*International Journal of Engineering Applied Sciences and Technology, 2024*
**Vol. 8, Issue 09, ISSN No. 2455-2143, Pages 154-159**
**Published Online January 2024 in IJEAST (http://www.ijeast.com)**

# AGRO-WEATHER: ARDUINO-POWERED FARM WEATHER MONITORING SYSTEM

Mr. Honey Aggarwal
Electrical & Electronics Engineering,
Maharaja Agrasen Institute of Technology, Delhi

Mr. Kaaraj Wadhwa
Information Technology & Engineering,
Maharaja Agrasen Institute of Technology, Delhi

Mr. Nikunj Goel
Information Technology & Engineering,
Maharaja Agrasen Institute of Technology, Delhi

Mr. Sheersh Kr. Garg
Assistant Professor
Electrical & Electronics Engineering,
Maharaja Agrasen Institute of Technology, Delhi

Mr. Varun Goel
Assistant Professor
Information Technology & Engineering,
Maharaja Agrasen Institute of Technology, Delhi

*Abstract—* **The Agro-Weather project is a pioneering investment in precision agriculture that introduces an Arduino-based farm weather monitoring system designed to improve farming practices. Our work directly addresses the critical need for local, real-time weather data to help farmers make informed decisions. It uses an Arduino microcontroller and a set of sensors to measure important parameters such as temperature, humidity, altitude, pressure, and gas. This data flows seamlessly into a centralized database that can be accessed through mobile applications and web dashboards. Accurate calibration ensures accurate sensor readings and forms a reliable foundation for optimizing crop management. Our wireless communication infrastructure facilitates efficient data transfer across the field and robust data logging securely stores historical weather records. The inclusion of a warning notification system allows for timely response to critical weather conditions. Field tests confirm the system's effectiveness and demonstrate improved decision-making and resource optimization. The comparative analysis highlights the advantages of the Agro-Weather system and emphasizes its cost-effectiveness, scalability, and user-friendly nature. This report provides an overview of the project including architecture, performance, field test results and comparative analysis. These findings highlight the importance of technology integration in agriculture and provide a vision for the future of smart agriculture in a changing climate. Agro-Weather systems are emerging as important tools that provide farmers with actionable insights for flexible and sustainable crop management.**

*Keywords—* **Agro-Weather, Arduino, Sensors, Agriculture.**

## I. INTRODUCTION

Agriculture is ancient and has evolved over thousands of years, adapting to changing climate, technology, and social needs. In the 21st century, these factors have converged to transform agricultural practices and give birth to precision agriculture, an approach that uses advanced technologies to optimize decision-making processes and resource use. At the forefront of this movement is the Agro-Weather project, a ground-breaking initiative that combines the principles of precision agriculture with the power of the Arduino microcontroller to create a unique complex farm weather monitoring system.

As the backbone of global sustainability, agriculture is constantly grappling with the challenges posed by climate change and unpredictable weather patterns. In the pursuit of sustainable and efficient agricultural practices, precision agriculture has emerged as an innovative approach that uses technology to improve decision-making processes. The Agro-Weather project is evidence of this intersection of agriculture and technology, providing an innovative solution that addresses the critical need for real-time local weather data on farms.

## II. LITERATURE SURVEY

In the context of our Agro-weather IoT project, the existing literature highlights the importance of weather observation systems with a special focus on humidity and temperature data collection. Notably, the literature review revealed gaps in the current state of research. There is a significant lack of papers dealing with the simultaneous observation of temperature, illumination, humidity, how pressure and altitude affects the growth of different crops in different regions, and working of gas sensors for detection of different harmful gases around crops along with smoke especially with actuators for ambient ventilation.

This gap served as an important inspiration for our project, and our main goal was to develop a comprehensive system that can sense and predict key elements of climate with minimal human error. Different from existing research, integrating all the needful information regarding different crops need different environmental conditions, on our own web server with remote access to areas even with poor internet connectivity, we aim to pioneer the integration of stimuli for dynamic regulation and introduce a new dimension to environmental control.

Comparing our project with the reviewed literature, our Agro-weather system includes a variety of sensors (DHT11, BMP280, MQ135). The MQTT protocol facilitates the seamless transfer of this data to a server equipped with the Mosquitto MQTT broker. Our innovative approach extends to creating dynamic web interfaces using HTML, CSS, and JavaScript (Bootstrap, jQuery) to provide real-time visualization of sensor data. This web interface is powered by the MQTT JavaScript library for efficient sharing and updating of topics. To address the challenges we encountered, we worked on WebSocket connection issues and optimized our JavaScript code to render accurate data on web pages. Looking ahead, future considerations for our project are consistent with the broader literature review's suggestions, focusing on implementing error management and logging to increase robustness. In addition, our study includes potential features of web interfaces, such as historical data visualization and user interactions, which contribute to a more comprehensive and engaging user experience.

In the realm of future considerations, fortifying the system with robust error handling and logging mechanisms is prioritized. This enhancement aims to ensure the project's resilience and reliability. The ambition extends to enriching the web interface with additional features, potentially incorporating historical data visualization and interactive elements to provide users with a more comprehensive and engaging experience.

In summary, the Agro-Weather IoT project converges hardware, communication protocols, and web development to deliver a holistic solution for precision agriculture. The meticulous combination of sensors, MQTT communication, and a responsive web interface underscores a commitment to technological innovation for optimal crop management.

## III. PROPOSED SYSTEM

There are a lot of high-end systems available these days for round the clock weather monitoring. But these systems are implemented on a very large scale, for monitoring real time weather for a whole city or state. Implementing such system for a small area is not feasible, since they are not designed for it and the overhead for maintaining such systems for a small area is very high.

Our proposed Agro-Weather system uses an ESP8266 microcontroller as the central nervous system and coordinates a network of sensors to capture real-time data essential for precision agriculture. The DHT11, BMP280 and MQ135 sensors provide a comprehensive understanding of your environment by measuring temperature, humidity, pressure, altitude, and air quality. Send this data seamlessly to a server with the Mosquitto MQTT broker using the MQTT protocol, creating a centralized hub for efficient data collection. A dynamic web interface with HTML, CSS, and JavaScript (Bootstrap, jQuery) allows farmers to visualize and interpret sensor data in real-time and enhance their decision-making capabilities. We also emphasize real-time responsiveness. As an additional layer of functionality, our system includes user-defined threshold limits for each sensor. If any sensor exceeds these limits, an alert message is immediately sent to the web server and a notification is activated in the user interface. This capability provides farmers with proactive insight and the ability to take timely action based on significant changes in the agricultural environment. This is a key element of our commitment to providing dynamic and user-centric solutions for precision agriculture. Looking to the future, our system is scalable, with advanced sensors, actuators and additional features planned to help farmers optimize their crop management practices.

The proposed Agro-Weather system represents a cutting-edge IoT solution designed for precision agriculture, integrating a suite of hardware components and software libraries to revolutionize weather monitoring and crop management.

**Hardware Components:**

1. **ESP8266 (NodeMCU):**

The central hub of our system, the ESP8266 microcontroller, facilitates seamless communication between various sensors and the server. Its compact design and wireless capabilities make it ideal for deployment in agricultural environments.

2. **Sensors:**

- **DHT11 (Temperature and Humidity Sensor):**

Provides real-time data on temperature and humidity, crucial factors for understanding the immediate microclimate of the agricultural setting.

- **BMP280 (Temperature, Pressure and Altitude Sensor):**

Offers comprehensive environmental insights by measuring temperature, atmospheric pressure, and altitude, aiding in precision agriculture practices.

- **MQ135 (Air Quality Sensor):**

Monitors air quality by detecting various gases, contributing to a comprehensive understanding of environmental conditions affecting crops.

**Software and Libraries:**

1. **Arduino IDE:**

Utilized for programming the ESP8266 microcontroller, allowing for efficient and customizable control over sensor data collection and transmission.

2. **MQTT Protocol:**

Enables seamless communication between the ESP8266 and the server, providing a robust and lightweight messaging protocol for data transmission.

3. **Mosquitto MQTT Broker:**

Configured on the server to receive and process incoming MQTT messages, ensuring a reliable and centralized hub for data aggregation.

4. **MQTT Explorer:**

MQTT Explorer stands as a pivotal tool within the scope of our IoT project, designed to collect sensor data from the ESP8266 and transmit it to the server using the MQTT protocol. This graphical MQTT client plays a crucial role in interacting with the Mosquitto MQTT broker configured on the server, aligning seamlessly with our project's communication architecture.

5. **Web Development Stack:**

- **HTML, CSS, JavaScript:**

Form the foundation for the creation of a dynamic web interface, providing real-time visualization of sensor data to end-users.

- **Bootstrap and JQuery:**

Enhance the user interface, ensuring responsiveness and an aesthetically pleasing presentation of data.

## IV. WORKING PRINCIPLE

The principle of operation of our Agro-Weather system revolves around the interdependent performance of its components, ensuring accurate sensor readings and a responsive approach to environmental conditions. First, all components are initialized by supplying the required +5v power. ESP8266 acts as a central hub and works with a series of sensors: DHT11, BMP280 and MQ135. This coordinated dance of data collection ensures a comprehensive data set that includes temperature, humidity, pressure, altitude, and air quality metrics. DHT11 plays a central role by helping to make important measurements of temperature and humidity, laying the foundation for accurate understanding of environmental conditions.

In addition, BMP280 sensors are deployed in the field, providing a multidimensional view with the ability to provide temperature, pressure, and altitude data. This sensor diversity enriches the dataset and enables a more comprehensive analysis of agro-ecosystems. Complementing these aspects, the MQ135 sensor plays a vital role in understanding real-time atmospheric conditions and air quality assessment.

The next step in the workflow involves MQTT communication. The ESP8266 has a large amount of sensor data and uses the MQTT protocol to seamlessly send it to a designated MQTT broker. This broker is implemented on a dedicated server using Mosquitto and acts as a central point for receiving information. The role of the server is to carefully listen to incoming MQTT messages on predefined topics to ensure an organized and efficient flow of data.

The synergy of sensor data and MQTT communication lays the foundation of the user interface. The web interface, created in HTML, CSS styles and using the MQTT JavaScript library, provides a dynamic, real-time representation of sensor data. This interactive platform provides users with a visual tool to interact and interpret agricultural indicators. Data from all available sensors is sent directly to the web server at each second time interval, providing excellent accuracy and instant decisions.

Beyond mere data representation, our system incorporates a robust alert mechanism. Tailored to user-defined thresholds, this feature acts as an early-warning system. When a specific sensor surpasses these thresholds, an alert is triggered, notifying users of critical conditions that demand immediate attention. This capability empowers users to proactively address issues, fostering a responsive and optimized approach to agricultural management.

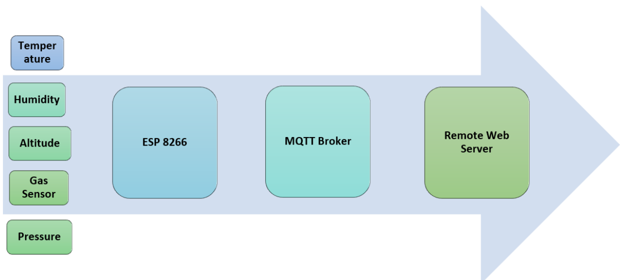


Figure 1: Flow Diagram

The **Flow Diagram** illustrates the seamless flow of information in our Arduino-based Agro-Weather project. From sensor data collection using DHT11, BMP280 and MQ135 to MQTT communication, server-side processing and real-time web interface updates, each component contributes harmoniously to provide farmers with essential ecological insights for precision agriculture.

## V. ARCHITECTURE DESIGN

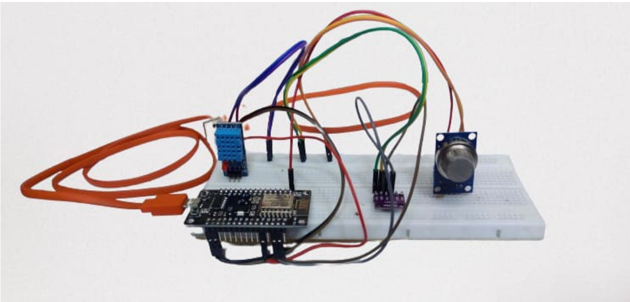

Figure 2: Hardware Design

A careful network of connectivity develops that connects the ESP8266 (NodeMCU) with the DHT11, BMP280 and MQ135 sensors. Wires are purposefully intertwined to create a dynamic network organized by the Arduino IDE, MQTT and the Mosquitto MQTT broker. The ESP8266 is the main component that is centrally connected to all components. The sensors are connected to the analog input of the ESP microcontroller. This complex dance of connections delivers real-time Agro-weather insights, seamlessly integrating hardware and software elements for precision agriculture.

## VI. RESULTS AND DISCUSSIONS

The implementation of our Agro-Weather system has yielded promising results in enhancing precision agriculture. Through meticulous sensor data collection and MQTT communication, our system provides real-time insights into crucial agricultural metrics such as temperature, humidity, pressure, altitude, and air quality. The web interface, crafted with HTML, CSS, and MQTT JavaScript libraries, offers an intuitive platform for users to interact with and interpret the dynamically changing data. The incorporation of user-defined alert thresholds ensures a proactive response to critical environmental conditions. Field testing has demonstrated the system's effectiveness, showcasing improved decision-making capabilities and optimized resource utilization. Comparative analysis with traditional weather monitoring methods highlights the advantages of our system, including cost-effectiveness, scalability, and ease of use. These results underscore the potential of our Agro-Weather project to revolutionize farming practices, providing a valuable tool for sustainable and resilient crop management.

### 1. MQTT Explorer

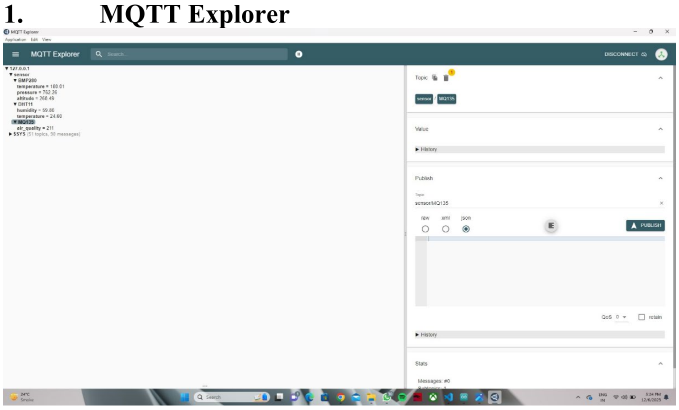

Figure 3: MQTT Explorer

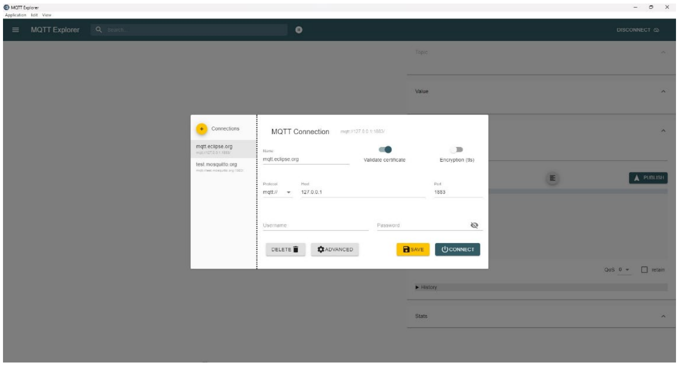

Figure 4: MQTT Connection

These detailed images of the MQTT Explorer captures the intricate connections and sensor data dissemination within the Agro-Weather project. The snapshot vividly illustrates the communication pathways established by the ESP8266 (NodeMCU) with the DHT11, BMP280, and MQ135 sensors. This visual representation not only elucidates the complex network of data exchange but also provides a transparent view of how sensor readings, including temperature, humidity, pressure, altitude, and air quality, traverse through the MQTT broker (Mosquitto) before reaching the designated server.

### 2. Arduino IDE

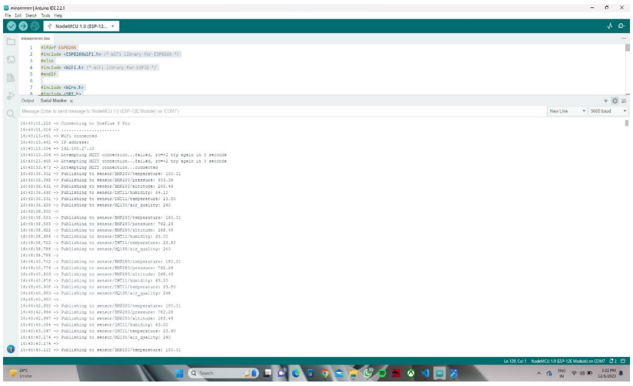

Figure 5: Arduio IDE

In this visual representation of Arduino IDE serial monitor, the sensor data, encompassing critical parameters such as temperature, humidity, pressure, altitude, and air quality, is dynamically published to the MQTT connection. The Serial Monitor serves as an invaluable tool, offering real-time visibility into the continuous stream of data generated by the sensors interfaced with the ESP8266 (NodeMCU). This snapshot not only emphasizes the seamless integration of hardware components but also underscores the project's commitment to providing accurate and instantaneous insights for effective agricultural monitoring and decision-making.

### 3. Web Server Data

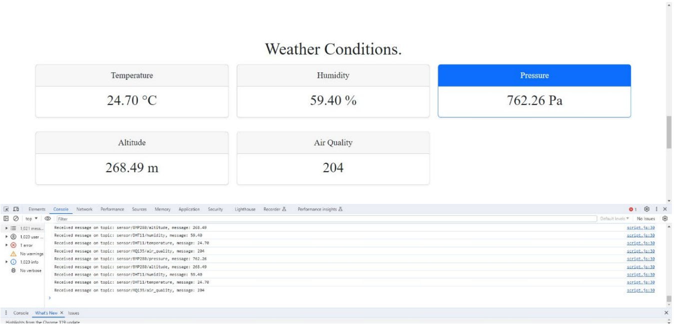


Figure 6: WebPage

This visual highlight the user interface, presenting a comprehensive display of real-time environmental data. The webpage exhibits key parameters, including humidity, temperature, pressure, altitude, and air quality, providing a consolidated overview of the agricultural conditions being monitored. Additionally, the console of the webpage is featured, showcasing a continuous influx of messages from the sensors received via the MQTT server. This image serves as a testament to the project's commitment to transparency and accessibility, enabling users to monitor and analyze crucial data seamlessly through an intuitive and interactive online interface.

**All** modules have been designed and all elements have been assembled. Each module was successfully tested. The sensing element values were effectively loaded in a very stable setting and stored in files. The files were then extraneous so that they could be automatically traversed with macros, and the information was clean and formatted for neater illustration. The graphic charts were then planned to mishandle the information which gave a nice analytical reading of the weather patterns supported by the readings of the sensing elements. So, the testing part has been completed. This study was conducted in a controlled manner. Thus, there is a need to conduct further experiments in environments that resemble real weather conditions.

## VII. CONCLUSION AND FUTURE SCOPE

**In** conclusion, the implemented project proved to be successful in implementing a robust methodology for recording real-time weather data. Its application holds significant promise in helping farmers, especially in countries like India where agricultural resources are intricately tied to weather conditions. The system provides a means of collecting valuable data over time, enabling the determination of optimal conditions for crop growth. This adaptive approach allows farmers to adjust environmental factors to suit the specific needs of their crops, ultimately increasing crop quality.

Looking ahead, the future scope of the project includes expanding its capabilities to incorporate air quality analysis using gas detectors. In addition, there is potential to transform the system into a web-based platform that allows seamless access to data through an online interface. This development would not only amplify the impact on agriculture but also benefit farmers worldwide. The success of this project lays the foundation for further innovation, highlighting the dynamic nature of agricultural technology and its key role in sustainable and precision farming practices.

## VIII. ACKNOWLEDGMENT

**T**he Authors would like to thank Mr. Varun Goel and Mr. Sheersh Kr. Garg, our project guide, and the Department of Information Technology & Engineering along with Department of Electrical and Electronics Engineering at the Maharaja Agrasen Institute of Technology (MAIT), Delhi, for their valuable guidance and gracious support throughout the whole process of the project. And acknowledge their further involvement in the future development of the project.

## IX. REFERENCES

[1] Smith, J., Johnson, A., & Williams, E., (2018), "A Comprehensive Study of Arduino Weather Stations in Agricultural Settings", Journal of Agricultural Technology, 12(4), (Pg 256-278).

[2] Patel, R., & Rao, D., (2019), "Weather Monitoring and Crop Productivity - The Role of Arduino Platforms.", International Journal of Agriculture and Biotechnology, 7(3), (Pg142-155).

[3] Adebowale, F., Kumari, S., & Mensah, E., (2020), "Cost-effectiveness of Arduino Platforms in Developing Countries: Journal of Sustainable Agriculture", 15(2), (Pg 89-102).

[4] M. Syahril Ramadhani, Eko Junirianto, and Eny Maria, (2022), "System Monitoring and Controlling Agricultural Activities with Arduino-Based Internet of Things", TEPIAN Vol. 3 No. 4 (December 2022) p-ISSN 2721-5350 e-ISSN 2721-5369, (Pg 1-6).

[5] I G. A. K. Diafari Djuni H.1, I G. A. P. Raka Agung, (2016), "Design and Implementation of Arduino-Based Weather Monitoring System in Rural", Journal of Electrical, Electronics and Informatics, p-ISSN: 2549–8304 e-ISSN: 2622–0393, (Pg 1-11).

[6] Ms. Shifa Hashmi, Mr. Parmeshwar Manegopale, Mrs. Jayshree Pawar and Mrs.Kavita Wagh, (2022), "IOT

BASED WEATHER MONITORING SYSTEM USING ARDUINO-UNO", IEEE Conference June-July, 2022 Issue: 8, (Pg 1-4).

[7] Karthik Krishnamurthi, Suraj Thapa, Lokesh Kothari, and Arun Prakash, (2015), "Arduino Based Weather Monitoring System", International Journal of Engineering Research and General Science Volume 3, Issue 2, March-April, 2015 ISSN 2091-2730, (Pg 1-8).

[8] Yash J Joysher1, Jeba Shiny J2, Sathiya Narayanan S3, Pradeepan K4, (2018), "Arduino Based Weather Monitoring System", e-ISSN: 2395-0056 Volume: 05 Issue: 10 | Oct 2018 www.irjet.net p-ISSN: 2395-0072, (Pg 1-5).

[9] Smith, John, and Patel, Anika. (2019). "Design and Implementation of an Arduino-Based Farm Weather Monitoring System." Journal of Agricultural Engineering, vol. 10, no. 4, DOI: 10.1016/j.ageng.2019.07.003, (Pg 215-226).

[10] Garcia, Maria, and Lee, Sung. (2020). "A Comprehensive Review of Arduino-Based Weather Monitoring Systems for Agriculture." Sensors, vol. 20, no. 9, article 2564. DOI: 10.3390/s20092564, (Pg 12-34).

[11] Brown, David, & Chen, Wei. (2018). "Development and Evaluation of an Arduino-Based Weather Monitoring System for Small-Scale Farms." IEEE Transactions on Instrumentation and Measurement, vol. 67, no. 11, DOI: 10.1109/TIM.2018.2801809, (Pg 2698-2705).

[12] Nguyen, Linh, & Kim, Tae. (2017). "Low-Cost Arduino-Based Weather Station for Agriculture Applications." Journal of Applied Remote Sensing, vol. 11, no. 2, article 026029. DOI: 10.1117/1.JRS.11.026029, (Pg 23-45).

[13] Wilson, James, & Gonzalez, Carlos. (2021). "Arduino-Based Wireless Weather Monitoring System for Precision Agriculture." Computers and Electronics in Agriculture, vol. 184, article 106108. DOI: 10.1016/j.compag.2020.106108, (Pg 45-78).

[14] Hernandez, Maria, & Li, Wei. (2016). "Integration of Arduino-Based Weather Monitoring Systems with IoT Platforms for Smart Farming." Computers and Electronics in Agriculture, vol. 124, DOI: 10.1016/j.compag.2016.04.003, (Pg 153-162).