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An Improved Internet of Things Based Weather Monitoring System for Effective Farming

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ABSTRACT
Agriculture serves as the backbone of numerous global economies, and its success heavily relies on weather conditions. This study introduces an enhanced Internet of things (IoT) based weather monitoring system crafted to elevate the efficiency of agricultural operations. The key features of the proposed system include the ability to monitor weather conditions remotely and make data-driven decisions in real-time. The system integrates various IoT sensors such as DHT11, BMP 280, rain and LDR sensors to collect real-time weather data. The system is designed to use a NodeMCU Microcontroller + Wi-Fi Modulus, Blynk cloud API and a mobile based application to show the various readings from weather data logs monitored. The weather data collected are transmitted to a central server through IoT technology, allowing farmers to access crucial information through a user-friendly interface on their smartphones or computers. This paper discusses the system architecture, sensor deployment, data transmission, and user interface design, highlighting its practical utility and potential for revolutionizing modern farming practices. By utilizing this IoT-based weather monitoring system, farmers can optimize resource usage, increase crop yields, reduce operational costs, and mitigate the impact of adverse weather events. It is recommended that farmers, researchers, and industries can harness the power of real-time weather data in order to improve decision-making processes, optimize resource usage, and as well enhance the resilience of communities and agricultural ecosystems.

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I. INTRODUCTION

Climate and weather conditions impact the quality of crop production [1]. The Weather delineates the current atmospheric conditions at a specific location and moment. The concept of monitoring weather conditions did not just begin. It has been in existence. People of old learnt to monitor weather because of its impact on agriculture and on our day-to-day activities. Various instruments have been used to predict and monitor weather. But the need for systems that can interpret atmospheric conditions with little or no human intervention was required. Agricultural productivity is highly dependent on environmental factors, particularly weather conditions. Effective farming practices rely heavily on these weather conditions. To ensure efficient and sustainable farming practices, it is essential to have accurate and timely weather information. One primary objective of agricultural weather monitoring systems is that farmers will be provided with accurate and real-time weather information relevant to their specific crop and location. By continuously monitoring environmental conditions, farmers can obtain valuable insights about the condition of their crops, make data-driven decisions and apply precision agricultural techniques [2]. In this context, the adoption of Internet of Things (IoT) technology in the agricultural sector has garnered considerable attention. The Internet of Things (IoT) has made a significant impact on effective farming practices and in turn revolutionized the way farmers monitor and manage their crops [3]. By integrating IoT technologies into farming operations, farmers can enhance efficiency, improve productivity, reduce costs, conserve resources, and make more informed decisions. Farmers can also access the weather data through user-friendly interfaces such as mobile applications or web-based dashboards, allowing them to monitor real-time conditions, view historical trends, and receive alerts based on specific thresholds.

Smart weather monitoring stations utilizes Internet of things and cloud computing to help collect, analyze and share real-time weather information [4]. One of the primary objectives of IoT weather monitoring systems is to furnish farmers with real-time, precise and localized information regarding the weather conditions affecting their crops and specific location. Weather factors contribute to the optimal growth, development and yield of crops and livestock. These factors figure prominently in the incidence and spread of pests and diseases [5]. Monitoring them requires critical analysis of different climatic conditions, examining the patterns and processing data obtained to generate results.

The Agriculture industry relies significantly on conventional machinery [6]. Traditional weather monitoring systems in the field typically involve conventional and bulky machinery with numerous moving parts. Consequently, they demand regular maintenance and periodic manual checks and adjustments. This improved IoT based system solves this problem efficiently by saving the user the stress of manually checking the instruments. It also provides timely warning about bad weather and changes in forecast. Weather Forecasting deals with the analysis of data and the application of meteorology to predict future weather. In weather forecasting, humans play a vital part in order to determine the weather conditions. This makes weather predictions insufficient since they results obtained may at times be inaccurate. In the event where a weather forecasting system will predict rainfall all over the city or metropolis, however, it rains in only a certain percentage of the area, this makes the system unreliable. The weather monitoring system will, however, predict the weather, but this time covering a smaller distance which will provide better accurate results, give information about the real feel of the weather and effectiveness against a weather forecast.

Furthermore, weather monitoring systems encounters challenges such as restricted coverage, a shortage of real-time data updates, and elevated costs linked to infrastructure maintenance [7]. The enhanced IoT-driven weather monitoring system introduces a cutting-edge approach, delivering comprehensive coverage, real-time data updates, and enhanced accessibility. The system serves an essential tool for modern agriculture, furnishing farmers with precise and real-time information on current weather conditions. This empowers them to make well-informed decisions and proactively manage potential risks associated with planting. As a result it plays a crucial role in enhancing crop yields, optimizing farm management practices and contributing to the overall success and sustainability of the agriculture industry. The research provides a comprehensive exploration of the design, implementation, and performance evaluation of the proposed system. Also it incorporates a user-friendly interface accessible through mobile devices, allowing farmers to remotely monitor and control their agricultural operations. Temperature and humidity sensors play a crucial role in agricultural weather monitoring systems [8]. They help farmers understand the ambient conditions in the field, which is essential for crop growth and development. Monitoring temperature allows farmers to track frost events, heatwaves, and growing degree days, enabling them to adjust planting schedules and optimize crop selection accordingly. Humidity data provides insights into the moisture levels in the air, helping farmers manage irrigation and prevent diseases caused by excessive moisture or humidity. Furthermore in their 2022 publication, In [2] introduced ‘An IoT-based Low-cost Weather Monitoring System for Smart Farming’. The system effectively monitored real-time weather conditions such as temperature, humidity, rainfall, atmospheric pressure, light intensity, CO_2 levels, and wind speed direction. The primary aim of their study was to design a modular and cost-effective mechanism for the real-time monitoring of weather conditions, with a concurrent focus on enhancing farming practices through the utilization of low-power technologies. The research conducted by Suleiman in 2022 [9] a Wireless Weather Monitoring System based on the Internet of Things (IoT) was proposed, employing GSM technology. The core component of the system included an ATMEGA-328 Microcontroller, SIM 800 GSM Module, LCD, various sensors, and a stable 5V, 500mA power supply. The microcontroller played a pivotal role in converting data obtained analog sensors into digital format through its integrated ADC. The resulting information was then presented to users through an LCD screen, serving as the system’s user interface. The study stated that the challenges encountered in the IoT system constructed are high power consumption due to the use of GSM modules and LCD screen. Also the inability of the prototype to measure some weather variables which are crucial for farming purposes.

Apurva Pusatkar et al. [10] introduced a Wireless Sensor Network (WSN)-based system for real-time monitoring of agricultural fields. This innovative approach recognizes the evolving nature of agricultural yield rates and incorporates additional parameters beyond conventional ones. This ensures a comprehensive assessment of the agricultural environment, enabling more effective and timely monitoring. Rasagna et al. [11] introduced a Solar-Powered Soil and Weather Monitoring System employing IoT. This innovative system tracks various environmental parameters, including temperature, humidity, soil moisture, rain level, and light intensity. The microcontroller processes the gathered data, which is then transmitted to a cloud platform for storage and analysis. By offering farmers access to real-time information, this system not only enhances their decision-making processes but also contributes to the overall sustainability of their farming practices. In their research, "IoT-Based Weather Monitoring Systems for Smart Agriculture," Chandini NS et al. [12] highlighted the profound influence of weather and climate on agriculture. In the contemporary context, the escalating challenges posed by global warming and pollution have significantly heightened the imperative to closely monitor weather conditions. In 2019, Abdulkadir A. et al. [13] introduced an automated weather monitoring system. This system was meticulously crafted, implemented, and assessed through the utilization of electronic sensors. It successfully tracked and measured key meteorological parameters such as temperature, humidity, wind speed, wind direction, solar illumination, and rainfall, providing near-real-time data. In 2018, Girija et al. [14] introduced a sophisticated approach to weather monitoring at specific locations, leveraging IoT as an advanced and efficient solution. This methodology not only facilitates local weather observation but also ensures global accessibility to the information. By employing IoT, the system efficiently connects various elements to the internet, establishing a comprehensive network that interconnects the entire spectrum of things worldwide.

Therefore, our study aims to develop an IoT based weather monitoring system. This system will utilize a network of sensors linked to a Node MCU, which effectively gathers and processes the data, enabling real-time measurement of diverse weather patterns within and around the farm. Farmers can then gain access to this data remotely via mobile applications or web through the blynk IoT platform. The goal of this research is to provide farmers insights for adverse weather conditions allowing them to take preventive measures and also protect their crops. The study demonstrates the system's practicality and effectiveness in real-world farming scenarios.

II. ANALYSIS EXISTING SYSTEM

An existing model was selected for this study. The system consists of Arduino Uno board, which comes with a microprocessor. The various sensors and the LCD screen are appropriately interfaced with the microcontroller pins. Real-time data transmission occurs, and the results are promptly showcased on the LCD screen. Additionally, the system incorporates the SIM 800 GSM module, enabling seamless wireless SMS transmission to a mobile phone.

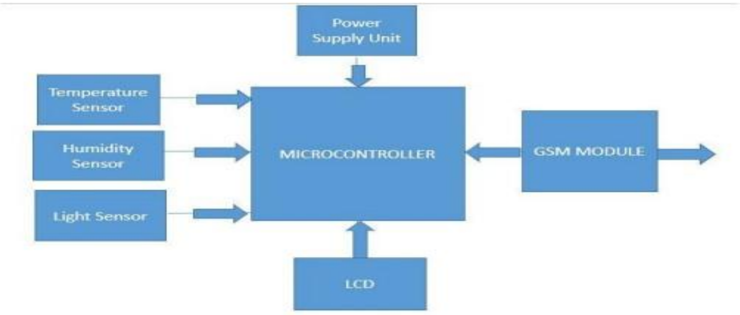


Figure 1. Block Diagram of the Existing system [9]

Drawbacks existing system

- One significant challenge in the current system is its reliance on DC batteries, which tend to deplete rapidly due to the high power consumption of the GSM module and LCD screen. Consequently, there is a pressing requirement for a portable power source.
- Another drawback is the inability to measure some weather variables which are critical for agricultural activities.
- Measurements cannot be saved on the internet because no provision for the system to be connected to the computer via a USB cable.
- Insufficient Real time Monitoring.
- Inability to send alarm or a prompted update when weather condition exceeds a certain threshold.

III. MATERIAL AND METHODS

The system proposed is an advanced solution for weather monitoring that uses IoT to make its real time data easily accessible over a very wide range. The proposed system comprises of network of sensors and actuators sensing and collecting data from the environment. The system utilizes NodeMCU ESP8266 Microcontroller at each sensor node to collect, process, and transmit data and also Wi-Fi for communication within the farm. The system leverages cloud-based platform for storing, processing and analyzing weather data collected from the farm, and the user accesses weather data through their smartphone. The architecture of IoT comprises three layers: the perception layer, which is made out of the physical devices, the network layer for data transmission, and finally the application layer for providing services.

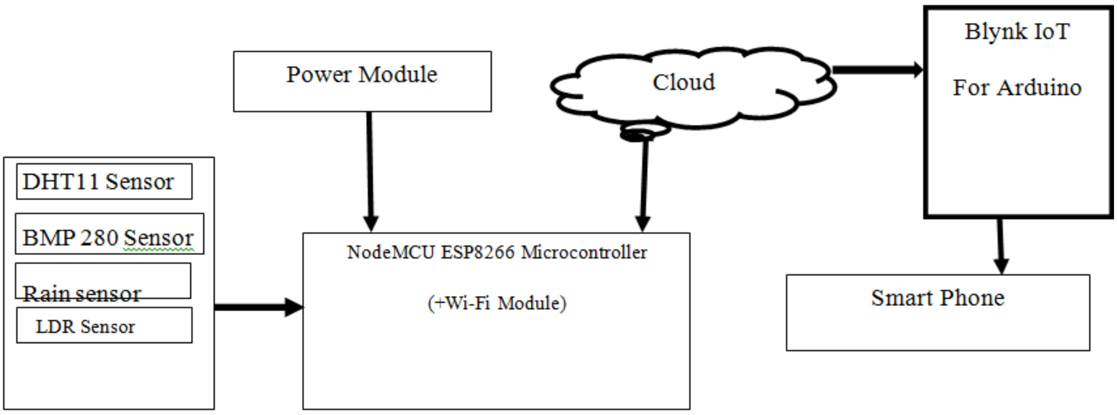


Figure 2. Architecture of the Proposed System

A. Required Modules

The proposed system architecture as shown in figure 2 provides the information of the required modules.

B. Hardware Requirements

- NodeMCU
- Wi-Fi Technology
- DHT11 Humidity and Temperature Sensor
- BMP 280
- Rain Sensor
- Light Dependent Resistor (LDR)
- Breadboard
- Jumper wires
- Smart Phone

C. Software Tools Required

- Arduino IDE for sketching and programming the microcontroller.
- C++ programming language.
- Fritzing software for component interfacing
- Blynk Platform.
- Android Operating System.

- Node MCU

The term "Node MCU" is derived from the combination of "node" and "MCU" (microcontroller unit). It represents an open-source firmware and development kit designed to facilitate the swift prototyping of IoT products through the use of concise Lua scripts. The platform is centered on an economical System-on-a-Chip (SoC) known as the esp8266.

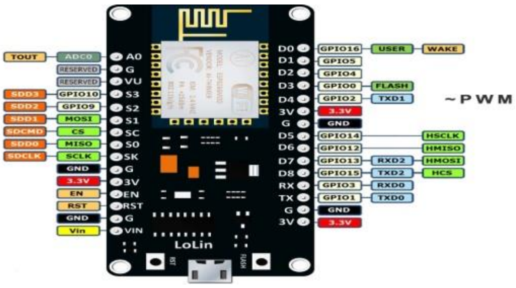


Figure 3. NodeMCU ESP8266

- Wi-Fi Technology

Wi-Fi is a wireless technology that facilitates seamless connectivity for computers, smartphones, tablets, and various electronic devices to access the internet. This technology empowers devices to effortlessly exchange information, establishing an interconnected network.

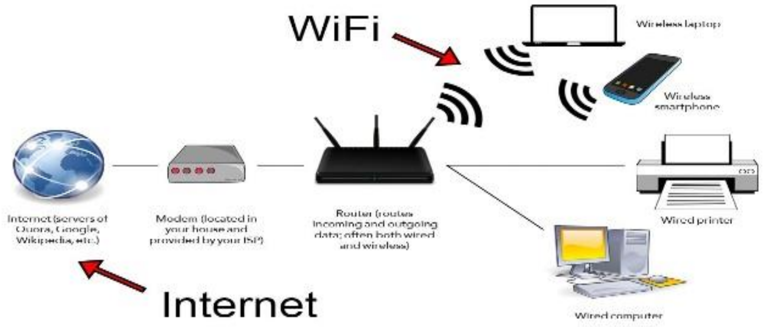


Figure 4. Wi-Fi Source: https://www.hellotech.com/blog/what-is-the-difference-between-bluetooth-and-wifi

- DHT11 Humidity and Temperature Sensor

The DHT11 is a basic, reliable and low-cost digital sensor used for sensing temperature and humidity.

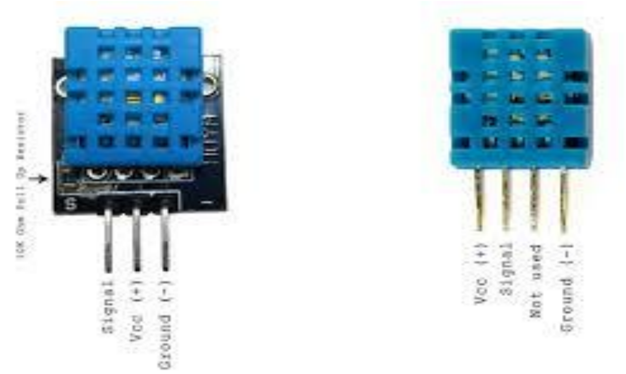


Figure 5. DHT11 Humidity and Temperature Sensor

- BMP 280

BMP 280 is an advanced sensor of BMP series. It is a high precision sensor module that monitors atmospheric pressure with great accuracy. The BMP280 sensor is tiny in size with low power consumption and robust performance.

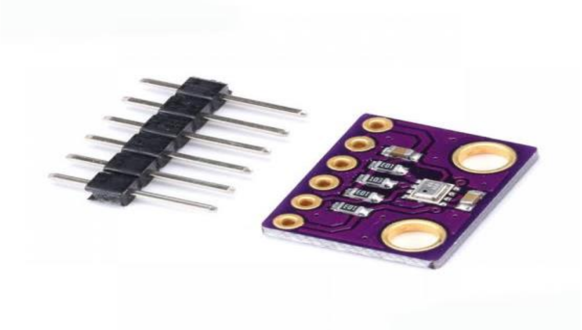


Figure 6. BMP 280 source:

- Rain Sensor

A rain sensor serves as a specialized switching device designed for the detection of rainfall. It comprises two primary components: a sensing pad and a sensor module. When raindrops make contact with the sensing pad's surface, the sensor module captures the data from the pad, processes it, and converts the information into either analog or digital output.

Figure 6. Rain Sensor

- Light Dependent Resistor (LDR)

A Light Dependent Resistor (LDR) is a distinctive type of resistor operating on the photoconductivity principle. This implies that its resistance dynamically adjusts in response to the intensity of light. When exposed to higher intensity light, the LDR experiences a decrease in resistance. Conversely, as the light intensity diminishes, the resistance of the LDR increases.

Figure 7. Light Density Sensor

- Breadboard

Breadboard is a type of circuit board which is used to build and test prototypes.

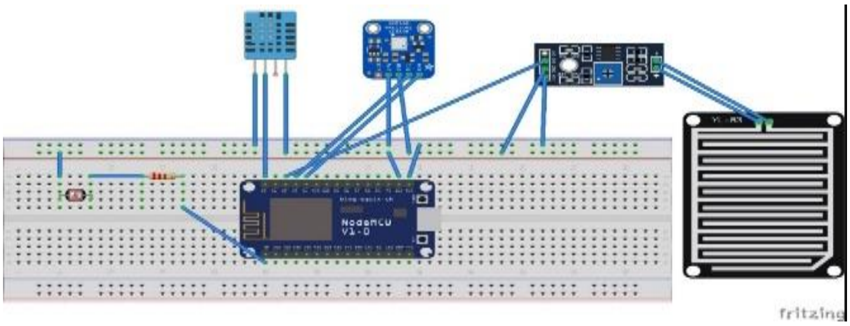


Figure 8. Breadboard Diagram of the System

- Jumper Wires

Jumper wires are typically equipped with connector pins at both ends, enabling them to establish electrical connections between two points in a circuit without the need for soldering. These wires are commonly employed to create links between components on a breadboard.

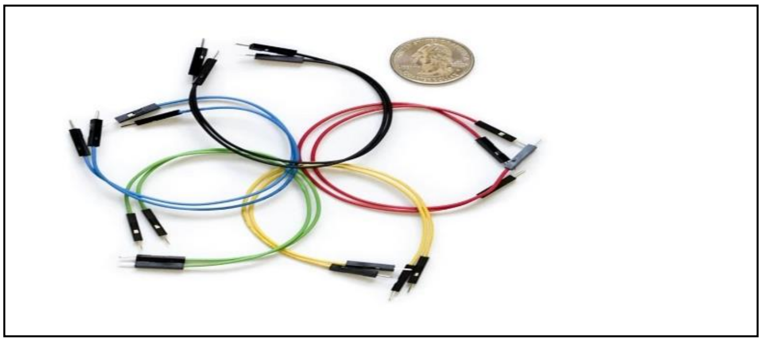


Figure 10. Jumper Wires

- **Smartphones**

Smartphones are uniquely suited to IoT because it is going to be everywhere since everyone carries a smartphone at all times. Smartphone is an IoT devices that can sense, control and communicate with other smart objects. With your smartphone you can control many IoT devices through an application.

Figure 11: Smartphone

- Blynk Platform

The blynk is an IoT platform which is responsible for the linking the hardware automatically to the internet. Once you have your login details, you can have access to the weather information from any part of the world.

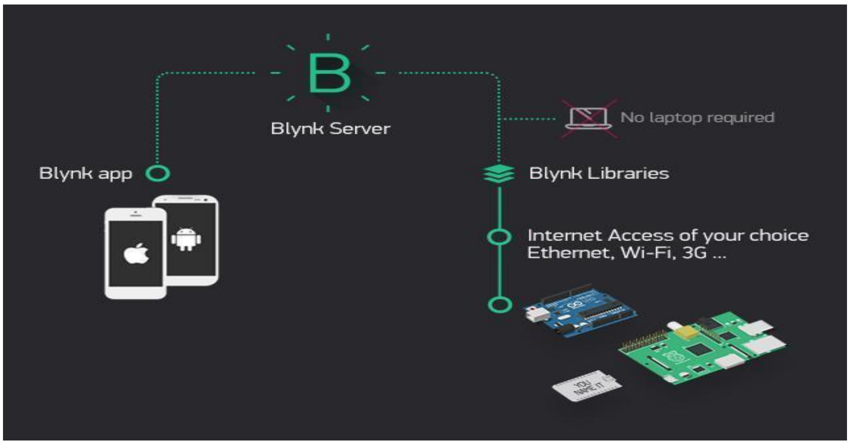
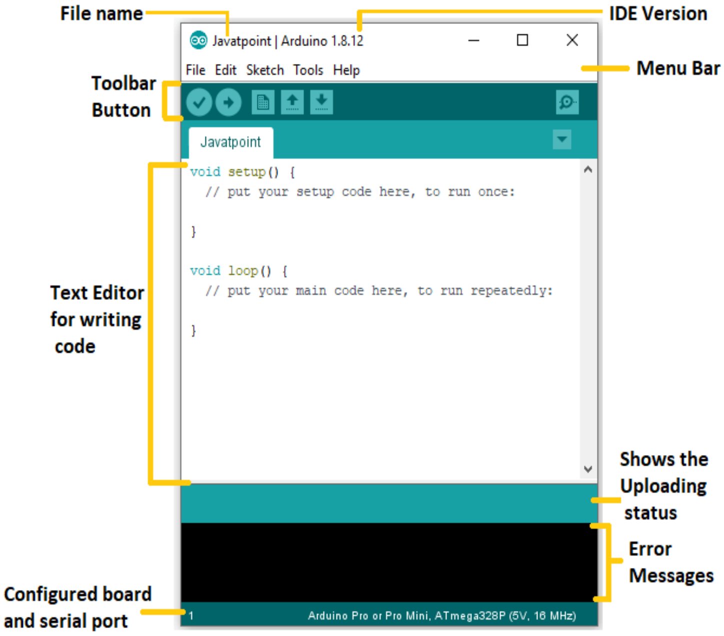


Figure 12: Blynk Cloud Architecture

- Arduino Integrated Development Environment (IDE)

The Arduino integrated development environment (IDE) is an open-source software that allows you to write and upload code to the Arduino boards. Arduino supports C++ and C programming language.



```
void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

}
```

Figure 13. Arduino IDE

- Fritzing software

Fritzing software is an open-source EDA software that allows you to model the interfacing of various component parts of the system. It was used for the virtual implementation of the system. Fritzing software is used for designing circuits on the breadboard. It provided models for most of the components used in building and modeling the circuits.

Figure 14. Fritzing interface

Mathematical representation of the Proposed system:

Let's denote:

i. T as the temperature measured by the DHT11 sensor in Celsius (°C).
ii. P as the pressure measured by the BMP280 sensor in hectopascals (hPa).
iii. R as the rainfall measured by the rain sensor in millimeters (mm).
iv. L as the light intensity measured by the LDR sensor in lux (lx).

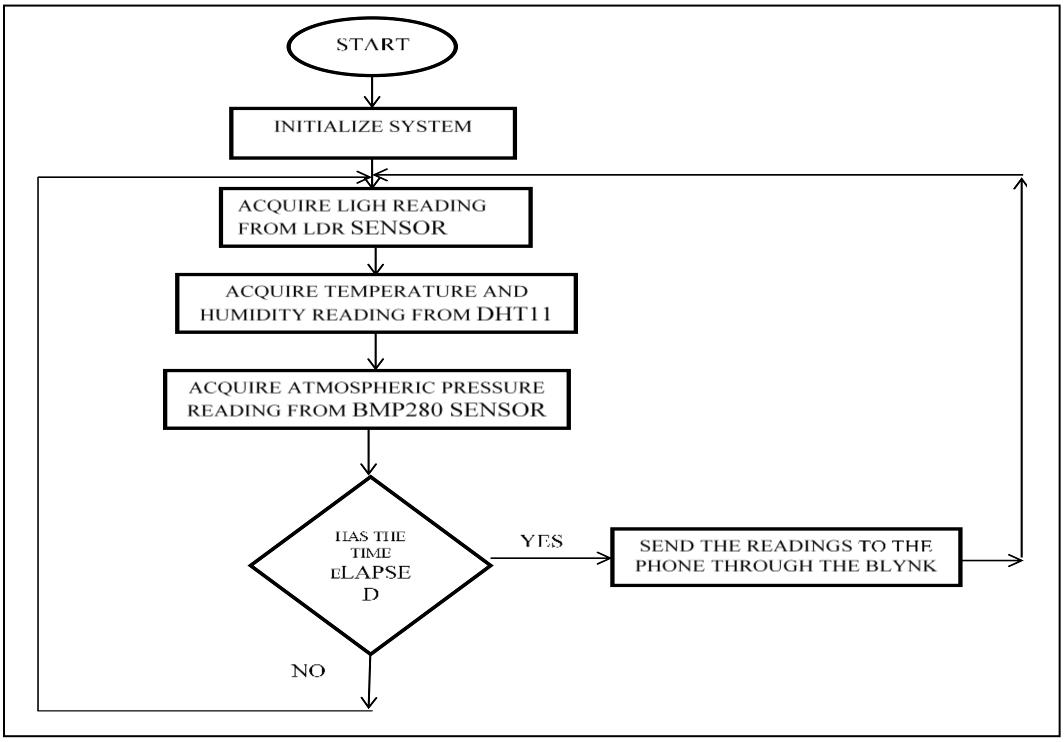


Figure 15:. Flowchart of the Proposed System

Algorithm of the Proposed System

The proposed algorithm for the system:

Step 1:
- Initialize the Node MCU ESP 8266 microcontroller and set up the Blynk app integration.
- Configure pins for connecting the DHT11 sensor, BMP 280 sensor, Rain Sensor, and LDR sensor
- Establish communication between the Node MCU ESP 8266 and the Blynk cloud platform.

Step 2:
- Continuously poll the DHT11 sensor to collect temperature and humidity data.
- Monitor the Rain Sensor to detect rain presence or absence.
- Retrieve atmospheric pressure data from the BMP280 pressure sensor.

Step 3:
- Preprocess the collected sensor data to ensure accuracy and reliability.
- Calculate the dew point from temperature and humidity readings.
- Aggregate the data from all sensors into a cohesive dataset.

Step 4:
- Analyze the rain sensor output to determine if it's currently raining or not.
- Process the pressure sensor data to understand changes in atmospheric pressure.

Step 5:
- Store cleaned and processed data on the Blynk cloud platform for historical reference.
- Utilize Blynk's data logging and storage capabilities for efficient historical data storage.

Step 6:
- Create a Blynk app dashboard with widgets for temperature, humidity, rain status, and pressure.
- Use Blynk's Virtual Pins to update the dashboard with real-time data.

Step 7:
- Set up threshold values for rain intensity and pressure changes on the Blynk app.
- Trigger Blynk notifications (push, email) when thresholds are exceeded.

Step 8:
- Regularly check sensor readings for anomalies or outliers and report to the Blynk app.
- Implement error handling to address sensor malfunctions or communication issues.

Step 9:
- Encourage users to provide feedback through the Blynk app interface.

- Use user feedback to enhance the Blynk app interface and system functionality.

Table 1: List of components required for the Proposed System

S/N	Name	Quantity
1.	Node MCU	1 piece
2.	DHT11	1 piece
3.	BMP 280	1 piece
4.	Rain Sensor	1 piece
5.	LDR Sensor	1 piece
6.	Breadboard	1 piece
7.	Jumper Wires	8 pieces
8.	Wiring and Miscellaneous	

Table 2: NodeMCU Specifications

Microcontroller	ESP-8266 32-bit
NodeMCU Model	Clone LoLin
NodeMCU Size	58mm x 32mm
Pin Spacing	1.1" (27.94mm)
Clock Speed	80 MHz
USB to Serial	CH340G
USB Connector	Micro USB
Operating Voltage	3.3V
Input Voltage	4.5V-10V
Flash Memory/SRAM	64GB /5MB
Digital I/O Pins	11
Analog In Pins	1
ADC Range	0-3.3V
UART/SPI/I2C	1 / 1 / 1
WiFi Built-In	802.11 b/g/n
Temperature Range	-40C - 125C

Table 3: BMP 280 Module Specifications

Specifications		BMP 280 Module Specification	
Operating Voltage	3.5V – 5.5V	**Operating Voltage**	1.3v-3.6v
Operating Current	0.3 mA	**Input Voltage**	3.3v-5.0v
Output	Serial data	**Peak Current**	1000uA
Temperature Range	0° - 50° C	**Operating Temperature**	40^{o}c to $+80^{o}$c
Humidity Range	20 – 90%	**Consumes standby**	0.1µA
Resolution	16-bit	**Maximum Voltage at SDA, SCL**	VCC +0.3v
Accuracy	±1% and ±1°C		

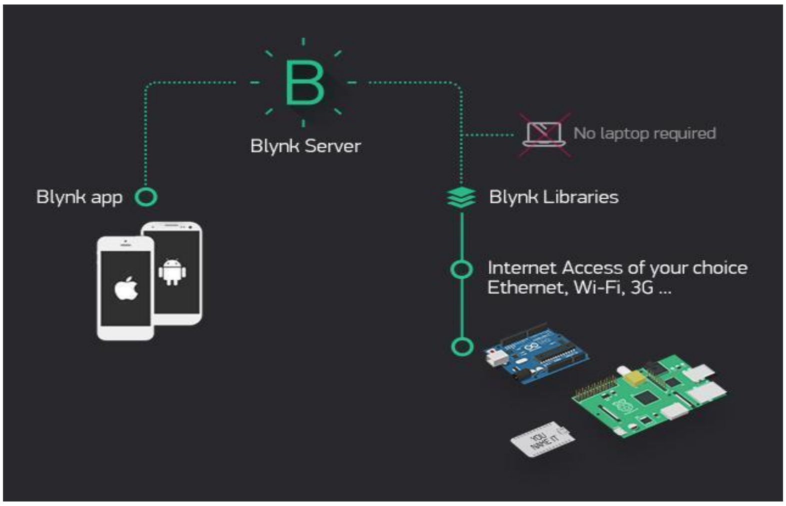


Figure 16: Blynk Cloud Architecture

IV. RESULTS AND DISCUSSION

Mode of Operation IoT Weather Monitoring System

Figure 17: Home screen **Figure 18: Online IoT Weather Monitoring System**

Figure 18 indicates that connectivity to the IoT weather station is successful. Therefore from any part of the world you can automatically gain access IoT weather monitoring system.

Display Storage of Weather Data Parameter

Figure 19 shows where the total reading of all-weather parameters are stored for every complete testing and references, this weather logged data may be retrieved by farmers for use and research purposes. The proposed system displays observations generated by the system, with weather conditions detected by the sensors thereby enabling the real-time visualization of weather parameters of temperature, humidity, pressure, rain and light.

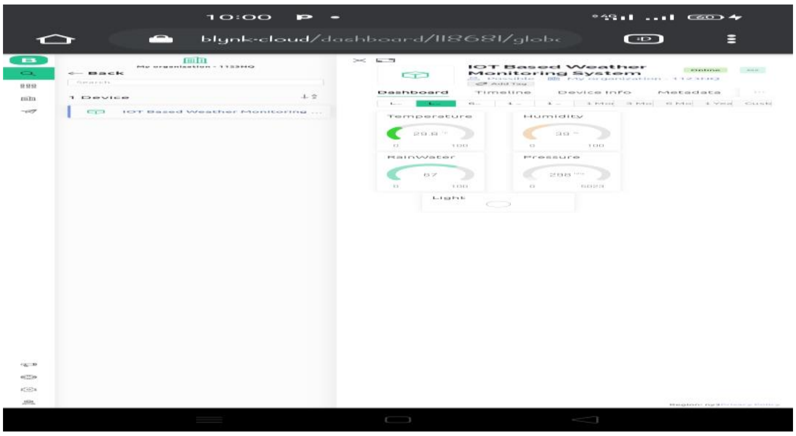


Figure 19: Display Storage of Weather Data Parameter

Speedometers Readings of Weather Parameters in the Absence of Rain and Light

Figure 20, shows the speedometer readings of the various parameters including temperature, humidity, pressure, rain water and light at different time interval from the weather station when there was no access to any light reflection and there was no rainfall or drop of water on the rain sensor. Most of the weather stations parameters required monitoring including temperature, pressure, rainfall and humidity. These parameters were tested at different interval of time frame to ascertain the appropriate weather conditions for the farmer.

The system was again tested to determine the appropriate weather conditions that are best suitable for farming and in this case, there was no rainfall considered. Demonstrates the responses obtained from monitoring a weather condition without rainfall, it was observed that the reading of the system at different timeframe reads temperature 31.1^{0c}, and 30.9^{0c}, and 31.1^{0c} respectively. For humidity reading we have $35.5^{\%}$, $35.7^{\%}$ and $35.6^{\%}$ respectively. For Pressure reading we have 311^{hpa}, 309^{hpa} and 311^{hpa} respectively. The sensor didn't perceive any light and as a result the light sensor remained off or was neutral when it didn't perceive or recognize the presence of light.

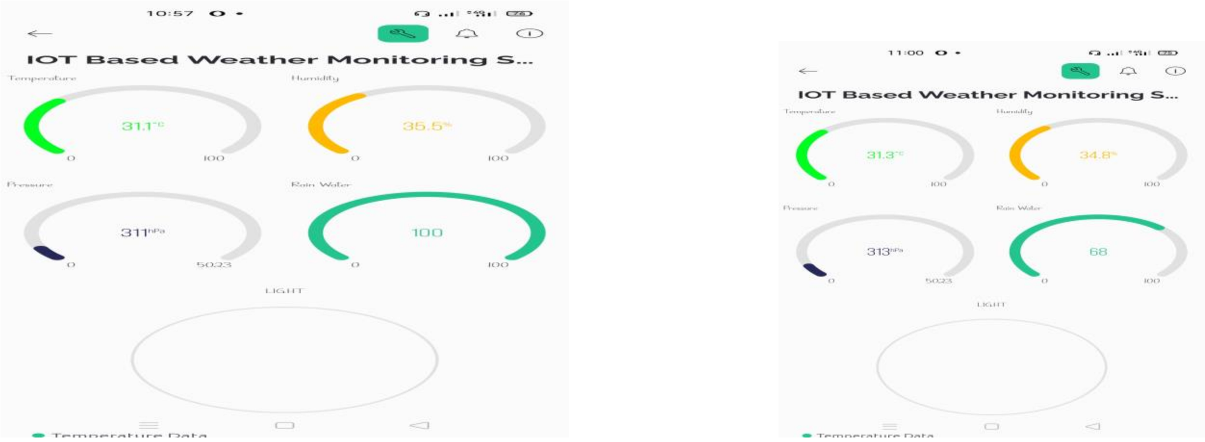


Figure 20: Speedometer readings of weather parameters in the absence of light and rain

Readings of Weather Parameters in the Presence of Light and Absence of rain

Figure 21 displays the speedometer readings of weather parameters at different timestamp when there was a reflection of light on the sensor and absence of rainfall. The rain water value is 100 by default. This means that there was no rain at the time the reading was taken or there was no drop of water on the sensor as well. The light sensor senses light just like a thermometer senses the temperature and a speedometer senses speed. The moment a flashlight is turned on, the light sensor detects surrounding ambient light and if the light disappears it automatically turns off. Moreover, the research related the results obtained for this reading to weather forecasting parameter and observed that the relative temperature suitable for planting in the Sub Sahara Africa is that plants grow well in moderate temperatures between 21°-29° C. Both higher and lower temperatures slow the plants rate of metabolism and growth. Plants grow fastest when the temperature during the lit period is kept between 22°-26°C, Most seeds prefer a relative humidity level between 50^{0c} and 60^{0c}, but this can vary depending on the type of seed the responses obtained in the system without rain water, it was observed that temperature reading was 30.1^{0c}, humidity $36.9^{\%}$, and $37.3^{\%}$, atmospheric pressure of 301^{hpa}

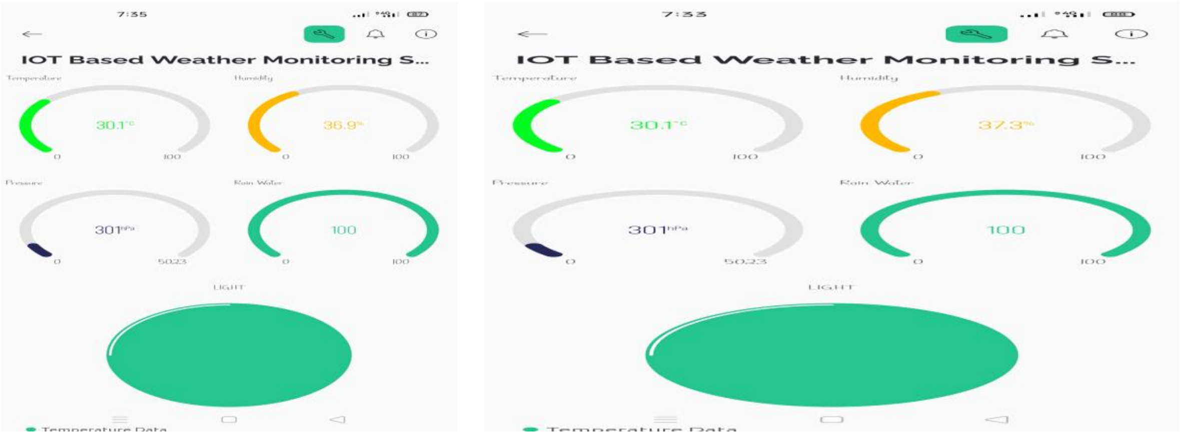


Figure 21: Readings of the Parameters in the Presence of Light and Absence of Rain

Evaluation of Weather Parameters on IoT Weather Monitoring System

Most of the reading obtained on the IoT based monitoring system was on real time based on the weather parameters such as temperature reading, humidity and rainfall. Table 4 shows the weather monitoring data log on Wednesday 23rd November, 2023, the monitoring was done on various time intervals.

Table 4: Weather Reading for Thursday 23rd November, 2023

Timestamp	Temperature Readings	Humidity Readings	Rainfall
6:00 AM	31.36	35.87	0
7:00 AM	31.82	35.76	0
8:00 AM	31.77	36.18	0
9:00 AM	31.5	34.61	0
10:00 AM	31.6	33.79	0
11:00 AM	32.07	28.59	0
12:00 PM	31.55	30.28	0
1:00 PM	31.44	34.46	0

The results were also analyzed in Figure 21 to show the responses between the parameters at given time stamps on weather data log.

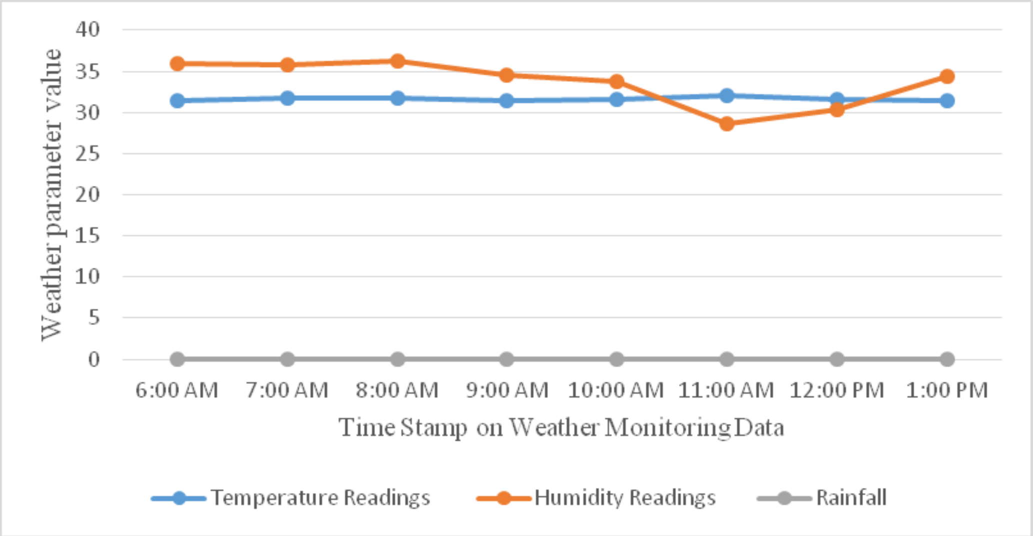


Figure 21: Responses on Temperature, Humidity and Rainfall on 23/11/2023

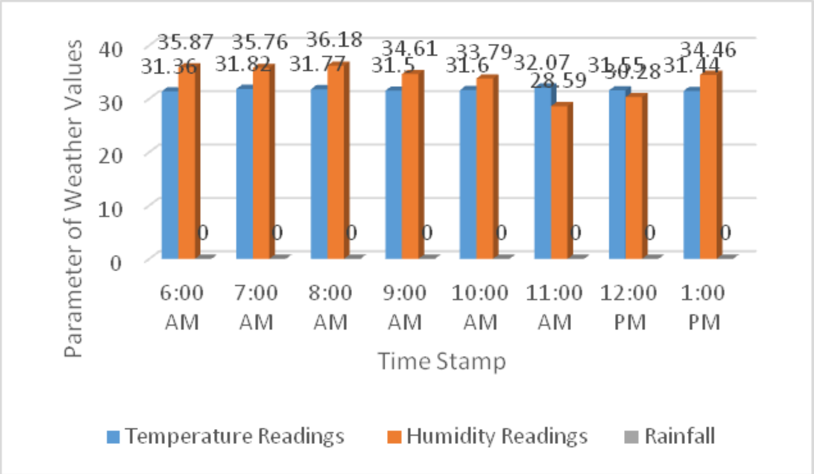


Figure 22: Bar chart Representation of Temperature, Humidity and Rainfall on 23/11/2023

Figure 22 represents Thursday, 23rd November, 2023 weather report for temperature, humidity and rainfall parameters. It shows that at 6am the temperature was 31.36^{0c}, humidity of 35.87%, with 0^{0} rainfall, at 7am the report obtained was that temperature was 31.82^{0c}, humidity of $35.76^{\%,}$ at with 0^{0} rainfall, 8:0am the temperature was 31.77^{0c}, humidity of $36.18^{\%}$, with 0^{0} rainfall, by 9am the temperature reading was 31.5^{0c}, humidity of $34.61^{\%}$ with 0^{0} rainfall. At 10am the temperature was 31.6^{0c} and humidity of $33.79^{\%}$, furthermore, by 11am the temperature was 32.07^{0c}, humidity of $28.59^{\%}$, again, at 12pm, the temperature raised to 31.55^{0c}, humidity was $30.28^{\%}$, and finally, at 1pm temperature was 31.44^{0c}, and humidity was $34.46^{\%}$ with 0^{0} rainfall in all.

Table 5: Weather Monitoring Reading for Friday, 24th November, 2023

Timestamp	Temperature Readings	Humidity Readings	Rainfall
6:00 AM	30.66	37.25	0
7:00 AM	32.95	23.75	0
8:00 AM	32.4	26.63	0
9:00 AM	31.87	27.87	0
10:00 AM	31.75	33.18	60
11:00 AM	31.51	36.02	0
12:00 PM	31.55	34.58	0
1:00 PM	31.71	34.03	0

The reading obtained on the IoT based monitoring system was on real time based on the weather parameters such as temperature reading, humidity and rainfall. Table 5 shows the weather monitoring data log on Thursday 24th November, 2023, the monitoring was done on various time intervals 6:00 AM7:00 AM,8:00 AM, 9:00 AM, 10:00 AM, 11:00 AM, 12:00 PM and 1:00 PM.

The results were also analyzed in Figure 23 to show the responses between the weather parameters at given time stamps on weather data log**.**

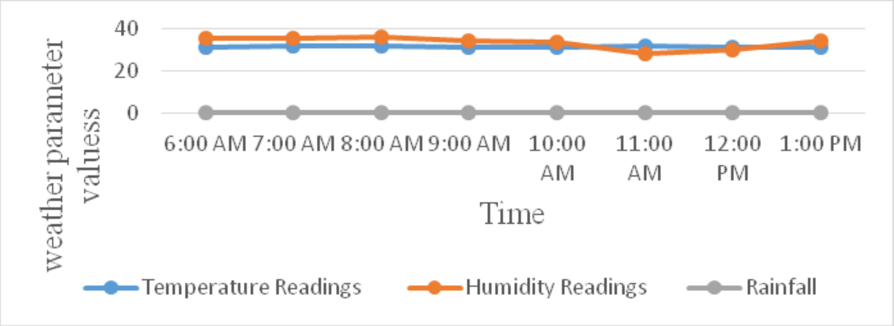


Figure 23: Relative responses of weather parameters on Friday, 24th November, 2023

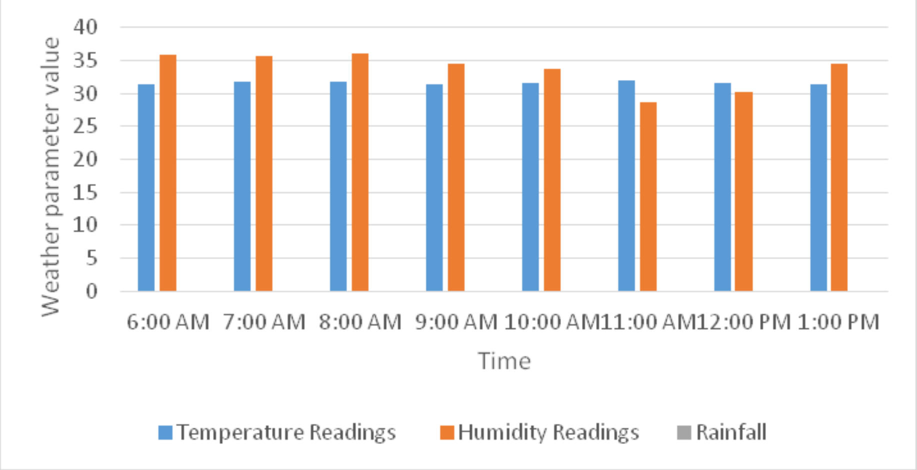


Figure 24: Bar chart of Temperature, Humidity and Rainfall on 24/11/2023

Most of the reading obtained on the IoT based monitoring system was on real-time based on the weather parameters such as temperature reading, humidity and rainfall. Table 4.4 shows the weather monitoring data log on Saturday 25th November, 2023, the monitoring was done on various time intervals.

Table 6: Weather monitoring reading for Saturday November 25th, 2023

Time	Temperature	Humidity	Rainfall
6:00 AM	32.2	26.84	0
7:00 AM	32.44	26.41	0
8:00 AM	31.78	27.15	0
9:00 AM	32.29	30.69	0
10:00 AM	32.15	35.7	0
11:00 AM	31.85	36.91	0
12:00 PM	31.82	36.13	0
1:00 PM	31.85	35.37	0

Figure 25 represents Saturday, November 25th, 2023 weather report for temperature, humidity and rainfall parameters it shows that at 6am the temperature was 33.26^{0c}, humidity of 25.84%, with 0^{0} rainfall, at 7am the report obtained was that temperature was 313.82^{0c}, humidity of $25.96^{0,}$ at with 0^{0} rainfall, 8:0am the temperature was 35.12^{0}, humidity of 35.88^{0}, with 0^{0} rainfall, by 9am the temperature reading was 34.45^{0}, humidity of 34.61^{0} with 0^{0} rainfall. At 10am the temperature was 31.6^{0} and humidity of 33.79^{0}, furthermore, by 11am the temperature was 32.07^{0}, humidity of 28.59, again, at 12pm, the temperature raised to 32.15^{0}, humidity was 35.28^{0}, and finally, at 1pm the 32.14 and humidity was 35.10^{0} with 0^{0} rainfalls in all.

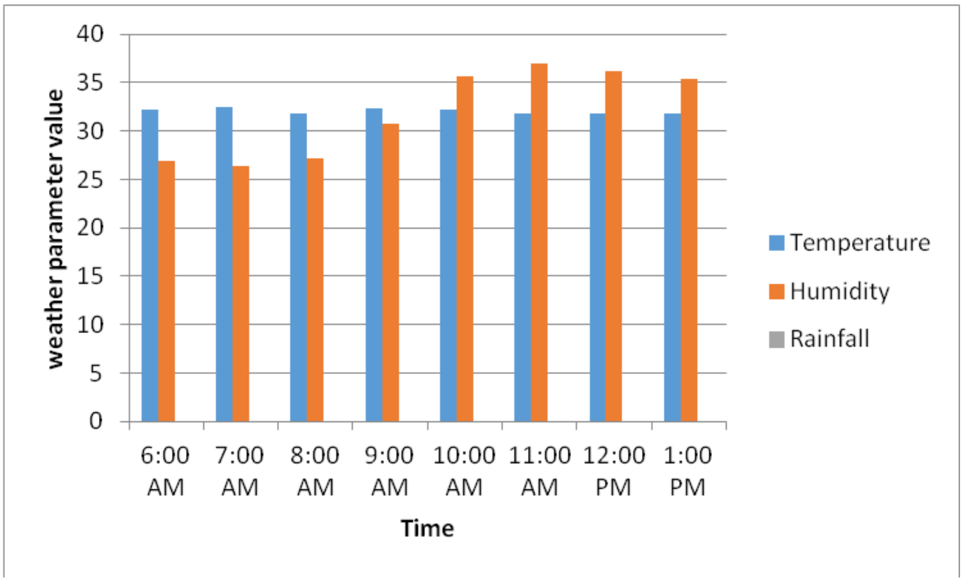


Figure 25: Bar chart of Temperature, Humidity and Rainfall on 25/11/2023

Table 7: Weather monitoring reading for Sunday November 26th, 2023

Time	Temperature	Humidity	Rainfall
6:00 AM	29.88	35.59	0
7:00 AM	30.45	33.02	0
8:00 AM	31.00	31,54	0
9:00 AM	32.23	31.96	0
10:00 AM	31.14	33	0
11:00 AM	31	33.86	0
12:00 PM	31.37	34.38	0
1:00 PM	31.44	34.46	0

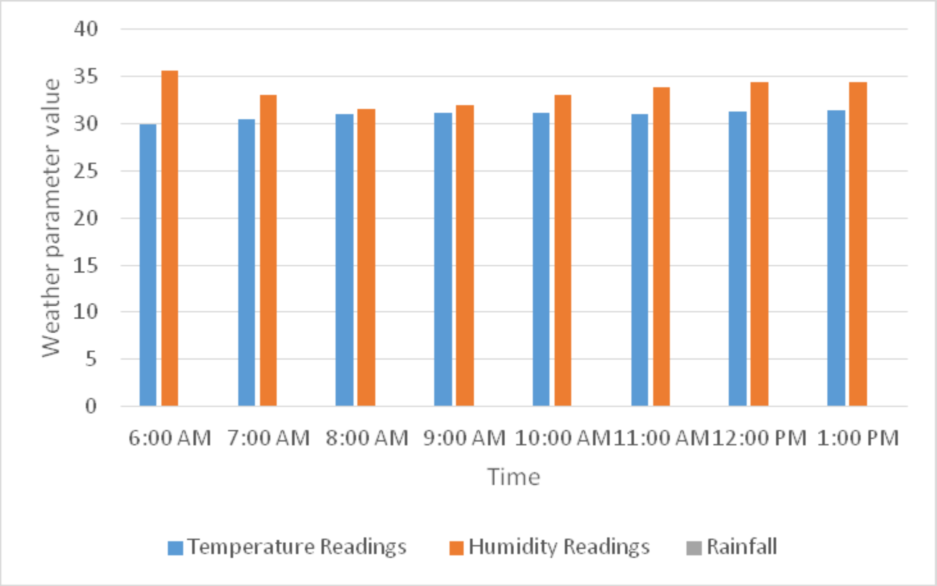


Figure 26: Bar chart of Temperature, Humidity and Rainfall on 26/11/2023

Improvements Made on the Existing System

Table 8: Improvements Made

S/N	Existing System	Proposed System
1	The existing system utilizes a 5v battery leading to shorter operating times before needing recharging or replacement. Voltage drops may occur, especially if the battery capacity is low or when multiple components are active simultaneously, impacting the stability and reliability of the system. Some components may require a higher voltage input for optimal performance, leading to compatibility issues or the need for additional voltage regulators future enhancements or additional features requiring higher power consumption may be limited due to the constraints of the lower voltage battery.	The new system utilizes a 9v battery offering a higher capacity, allowing for longer operating times and reduced frequency of recharging or replacement. The higher voltage provides a more stable power supply, minimizing voltage drops and ensuring consistent operation of the system. Components requiring higher voltage inputs can be easily accommodated without additional converters or regulators, improving overall compatibility and performance. The higher voltage capacity of 9v allows for easier integration of additional features or enhancements that may require power consumption in the future, enhancing the system's overall flexibility.
2	The existing system that measured pressure utilized BMP 180 sensor or Less. The BMP180 sensor may have lower accuracy compared to more advanced sensors like the BMP280, leading to less precise pressure measurements. The BMP180 sensor may have a limited measurement range, which can be a constraint in certain weather monitoring scenarios where a wider range is required. Older or less advanced sensors like the BMP180 may lack advanced features such as temperature compensation or additional data inputs.	The new IoT-based weather monitoring system is designed to utilize BMP280 sensor. The BMP280 sensor offers higher accuracy in pressure measurements, providing more reliable and precise data for weather monitoring applications. With a wider measurement range, the BMP280 sensor can capture a broader range of pressure variations, making it suitable for diverse weather conditions. The BMP280 includes advance features like temperature compensations, which ensures the accuracy of pressure measurement readings, and additional data inputs, providing more comprehensive weather data for analysis. Overall this makes the system more effective and reliable for farming applications.
3	The existing system might depend on LCDs for display. LCDs are limited by the size of the screen, often requiring scrolling or limited display information at once. LCD-based systems typically have limited user interaction options, such as buttons or menus, which may not provide a rich user experience. LCDs are static and require physical access to view data, limiting remote monitoring capabilities and real-time data access. LCD-based system may have limited integration capabilities with other devices, making it challenging to expand functionalities or integrate with cloud services. LCD-based system may require additional hardware components, wiring, and maintenance, adding to the overall cost and complexity.	The new system offers a larger and more flexible display area via the Blynk IoT platform allowing for comprehensive and easy-to-read visualizations of weather data. Blynk IoT platform provides a dynamic and customizable interface through smartphones, enabling interactive features like touch controls, real-time updates, customizable widgets enhancing user engagement and convenience. Blynk IoT platform allows remote monitoring of weather data from anywhere with internet connectivity providing instant access to sensor readings. Blynk IoT platform offers seamless integration with a wide range of IoT devices, sensors, and cloud services facilitating easy expansion, customization and integration of new features or third-party services as need. Blynk IoT platform via smartphones reduces hardware costs, simplifies installation and maintenance and leverages existing devices (smartphone), making it a more cost-effective and user-friendly solution in the long-run.
4	The existing system may require an uninterrupted power supply from a solar panel, which may be affected by sunlight availability, and energy storage capacity, leading to potential system downtime or data loss.	The new system offers flexibility by providing a USB port for connecting to solar power. This allows for more reliable power supply management, backup options, and the ability to utilize storage devices or backup power sources, minimizing the risk of system interruptions and ensuring continuous operations.

Evaluation of Results of the Existing Systems and Proposed System

Table 9: Traditional Method versus Proposed System

Thermometer(Conventional)	DHT11 Sensor (Proposed System)	Difference
28.7	30.66	-1.96
29.2	32.95	-3.75
29.9	32.4	-2.5
29.9	31.87	-1.97
30.1	31.75	-1.4
29.4	31.51	-2.11
29.8	31.55	-1.75
30.5	31.71	-1.21

Table 9 shows the conventional approach reading for weather temperature, the DHT11 sensor was proposed for the study. The difference between the conventional and the proposed system are all negative due to weather climate change, deforestation and weather mitigations. The results could also be analyzed in Figure 27

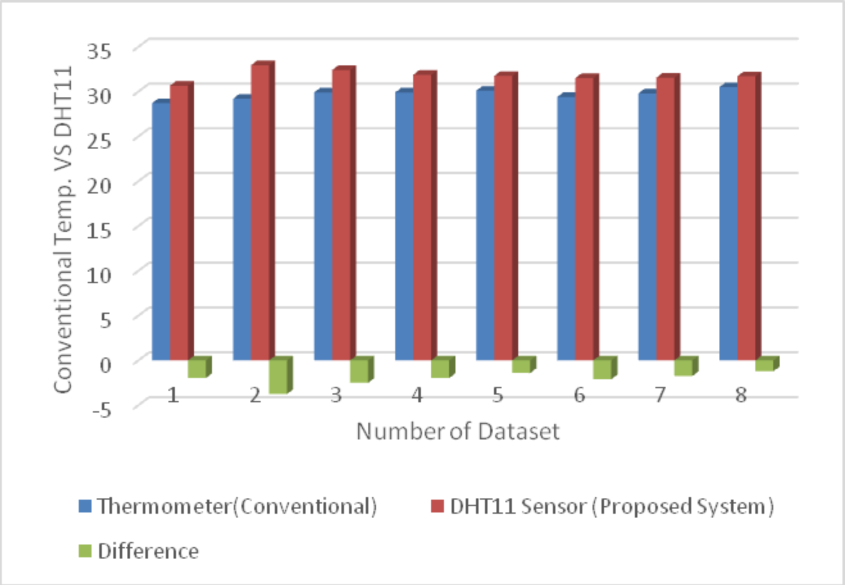


Figure 27: Comparison of Conventional Temperature Reading with DHII Sensor

Table 10: Evaluation of Existing Study (Suleiman et. al, 2022) with the Proposed System

Existing System (DHT11)	Proposed system(DHT11)	Difference
28.5	30.66	-2.16
29.6	32.95	-3.35
29.6	32.4	-2.8
29.5	31.87	-2.37
29.1	31.75	-2.62
29.3	31.51	-2.05
28.9	31.55	-2.65
29.6	31.71	-1.81

As shown in Table 10, the value 28. 5, 29.6, 29.6, 29.5, 29.1, 29.3, 28.9, 29.6 degree Celsius represents the temperature measured by the DHT11 sensor in the existing system under specific conditions and the value 30.66, 32.95,32.4,31.87, 31.75,31.55,31.71 degree Celsius represents the temperature measured by the DHT11 sensor in the new system under different conditions. The variation in DHT11 sensor readings for temperature between the existing system and the proposed system can be attributed to the hardware differences. The existing system used ATmeg32 microcontroller, while the new system utilized ESP8266 microcontroller. These microcontrollers have different analog-to-digital converters (ADCs), clock speeds, and handling of sensor data, which can lead to slight variations in readings.

However, the proposed system utilized a 9v battery, whereas the existing system used a 5v battery. The DHT11 sensor's performance can be affected by the voltage supplied to it. Even though the DHT11 sensor is designed to operate within a certain voltage range, variations in voltage supply can impact its accuracy.

As a result of these variations we ensured that our power supply voltage was stable and within the recommended range for the DHT11 sensor to improve accuracy of our results and our ESP 8266 performs more optimally than the ATMEGA32. The results could also be analyzed in Figure 28

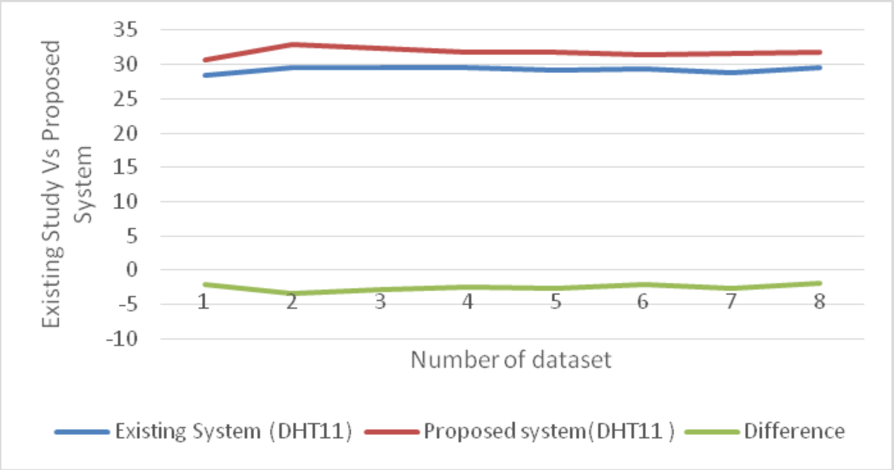


Figure 28: Comparison of the Existing Study and the Proposed System.

V. CONCLUSION

This study improved IoT-based weather monitoring system for effective farming builds upon the foundation of traditional weather monitoring methods by integrating IoT devices, advanced sensors and cloud technologies. The proposed model, the system captures a wide range of weather data including temperature, humidity, pressure, rainfall and light intensity providing a comprehensive view of environmental conditions crucial for farming. The integration of IoT technology and the Blynk IoT platform, allows farmers monitor weather conditions in real-time through their smartphones. The weather data is securely stored and easily retrievable allowing farmers to access data and informed-decision making. This enhances the system's utility as a decision support tool for effective farming practices. By utilizing solar power along with a 9v battery for the power supply, the system promotes energy efficiency and sustainability. This ensures operation of the weather monitoring system while minimizing environmental impact and operational costs. The system offers a cost-effective solution for weather monitoring compared to traditional weather stations. The smartphone interface provided by the Blynk IoT platform offers a user-friendly experience for farmers to access weather data and interact with the system, this enhances usability and adoption of the weather monitoring system in agricultural settings.

The system's modular design allows for easy integration of addition sensors or functionalities as needed. Farmers can scale up the system to monitor additional parameters or integrate with other agricultural systems for comprehensive farm management. By providing accurate and timely weather data, the system empowers farmers to make data driven-decisions regarding irrigation, pest control, planting schedules, and resource allocation. This leads to improve crop yields, reduced losses, and optimized farming practices. The proposed system tailored for capturing, storing and retrieving weather data using advanced sensors, IoT technology and smartphone integration offers a robust solution for effective farming. It enhances farm management, productivity, and sustainability while providing farmers with insights to make informed decisions and mitigate risk.

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