Various Applications of IoT-based Weather Monitoring Systems in the Agricultural Sector for Bangladeshi Farmers.

Varias aplicaciones de los sistemas de monitoreo meteorológico basados en IoT en el sector agrícola para los agricultores de Bangladesh.

Md Sofiqul Islam
mdsofiqulislamsumon66@gmail.com
Md.Saiful Islam
222198040@student.presidency.edu.bd
Jahangir Hossain Rabbi
222198040@student.presidency.edu.bd
A S M Binjer Anayet Biddut
222198040@student.presidency.edu.bd
Md.Salman Hossen
222198040@student.presidency.edu.bd

Department of Electrical and Electronics Engineering, Presidency University, Dhaka-Bangladesh

Abstract : Climate change is playing a significant role in agriculture. As an agriculturally efficient country like Bangladesh, smart farming is needed to effectively help farmers adapt to this climate change. The main objective of this IOT based project is to increase efficiency, especially in mushroom farming and shrimp fishing. In both cases, smart farming requires real-time weather information from farmers. This system enables farmers to monitor temperature, humidity, and water levels at any moment from anywhere in the world using their smartphones. This system focuses on local farmers in different districts of Bangladesh, where they are able to monitor the weather for their decision-making and optimize the concept of real-time scheduling for specific food crops. Local rice farmers who are using real-time weather monitoring systems can know the exact moment of their rains, which helps them determine the time to harvest their mature rice. This approach will open up a new avenue for our local farmers through which they can increase their capacity through mushroom cultivation and shrimp farming more than before, which will help boost the economy of a country like Bangladesh a lot.

Keyword : IoT,Esp-8266,DHT-11 Sensor, Farming-Bangladesh

1.Introduction

Most of the people of Bangladesh are very involved in agriculture, so they need to know the weather conditions very well. Most of the farmers in Bangladesh are local farmers, and if the crops they produce can be produced smartly, then there is a very good potential in the economic sector of Bangladesh. Good crop production has become a big problem in Bangladesh now. Rapid urbanization and population growth have led to climate change in Bangladesh, Holovatyy, A., 2021 [1]. As a result, the weather in Bangladesh is now very unpredictable. In such a situation, if you want to cultivate mushrooms and shrimp, whether the temperature and water level are constantly changing or not and whether there is a possibility of rainfall, farmers need to know real-time information about all these things, Annika, V. O. (2023). [2]. Every year in Bangladesh, it is seen that many farmers suffer extensive damage to their winter vegetables due to unexpected rains during the winter. At that time, farmers claimed that they could not be on alert in advance because they did not know whether the rain would come or not, which resulted in maximum damage to their crops.

Shrimp farming and mushrooms are among the agricultural products exported by Bangladesh. Mushroom and shrimp farmers in Bangladesh have not yet been able to significantly increase the effectiveness of their farming because they have not yet implemented smart cultivation, meaning they have not yet implemented the proper use of IoT-based weather monitoring systems, .Islam M.S.,(2024) [3]. Due to excessive water height and low water pressure, shrimp farmers in Chittagong often face the danger of many shrimp fish dying because they are not yet familiar with the use of IoT-based technology, which has resulted in their productivity not increasing much. Also, many farmers in Bangladesh cultivate salt, and measuring water levels is very important for this salt, and in this case, an IoT-based weather monitoring system is an acceptable system through which farmers can always be informed about the water level.

To address the climate change problem in Bangladesh, Bangladeshi farmers need to adapt very quickly to the best weather monitoring system built on our own technology, through which they will be able to collect real-time monitoring information and make decisions very easily. Our system is primarily designed for the farmers of our country so that they can get daily forecasts and make informed decisions very quickly to save their resources from being wasted[4].Our proposed system uses a variety of sensors that are integrated and perfectly installed to measure pressure, temperature, water level, humidity in a specific area and collect real-time data. Due to climate change, farmers in our country are worried about the weather in the coming months. If they have a summary of the real-time data from the previous year, they can easily use that summary to make a forecast for the next month. Since our system stores real-time data in the cloud system, farmers can easily review the data from the previous year or month and prepare a forecast for the next month. We have tried to make this proposed system as simple as possible so that all farmers at the village level can use it with very little difficulty and get the proper benefits and they can be financially successful.

The proposed system can update the farmer with accurate weather forecasts twice a day to help farmers make informed decisions on which activities to carry out without wasting resources[5]. A similar application was developed for greenhouse gases, where an IoT weather monitoring system was created to provide real-time data on greenhouses, updating weather conditions every moment[6]. This system stored real-time data, such as humidity, light, and air pressure, in IBM Store cloud storage. The advanced IoT weather monitoring system reviewed weather updates every moment and automatically notified the greenhouse manager via email if it saw any major changes in temperature, which is an excellent system that can quickly detect damage and balance the greenhouse temperature. As technology continues to advance, modern agricultural methods like greenhouse farming are becoming increasingly popular. These innovative practices enable effective monitoring and control of greenhouse environments, offering valuable insights for crop management. This can be achieved through cost-effective and low-power consumption systems, utilizing technologies such as Arduino. These systems can connect to WiFi networks and operate on the global internet system, facilitating the optimization of climatic conditions based on crop data[7].

2. Literature review

A literature review will focus on IoT-based weather monitoring systems using Esp-8266 and various sensors, including calibration techniques, data processing algorithms, and practical applications. It will describe various challenges that were faced and accurate information of weather conditions that sensors are provided. Along with power delivery, & consumption, its future fields will also be highlighted. Currently there are many ongoing studies on IoT based monitoring system and this paper will discuss its future. This paper will also study the basics of IoT based monitoring systems and will focus on its impact on various fields like agriculture, Industry and the future potentiality in numerous sectors[8].

Current existing methods for weather monitoring mainly use analog instruments such as thermometers, barometers, wind vanes, rain gauges to measure weather and climate changes. Most of the instruments use very simple analog technology and instead physically record the changes and store them in a database. This information is then transmitted to news stations and radio stations where weather reports are provided[9].In addition, existing weather monitoring systems use heavy equipment that is difficult to maintain and needs to be replaced frequently. Moreover, they have to be operated manually which is time

consuming. Apart from this, these machines consume a lot of power and also face a lot of problems in maintaining the accuracy of the data and if the temperature changes, it has to be checked manually. The data that is obtained manually is sent to the computer through the logger. Moreover, heavy winds make it very difficult to move the equipment from one location to another and many spaces are needed. The biggest problem to face is that it delays warning messages in case of sudden weather changes[10].

On the other hand, by this technique farmers don't need much equipment to measure the weather parameters. By using this technique they will aware the current situation in their farms or fields. If any bad condition occurred they will have enough time to solve the issues . Specially the shrimp farmers will get the temperature information in every moment which is necessary for the shrimp farming. Moreover it does not need a huge place to place it in the farms. So it is basically more convenient for the Bangladeshi farmers to operate and set up. So this IoT based weather monitoring system will have a huge impact on the agricultural sector in Bangladesh.

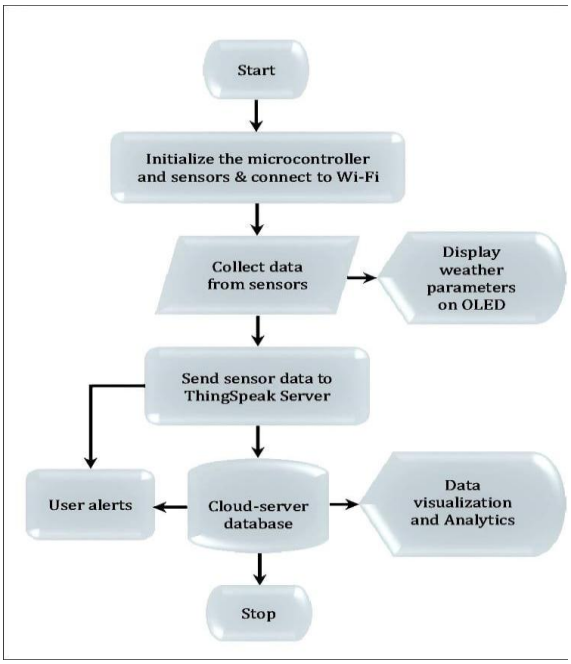
After the spread of the Internet, IOT has become a symbol of trust in various sectors, especially in the data sector, agricultural sector as well as business organizations. IoT basically means a system through which data can be exchanged and communicated continuously without any connection of wire. One of its purposes is to determine, observe, locate, and manage any object according to its predefined goal. And this idea has not only increased the capabilities of the Internet several times, but has also connected people to any object as well as among themselves. The IoT framework allows us to connect the various objects around us in a variety of ways.

The concept of IOT will stand as an emerging communication medium in the world with various everyday objects that will ensure that the objects are connected to a microcontroller or powerful communication device. This will ensure seamless communication between the objects themselves and with the users that will enable Internet use. IoT aims for the Ubiquitous introduction and expansion of the internet. Through it, we can connect electronic objects in our homes, surveillance cameras, cars, and important devices, which increases our own security several times. Individuals, government institutions, and business organizations analyze the data provided by IoT. Can be identified and used for various purposes. Contemporary technological advancements dictate the management and activities of various objects[11].

Daily weather monitoring affects our daily lives. These results significantly affect our various sectors, including agriculture, industry, and construction. But the primary impact can be felt by agriculture and industry. The weather monitoring system continuously displays the overall condition of a specific place. Basically, based on the data provided by the sensors, it predicts the weather of a specific region through some mathematical models. Daily weather monitoring affects our daily lives. These results significantly affect our various sectors including agriculture, industry, construction. But the primary impact can be felt by agriculture and industry[12]. Basically, based on the data provided by the sensors, it predicts the weather of a particular region through some mathematical models. At present, IoT is widely used by various reputed companies in their various canters such as the one based in Barcelona called open dot. This weather monitoring solution uses IoT technology to collect data on various topics including temperature, air pressure, humidity, gas, water level. Basically the sensors provide the data to the user in their mobile application and the user can access it in real time. So If our government want to plan how to increase our agricultural productivity by 2030 they will definitely need a modern solution to solve farmers limitations. If our government subsides heavily on the weather forecasting method like this one then our farmers can harvest much more crop than we have now. Because farmers don't get information in real quick to solve the weather issues in their farms. Government should spend around 100 millions to the real time weather forecasting like IoT based weather forecasting system.

Sensors are systematically installed at different locations and they collect the weather data of that location and display an accurate result. The main objective of this paper is to develop an effective weather monitoring system through which accurate information of important weather parameters of any place can be obtained and stored in the cloud. Usually sensors are connected to the environment so that they can present real data of different parameters. And of course, as the weather changes, the parameters and data

will continue to update and show the data for that particular period[13]. By this, our farmers will have a clue what to do next for their crops safety. For example, If this system give a data about heavy humidity then our rice or cabbage farmers will aware about mold or bacteria spread in the field. According to the information they can spry pesticides to the crops.



3.Methodology

IoT-based Weather Monitoring system is a system where using some sensors that collect to device, process and transfer the real time weather data. These sensors generally using for measuring temperature, humidity ,air pressure and environmental factors that are connected into internet either microcontroller or cloud based-platform[14]. The collected data is transmitted wirelessly, stored in a database, and used for analysis. Using IoT technology, this system ensures continuous monitoring, remote accessibility, and real-time updates, making it an effective and common solution for weather forecasting, agricultural planning, and disaster management [15].

3.1Working Principle

Here the first step is the process begins initializing to the system. Then initializing the microcontroller and sensors(like temperature, humidity, pressure)And the system established a connection with Wi-Fi for data transmission. Collect data from the sensors that are environmental parameters like temperature, humidity and pressure are gathered[16]. Started the parallel process that displays weather parameters on OLED and send sensor data to thingspeak server. The collected data shown on display then send into thingspeak server. Then sent data starting processing and stored the data further analyzing[17]. The stored data is used for visualization, trend analysis, and predictive weather modeling. Another step that if certain something went wrong (like over heat or humidity) alerts are sent to users.At the last when need to stop then stop the program[18]

Fig-1

3.2All Components

IoT based weather monitoring system, Some important sensors used in this project are 5V Buzzer, DTH11, Ultrasonic sensor, PIR sensor, LCD & 12C, MQ2 sensor, Nodemcu Board, Relay Module, 5V source etc. Below is a detailed idea about all these components.

Components Name :

1.Nodemcu (ESP-8266)	2.DHT-11 Sensor	3.Ultrasonic Sensor
4.Realy Module	5.LDR sensor	6. 5V Buzzer
7.Pair sensor	8.MQ-2 sensor	9.LCD & 12C Module
10.5V DC source		

5V Buzzer

The famous 5V passive buzzer is used in endless projects with all different kinds of microcontrollers including the Raspberry Pi and Arduino. It is great to add audio alert to electronic design. The buzzer will push straight into a breadboard for prototyping and can also be soldered to a standard 1.6mm PCB.

5V Buzzer(fig-2)

DTH11 Sensor

In this project, DTH11 is used to measure temperature and humidity. Basically, this sensor is used to detect the existence of temperature and humidity. It is a low-cost digital sensor for checking temperature and humidity. It can be easily connected to Arduino and take temperature and humidity readings**.**

DTH11 Sensor(fig-3)

Ultrasonic Sensor

An ultrasonic sensor is a device that measures the distance to an object using ultrasonic sound waves. It is a device that uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity. High frequency sound waves reflect across boundaries to produce distinct echo patterns.

Ultrasonic Sensor (fig-4)

PIR Sensor

Passive infrared sensor(PIR) is basically a motion detector sensor that detects whether any object is moving. It is a sensor used in motion detectors such as automatically triggered light devices and security systems that measure infrared light emitting devices in their field of view.

PIR Sensor(fig-5)

LCD & 12C Module

LCD & 12C refers to Liquid crystal display integrated with 12c communication interface that easily connect to the internet or any kind of pcb. Its basically made for Audino based system for allowing any kind of information get to by user.

LCD & 12C Module(fig-6)

MQ-2 Sensor

MQ-2 is a versatile gas sensor. Its capable to detect gas, alcohol, carbon monoxide, liquefied petroleum gas, propane and smoke. Such this detect the multiple gases but it has lack of the difference between them.

MQ-2 Sensor(fig-7)

ESP- 8266 Board

Nodemcu-8266 board design as a small, affordable development board that allows to connect with the internet so easily via Wi-Fi with utilizing esp8266 cheap. It basically designs for Audino IDE project and python-based project. It powerful board for this type of project.

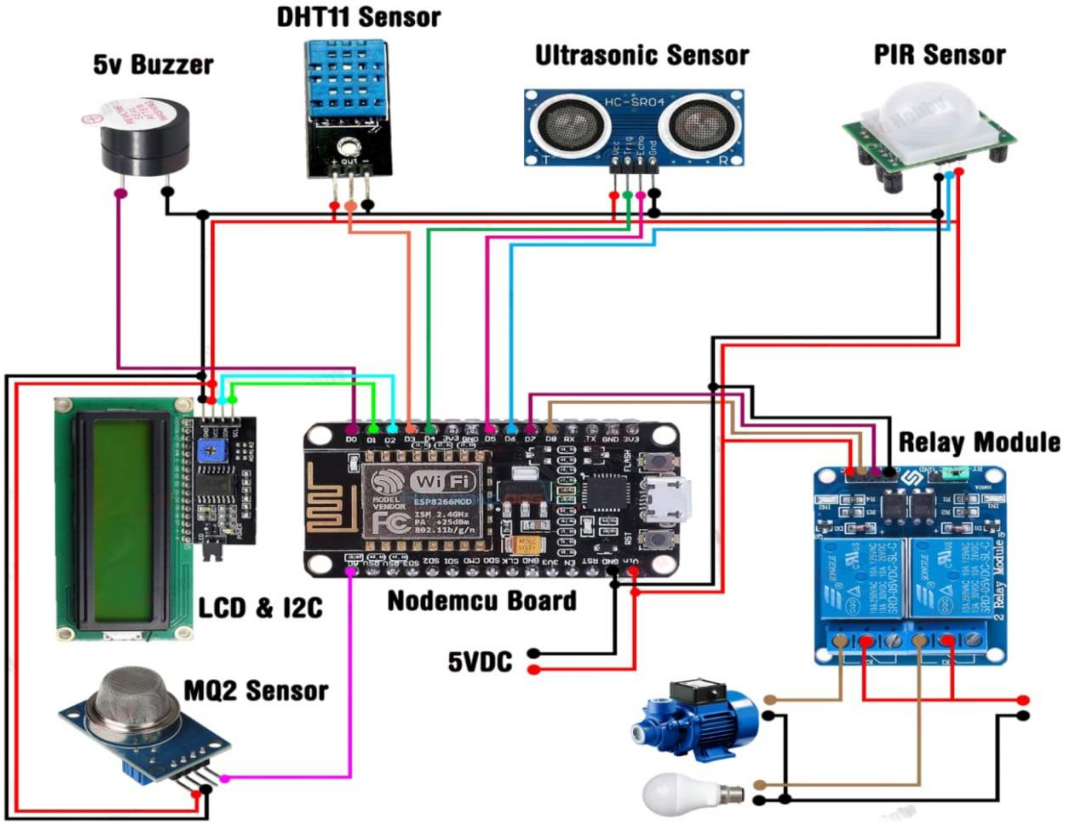
ESP- 8266 Board(fig-8)

Relay Module

A relay module's primary benefit is its ability to control high-power circuits using a low-power signal, effectively isolating the control circuit from the load circuit.

Relay (Fig-9)

3.3Circuit Diagram & System Working Process:



Circuit Diagram (Fig-10)

The circuit diagram shown in the figure above shows how all the sensors are connected to the ESP8266. This section will describe how the connections are made. First, we will connect the ground and power connections of all these sensors (including the relay module, MQ2 sensor, LCD module, DHT-11 sensor, 5V buzzer, ultrasonic sensor, PIR sensor) to the ground and power supply of the Esp-8266. Next, we will connect the Pair sensor, DHT-11 sensor, MQ-2 sensor, and 5V buzzer sensor to ESP8266 pin number D6, pin number D3, pin number A0, and pin number D0, respectively. The remaining two connection pins of the LCD module, the SDA pin and the SCL pin, will be connected to the pins numbered D2 and D1 of the ESP-8266, respectively. We will connect pin IN1 and pin IN2 of the relay module to pin numbers d7 and d8 of the ESP8266 respectively. Finally, if we connect an external source of five volts to this circuit, our entire system will receive power and run.

3.4Costs in System Design:

Table number-1 below shows the cost of building this system, including the cost of each sensor. Every effort was made to bill the system as low as possible.

Table-1

Serial Number	Sensors or parts name	Cost
1.	DHT-11	85 taka
2.	LDR Sensor	70 taka

3.	MQ-2 Sensor	110 taka
4.	ESP-8266	250 taka
5.	Relay Module	120 taka
6.	LCD Display with Module	250 taka
7.	PIR Sensor	80 taka
8.	5V Buzzer	10 taka
9.	Ultrasonic Sensor	70 taka
10.	5V DC source (Battery)	250 taka
11.	Connecting Wire	90 taka
12.	Stand	100 taka
	Total Cost :	**1,485 Taka(BDT)**

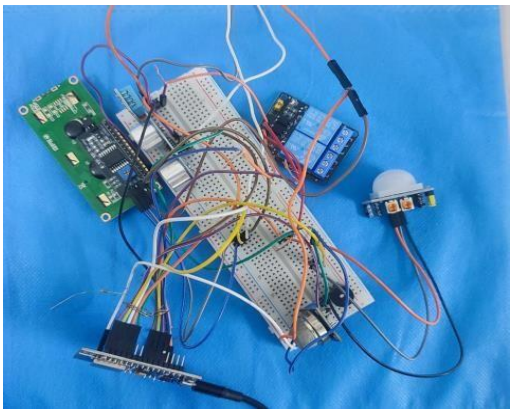
From table number-1 above we can see that to create this system it will take 1485 taka in Bangladeshi taka. We can easily say that this is a very low cost system. Any rural farmer in Bangladesh can buy this system and use it for his cultivation. Considering that the minimum income of any individual or farmer in Bangladesh is 10,000 taka as per the government data of 2024, we can say that farmers can easily buy this system and if the government provides this system to them for free, they will benefit even more. Since the cost of this system is very low, the government can easily provide it to the farmers for free.

3.5System Ability in Different Weather Conditions :

This system is capable of performing in all weather conditions from high temperatures to low temperatures and high water levels to low water levels, and it also provides an effective data in almost all cases. We have used this system in kutubdia, a southern region of Bangladesh, and found that it is capable of providing accurate data in high wind conditions. Not only that, this system uses a strong stand, through which it will be able to remain stable and provide data even during storms or floods. The percentage of effective value of this system or how it combines data is presented in the table in the results section [19].

3.6 Working progress

After all connection setup into the board then seems like to



. **Fig-11**

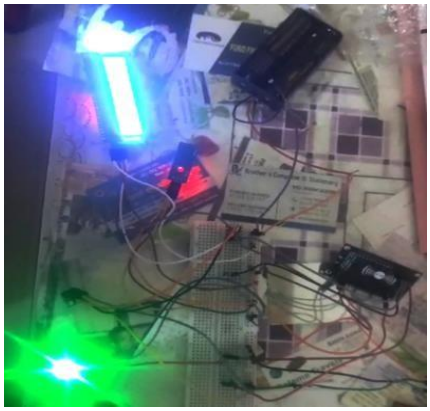


Fig-12

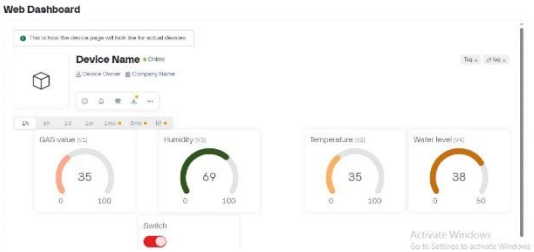
Here we can see that when all the connections are made, the power supply needs to be turned on to see if all the connections are successful. After turning on the power supply, we can see in the second picture that all the connections are fine. Also the all sensors were responding very well .

3.7Notification and Dashboard

After the successful implementation of the project, readings were taken in various ways and it responded very well. When the first measurement was taken, the temperature was 28.4 C, the humidity was 61%,pressure 300 and the water level was showing 100 because we had given more water at that time. Again, when I went to another area, some readings were also being given there, and we captured them. There, the temperature was showing 35 C, the humidity was 69, and the water level was 38. It was getting real-time measurements from the Blink ID server.

3.8 Process for Create Dashboard

We have used Blynk as a software in our system through which thirty thousand messages can be exchanged for free and through this Blynk we have created a dashboard. To create this dashboard, we will register in the blynk software and from there click on New Project. We will select the name of our project. In this case, we have selected the name of our project IoT based weather monitoring system. Then we will select our ESP-8266 board option and open a new control panel for each of our sensors where we will select our desired values, for example we will create one for humidity, one for gas sensor, one for water level and one for switching. Once our dashboard is created on the bylnk website, we will later create another control panel on our phone in the same way with the ID number of our dashboard and connect the phone's control panel to the dashboard we created via hotspot and upload the connected WiFi password and name to the programming, we will be able to control our system via the phone.



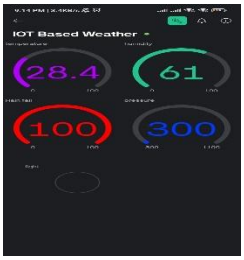


Fig-13(Dashboard) **Fig-14(Phone Control Panel)**

4.Result

This IoT based weather monitoring system developed with our own technology has been able to get the requested results after testing in several locations within Bangladesh, including salt farming located in Kutubdia, Cox's Bazar. Mushroom farming located in Rangpur and shrimp farming located in Pekua are

cultivated by farmers in this region. Our farmers can benefit from using this low-cost technology, which is presented through various graphs and tables in our results section.

4.1Salt Farming in Kutubdia, Cox's Bazar

Most of the people of Kutubdia Upazila, located in the southern part of Bangladesh, are involved in salt mining, through which they are achieving economic prosperity and contributing greatly to the economy of Bangladesh. But it is often seen that in Kutubdia Upazila and some other Upazilas of Cox's Bazar district, farmers do not get any immediate information about the water level due to not cultivating salt in a smart manner, resulting in wasting a lot of their money on salt[20]. In that case, if they are more efficient, then intelligent salt farming can make a huge contribution to our country's economy. Table 1 presents a sample of data storage using our best IoT weather monitoring system from a salt farm in Kutubdia.

Table 2: IoT based weather station in kutubdia salt farming filed (27 Jan 2025)

Time	Temperature	Humidity	Water level
12:00PM	22°C	50%	40
12:30PM	23°C	52%	50
1:00PM	24°C	54%	45

4.2Weather Forecast in Different location for Bangladeshi Farmers

By comparing different temperatures at different times in different regions of Bangladesh, this system will help farmers in those regions easily understand when they can economically benefit from growing which crops. Below are temperature charts for the months of May and June for three regions of Bangladesh, Lakshmipur, Netrakona, and Rangpur, as shown in Figure 1 and Figure 2.

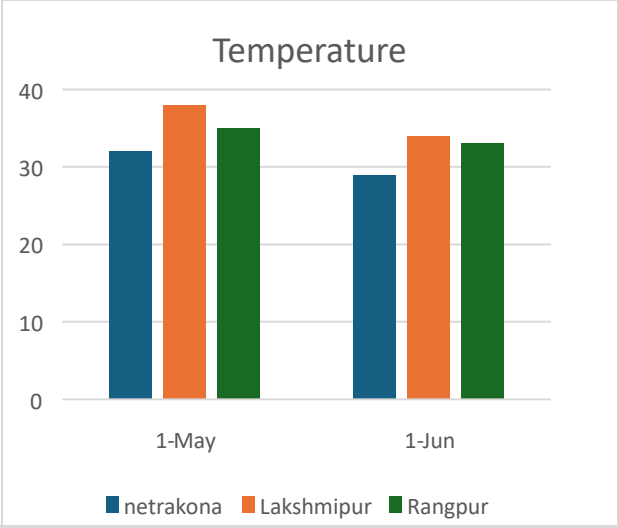


Fig -15

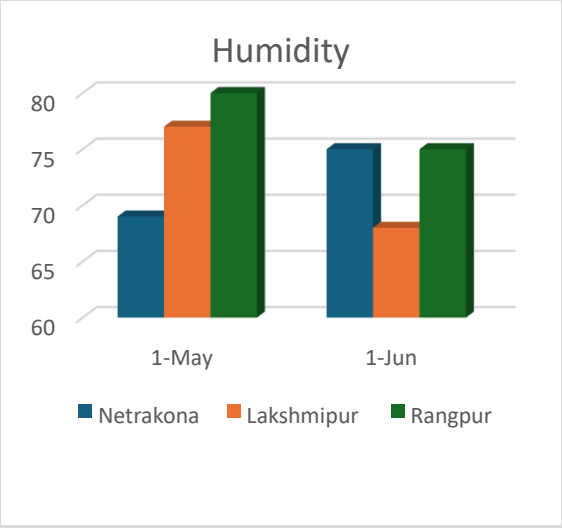


Fig -16

4.3System Performance Compare

Our system uses the maximum number of sensors to get accurate information. In market existing system we did not see the use of any ultrasonic sensors, but our system has ultrasonic sensors, due to which our system is able to easily measure the height of the water, which makes our system superior to other systems. Table number three below shows the overall performance of each sensor in our system.

Table-3(Performance):

Sensor Name	No.Test	No Response	Accurate value	Efficiency
PIR Sensor	20	20	19	95%
Ultrasonic Sensor	20	20	18	90%
MQ-2 Sensor	20	20	19	95%
DTH11 Sensor	20	20	19	95%

By reviewing the performance of the table-3, we can say that our IoT based weather monitoring system works effectively compared to other existing systems in the market which will play a very important role for the agriculture sector**.**

5.Discussion

IoT Best Weather Monitoring System is used in agriculture, smart city, marine navigation, disaster management, environmental and many more fields[21]. The importance of using IoT based weather monitoring system is immense.

5.1Application Of IoT Based Weather Monitoring System

The following figure -3 shows where IoT based weather monitoring systems are used and a brief description of them.

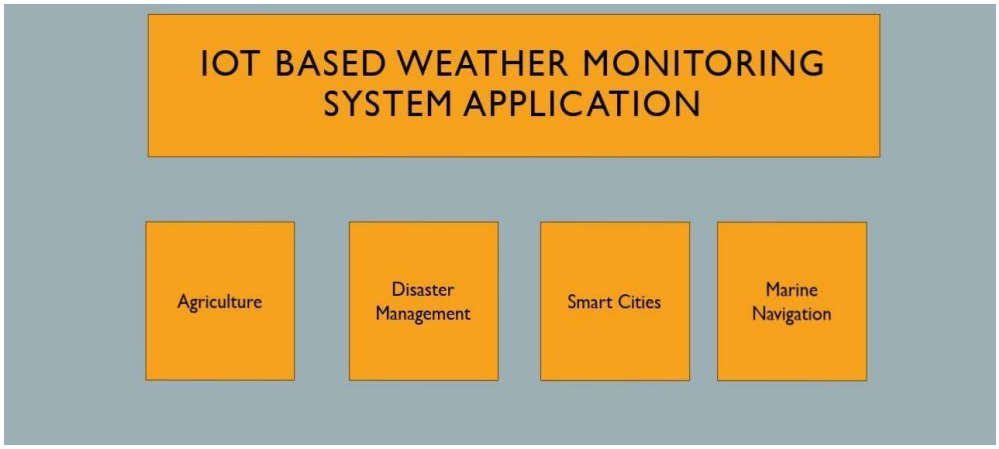


Fig-17:(Application)

Agriculture : The scope of use of weather monitoring systems in the agricultural sector is wide, from starting shrimp farming to mushroom farming, salt farming and which crops will grow well in the temperatures of that region, automatic notification via email when greenhouse gas temperatures change, and much more.

Disaster Management : IoT-based weather monitoring systems can also be used in disaster management, such as providing real-time information on flash floods to data centers, so that advance management can be taken to avoid floods.

Smart Cities : By using monitoring systems in smart cities, people in particular areas of the city will be able to know about the situation in real time and they will be able to manage all this accordingly.

Marine Navigation : Weather monitoring systems for maritime navigation can be called life-saving systems because through this system, weather conditions are known instantly and accordingly, sailors can also predict them and determine their destination based on the weather.

The Internet of Things (IoT) represents a powerful engine driving the data and communication generation industry, with its influence spreading worldwide. We have reviewed numerous technical and non-technical works to assess the current state of scholarly discourse, employing analysis sequence procedure models to prioritize IoT research areas[22]. In today's era, many prominent industries and companies are striving to advance this technology. It's crucial to enhance agricultural productivity, boost crop yields, and reduce human labor through the implementation of IoT techniques. IoT technology has the potential to significantly improve the efficiency of our agricultural systems. Consequently, research on IoT in agriculture is of paramount importance[23].

5.2Cost Benefit analysis :

From Table No. 1 in the Methods section, we can see that it cost us only 1485 Bangladeshi taka to build this system, which is much cheaper than all the existing IoT based weather monitoring systems in Bangladesh. Due to its low price, this system can be easily purchased by rural farmers in Bangladesh, such as Kutubdia, Lakhimpur , Rangpur, Kutubdia and other regions of Bangladesh. In this case, there will be no need for them and those who do business with this weather monitoring system to collect data from local areas. Due to its low cost, if its use starts in one rural area of Bangladesh, then its use will gradually spread to all rural areas of Bangladesh. Through this, mushroom cultivation and shrimp farming will be inspired in local areas of Bangladesh and many new mushroom cultivation and shrimp farming farms will be created, which will greatly reduce the unemployment rate in local areas.

5.3Future Implementation :

The Bangladesh government can financially support rural farmers to engage in this IoT-based weather monitoring system. In that case, the Bangladesh government can work with NGOs or create a system through which village families can purchase this weather monitoring system through low-interest loans. For example, the Bangladesh government can establish a large weather observation system in Kutubdia and connect many weather observation systems through a cloud-based system that can always store real-time information of meteorologists, which will later be useful for high-quality research work. Use machine learning to predict future weather patterns more accurately and provide advanced insights into crop management. Link the system with other agricultural platforms like market prices or pest control solutions. Partner with local agricultural departments to improve the system’s outreach and impact.

6.Conclusion :

In this research, the development and testing of the IoT-based weather monitoring system has been carried out, through which we can see that it is carrying very important information for our agricultural products and agricultural farms. By delivering its data in real time, we can see that a farm can easily and immediately receive accurate data about its products, which can prevent product waste and increase efficiency, while also increasing crop production. Through the effectiveness of this technology will carry an important aspect for Bangladeshi farmers.

Through the widespread use of such systems in the future, we can bring unprecedented changes and development to agricultural work, and it will also play a good role in raising awareness of climate change. Although this system is very important and will benefit the farmers of our country, the system can be

improved in some other areas. The collaboration of the sensors can be done more quickly so that we can get the data more accurately. In addition, the weather forecast period can be extended further so that our farmers can know well in advance what the next weather will be like and can take action accordingly. And we can look into how this system can be used on a larger scale. Our government also can do experimental use of this system in wide variety of agriculture fields like cow farming. As in Bangladesh the cow farming is growing day by day our farmers need to the accurate temperature in summer and winter duration. Also this system can be further improved to the bad weather condition.

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