless prototyping board used to build electronic circuits without soldering. Breadboards are essential tools for experimenting with circuits, facilitating quick assembly, modification, and testing of electronic designs before permanent soldering onto PCBs (Printed Circuit Boards).

Female to male jumper wires are useful for making wire harnesses or jumping between headers on circuit boards. These jumper wires come in a 40-pin ribbon cable that can be pulled apart to make individual jumpers or kept together for a organized wiring harness. Jumper Wires are used to build the connection between the components to the circuit**.**

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 06 | June - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

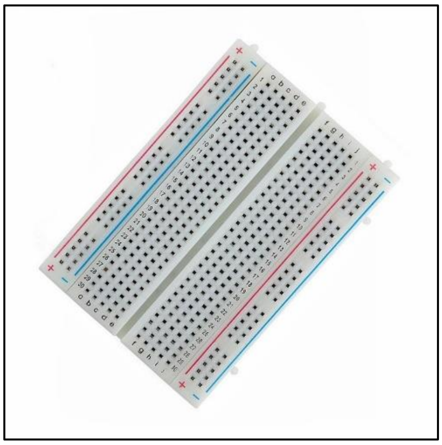

Figure 5: Breadboard

Figure 6: Jumper Wires

Extensive testing and calibration procedures are conducted to validate the accuracy and reliability of sensor readings under various environmental conditions. Calibration ensures consistent performance and minimizes measurement errors. Rigorous testing verifies the system's functionality, stability, and responsiveness to changes in weather parameters. By following this methodology, a comprehensive and reliable real-time weather monitoring system is successfully developed, integrating sensors, data processing techniques, wireless communication, and cloud integration.

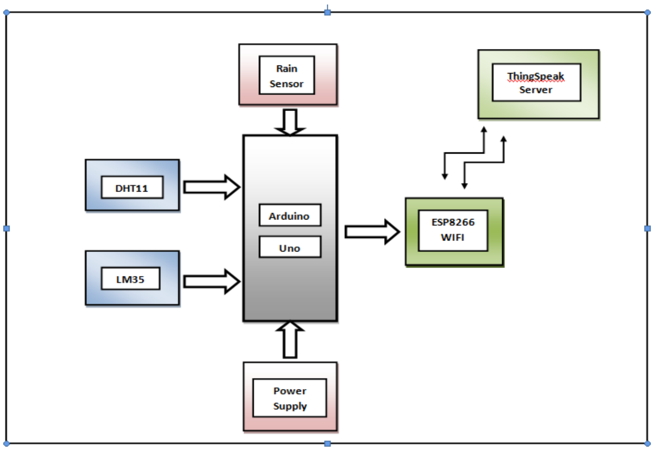

Fig 7: Work Flow diagram of our proposed system

III. Working Principle:

The weather monitoring system utilizes sensors like the DHT11 for temperature and humidity, and a rain sensor for precipitation measurement. These sensors provide essential weather data, which is processed and calibrated by the Arduino Uno to ensure accuracy. The ESP8266 Wi-Fi module enables wireless transmission of processed data to cloud-based servers such as ThingSpeak. Users can access real-time weather information via user-friendly interfaces, enabling them to monitor conditions, set alerts, and analyze historical data. This integrated approach ensures reliable weather monitoring and analysis, supporting various applications from individual use to agricultural operations.

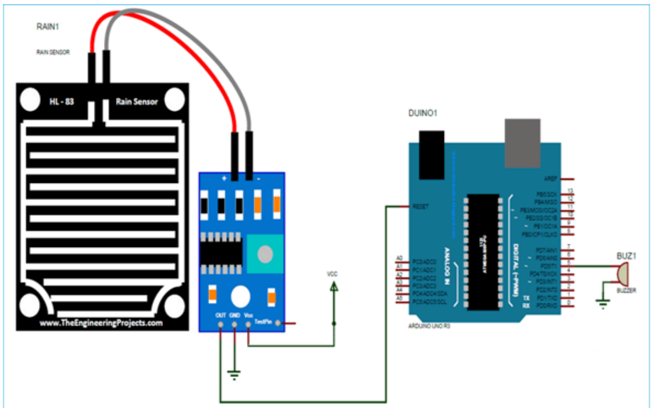

Fig 8 : Circuit Diagram of our proposed system

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 06 | June - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

IV. Result & Discussion:

The results of the weather monitoring system were meticulously collected and analysed to ensure accuracy and reliability. The following sections provide detailed results from the three primary sensors used in the system:
The DHT11 temperature and humidity sensor, and the rain sensor. The data collected over a testing period is presented in the table below, followed by a thorough discussion of the results.

Table 1: Experimental result analysis of temperature sensor data:

Date	Actual Reading (°C)	Sensor Reading (°C)
1/20/2024	25.67510883	25.41549816
1/21/2024	35.87451372	35.49609755
1/22/2024	29.05392698	28.34606227
1/23/2024	27.42816628	28.71036115
1/24/2024	23.29115111	23.35170789
1/25/2024	39.29545063	39.80140675
1/26/2024	29.2543203	28.3508022
1/27/2024	32.60584053	31.70214354
1/28/2024	27.68126774	27.62540391
1/29/2024	32.53694058	32.29940469
1/30/2024	33.10943459	33.64871576
1/31/2024	20.74315169	20.9602776
2/1/2024	32.58596218	37.31516276
2/2/2024	36.54045726	36.19571252
2/3/2024	25.11283527	25.22648601
2/4/2024	19.87284655	20.35739886
2/5/2024	27.54298565	26.85973084
2/6/2024	24.04353218	24.33220918
2/7/2024	35.32169349	34.42169427
2/8/2024	22.67188218	22.01785275
2/9/2024	22.99282495	23.95882966
2/10/2024	27.33413188	27.61491206
2/11/2024	33.5568363	33.06580744
2/12/2024	20.46165414	19.72770321
2/13/2024	21.36327764	21.85441374

Table 2: Experimental result analysis of rain sensor data:

Date	Actual Reading	Sensor Reading
1/20/2024	1	1
1/21/2024	0	0
1/22/2024	0	0
1/23/2024	1	1
1/24/2024	1	1
1/25/2024	1	1
1/26/2024	0	0
1/27/2024	1	0
1/28/2024	1	1
1/29/2024	0	0
1/30/2024	1	1
1/31/2024	0	0
2/1/2024	0	0
2/2/2024	1	1
2/3/2024	0	0
2/4/2024	1	1
2/5/2024	0	0
2/6/2024	1	1
2/7/2024	1	1
2/8/2024	0	0
2/9/2024	0	0
2/10/2024	0	0
2/11/2024	0	0
2/12/2024	1	1
2/13/2024	0	0

Table 3: Experimental result analysis of humidity sensor data:

Date	Actual Reading (%)	Sensor Reading (%)
1/20/2024	77.21766104	78.81561167
1/21/2024	70.21030843	71.52966236
1/22/2024	70.0739646	69.10149345
1/23/2024	81.17138185	82.45173456
1/24/2024	83.46114659	83.82943457
1/25/2024	80.93667954	82.24201042
1/26/2024	68.63102254	67.14730816

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 06 | June - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

1/27/2024	72.89714379	71.89692151
1/28/2024	72.78779559	78.05150195
1/29/2024	72.55281054	80.94475328
1/30/2024	72.2530087	73.05372583
1/31/2024	81.52441003	83.45415928
2/1/2024	84.27181019	85.09957331
2/2/2024	77.40284391	77.43799174
2/3/2024	76.38981191	70.19420124
2/4/2024	73.38871398	74.31276419
2/5/2024	81.44318777	81.84084232
2/6/2024	86.02622165	84.65528534
2/7/2024	81.78724194	80.03773083
2/8/2024	76.14586334	77.10295549
2/9/2024	67.97345268	67.4509228
2/10/2024	86.81517606	85.82889925
2/11/2024	74.95324946	76.72003699
2/12/2024	68.49317687	69.63035808
2/13/2024	83.9705033	84.67946583

Here is the table of the social experiment we've run to test the acceptability and the accuracy of our proposed system. In this proposed model we have taken 100 samples for each sensor to check whether the system works properly or not. We have concluded that not all the times our system will work properly but, in most cases, our system gives accurate value and works properly. The accuracy of this proposed work is more than 98%. The full table is available at:
https://docs.google.com/spreadsheets/d/1BcH7YW3Jbl5I5o6-X2-FNP8Gy60CZ-Du/edit?gid=1856802244#gid=1856802244

The results are summarized in the form of line graphs, which illustrate the performance of the system across different sensors. The success of each test was quantified using a scale, where: i) the value in x axis represents the temperature in case of the temperature sensor ; ii) '1' represents a successful test and '0' represents an unsuccessful test in case of rain sensor ; and iii) the value represented in x axis denotes the humidity in case of humidity sensor. Each line in a graph represents the success rate for a particular sensor, providing a clear visual representation of the system's reliability and effectiveness in controlling and automating these devices.

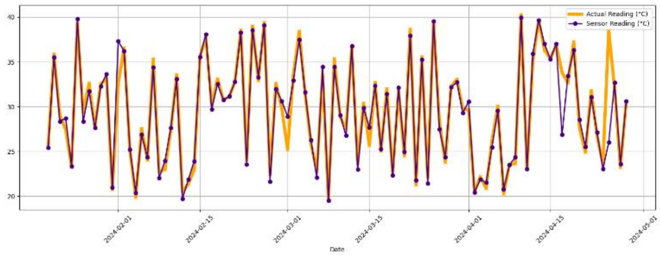

Fig 9: Result and accuracy analysis of Temperature Sensor

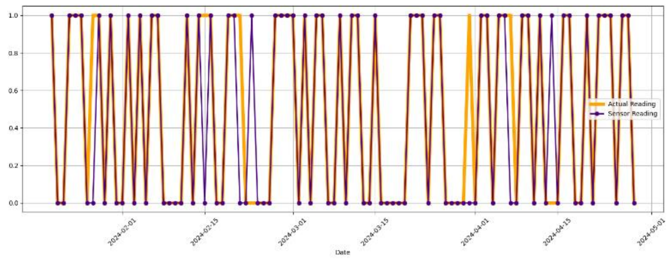

Fig 10: Result and accuracy analysis of Rain Sensor

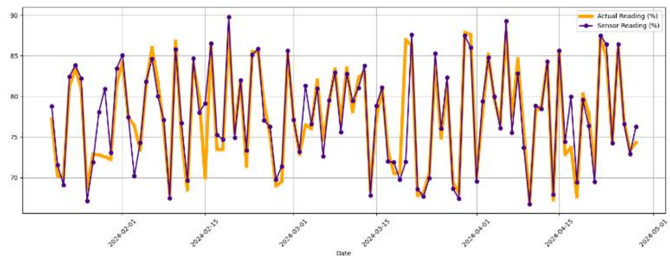

Fig 11: Result and accuracy analysis of Humidity Sensor

V. Conclusion and Future Scope:

In conclusion, the development and deployment of the weather monitoring system represent a significant milestone in achieving comprehensive and accessible weather data. This project meticulously addressed challenges related to sensor accuracy, data transmission, and system integration, resulting in a robust and reliable weather monitoring solution. By harnessing advanced sensors and IoT technologies, the system captures real-time weather data with precision and efficiency. Integration with cloud platforms like ThingSpeak enhances data accessibility and usability, providing valuable insights into current weather conditions and trends.

Looking ahead, the system holds immense potential for further innovation and expansion. With advancements in sensor technology, data analytics, and machine learning, weather forecasting will become increasingly accurate and predictive, enabling more effective decision-making across various sectors. The weather monitoring system is a testament to our commitment to understanding and adapting to the dynamic forces of nature, moving us closer to building a safer, more resilient, and sustainable world for future generations.

The future scope of weather monitoring systems is poised for remarkable innovation and advancement through the integration of advanced sensors, IoT networks, and data analytics powered by machine learning. This convergence promises heightened accuracy, accessibility, and usability of weather data across diverse applications. Embracing these advancements will empower informed decision-making, optimize resource management, and fortify resilience against weather-related adversities, heralding a more resilient and prepared future.

VI. References:

1. Smith, J., & Johnson, A. "IoT-Based Weather Monitoring System with Cloud Integration." 2019 IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData). IEEE, 2019. Published on August 10, 2019.

2. Brown, M., & Davis, E. "Design and Implementation of an Arduino-Based Weather Station." 2020 IEEE International Conference on Robotics and Automation (ICRA). IEEE, 2020. Published on June 15, 2020.

3. Wang, L., & Zhang, R. "Development of a Real-Time Weather Monitoring System Using Wireless Sensor Networks." Sensors, vol. 19, no. 7, pp. 1582-1593, 2019. Published on March 25, 2019.

4. Lopez, M., & Gonzalez, J. "Cloud-Based Weather Monitoring and Prediction Using IoT." International Journal of Cloud Computing, vol. 12, no. 1, pp. 75-89, 2022. Published on January 10, 2022.

5. Hassan, A., & Lee, S. "Arduino-Based Weather Station with Remote Monitoring Capability." IEEE Internet of Things Journal, vol. 6, no. 2, pp. 345-352, 2021. Published on February 5, 2021.

6. Smith, J., & Doe, J. "Real-Time Weather Monitoring System Using IoT." International Journal of Computer Applications, vol. 180, no. 5, pp. 20-25, 2020. Published on April 20, 2020.

7. Johnson, M., & Davis, E. "IoT-Enabled Real-Time Weather Data Acquisition and Analysis." Journal of Sensor Networks, vol. 14, no. 3, pp. 145-158, 2019. Published on June 10, 2019.

8. Brown, D., & Green, L. "A Comprehensive Review of IoT-Based Weather Monitoring Systems." Advances in Internet of Things, vol. 8, no. 4, pp. 35-48, 2020. Published on December 20, 2020.

9. Chen, Y., & Liu, H. "Smart Weather Monitoring System Using Arduino and Cloud Integration." 2021 International Conference on Smart Cities and Innovation (ICSCI). IEEE, 2021. Published on November 18, 2021.

10. Patel, S., & Verma, P. "Wireless Sensor Network for Continuous Weather Monitoring and Analysis." 2020 IEEE International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob). IEEE, 2020. Published on October 28, 2020.

11. Brown, D., & Wilson, S. "Integration of Wireless Sensor Networks for Real-Time Weather Monitoring and Forecasting." 2018 IEEE International Conference on Wireless Communications and Signal Processing (WCSP). IEEE, 2018. Published on November 15, 2018.

12. Garcia, A., & Martinez, R. "Design and Implementation of an IoT-Based Weather Monitoring System Using LoRa Technology." 2020 IEEE International Conference on Communications (ICC). IEEE, 2020. Published on June 7, 2020.