Green IoT Based Plant Growth Monitoring System

A Thesis submitted in partial fulfilment for the degree of B.Sc in Electrical & Electronic Engineering

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Declaration

We hereby declare that the thesis titled “Green IoT Based Plant Growth Monitoring System”, submitted to the Department of Electrical and Electronic Engineering of BRAC University in partial fulfillment of the Bachelor of Science in Electrical and Electronic Engineering. This is our original work and was not submitted elsewhere for the award of any other degree or any other publication.

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Abstract

The usage of Internet of things (IoT) for plant advancement and natural organization is a promising new field of research. Here an arrangement of reliably interfaced sensors are used to support data went for giving more profitable plant improvement and an unrivaled circumstance. In this part, we present a system where eight sorts of sensors are used to measure the air and soil quality. Our structure utilizes dispersed capacity for keeping the assembled sensor data which by then gets organized on the web in order to make exact figures on nature and plants using an auto-in reverse facilitated moving typical count. Likewise the structure has been arranged with a web interface and data portrayal, engaging people to obtain the persistent normal information to take better decisions for plant advancement and biological organization. Finally we highlight the accuracy of outcomes of predication data which is around 99.13%.

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Chapter 1

INTRODUCTION

1.1 Introduction to IoT based Plant Growth System

Earth is known as a green planet because of the nearness of plants on it. Plants are viewed as the main living creatures conceived on the earth. Without plants, the earth and human life on this planet can't exist. We develop plants in our homes, gardens, ranches, roadsides, and so forth. Their essence is inescapable for clean air, nourishment, and water in this world. Indeed, even these plants add to our economy. Individuals in numerous nations depend on plant items for their occupation and pay. Plants individuals' connections are so much interlinked that we require them to survive. Agronomic plants supply foods to about every single earthbound living being, including people like us. We eat either plants or different creatures which also eat plants. Plants keep up the air. These plants are feeding almost 8 billion people of the earth. There is a thought that there will be more than 9 billion people by the end of 2050 [5].

Advantages of plants to people Plants are in following routes as, Plants are the fundamental wellspring of sustenance for people. Plants, unlike people and creatures, produce their very own sustenance. They do as such by the procedure known as photosynthesis in their green leaves by utilization of daylight. From this fabricated nourishment, they expend some of it and store the remaining. This is put away as natural products, seeds, tuberous roots, and so forth. This products of the soil parts of plants are devoured by people. The nourishment is as vegetables, natural products, grains, oats, leaves, seeds, mushrooms, and so on. They give the entire food containing starches, fats, proteins, nutrients, and minerals. Yet at the same time, for couple of nutrients, we may need to depend on animals. Plants are the biggest suppliers of material and texture material. These materials are eco-accommodating, good and more affordable. So they are utilized for making fabric and bedding material which is required by people. Plants are the critical wellspring of furniture. The plant wood is utilized to manufacture houses and furthermore to make other furniture things. We utilize wood for the reason because of its highlights like sturdiness, in vogue completing, protection from temperature changes, and

so on. The trees like teak, neem, red shoe, and so forth are great wellsprings of wood for making entryways, seats, racks, tables, and so on.

Indeed, even the nearness of plants around the region of human life calms pressure. Subsequently we see numerous individuals developing little plants in their family unit to get outside air and furthermore give instinctive nature. Plants are a superb wellspring of medication notwithstanding forever compromising infections. Condition and the atmosphere are interlinked for the most part with plants. The nearness of plants impacts Rainfall, dampness, and temperature. Chopping down plants additionally unevenness nature which will in a roundabout way influence human life [58].

Prosperity of any nation relies on the success of its kin. Economy of most nations, is directly or indirectly reliant on their farming. Everywhere throughout the world, agriculture related workers don't profit, particularly little ranchers in light of the fact that there is next to one side after they pay for all sources of starting investment. Horticulture being needy of monsoon where the harvest efficiency is variable consistently. To build efficiency ceaseless endeavors should be made in lead of research on various parts of yield production, post reap. The job of research has been expanded hugely in perspective of globalization. The research is not like taking any begin and stop action. Be that as it may, it is a nonstop procedure for looking through the solution for the issues looked by the agriculturists [59].

In this Twenty first century nourishment creating plants are one of our greatest worries, as the populace is expanding quickly, it is of significant need to create food delivering plants. To encourage these individuals the measure of sustenance supply ought to be expanded. Advanced cultivating requests increasingly production without expanding its property estimate. Economic losses from natural disasters have reached a staggering average of USD 250 - 300 billion a year [60]. Reusing a similar land is one of the answers for increment production, anyway the farmland reusing strategy does not work out each time because of land conditions. We discover a few issues with reusing of land as far as having more generation. In an investigation it demonstrates earth has lost 33% of its arable land in the previous 40 years [61]. The real explanations for these, are disintegration and contamination which harm the farmland fundamentally. The debasement of soil and being unusable because of disintegration, around three million hectares of agrarian terrains are lost each year. Shrewd cultivating is being utilizing as an answer now a days.

The utilization of innovation like Internet of Things (IoT) in nourishing plants could have incredible effect. It additionally has an impact on the personal satisfaction of individuals and conveys long haul great impacts to by and large natural conditions. The use of IoT is being utilized to control discharge and cut down the dimension of air contaminations. Utilizing the IoT in a valuable way with long haul positive effects on the earth and food generation segment to make a green nation.

Consequently, to sustain this numerous individuals, the developing business must connected with IoT. Against the challenges, similar to terrible climate conditions and expanding environmental change, and ecological effect on account of escalated cultivating rehearses, the interest for more meal must be met. IoT is a tremendous thing which is characterized by universally interconnected gadgets or device and a more unified world. Thinking about the current worldwide circumstance of farmlands, an IoT based brilliant cultivating device has been developed for the eco-accommodating nation. With the end goal to screen a few variables different identified with the states of yield, soil and condition, extensive variety of heterogeneous IoT modules are utilized. Various sensors have been actualized to get the cultivating area's natural information, and soil information to screen the farmland and plants development and changes.

This device has been planned explicitly for the observing of soil and plants, and has been modified to break down them consequently. The calculation empowers this device to anticipate the prediction of soil and condition. So that, precaution steps can be taken ahead of time for exceed expectations loaned development of plants and to maintain a strategic distance from the harms.

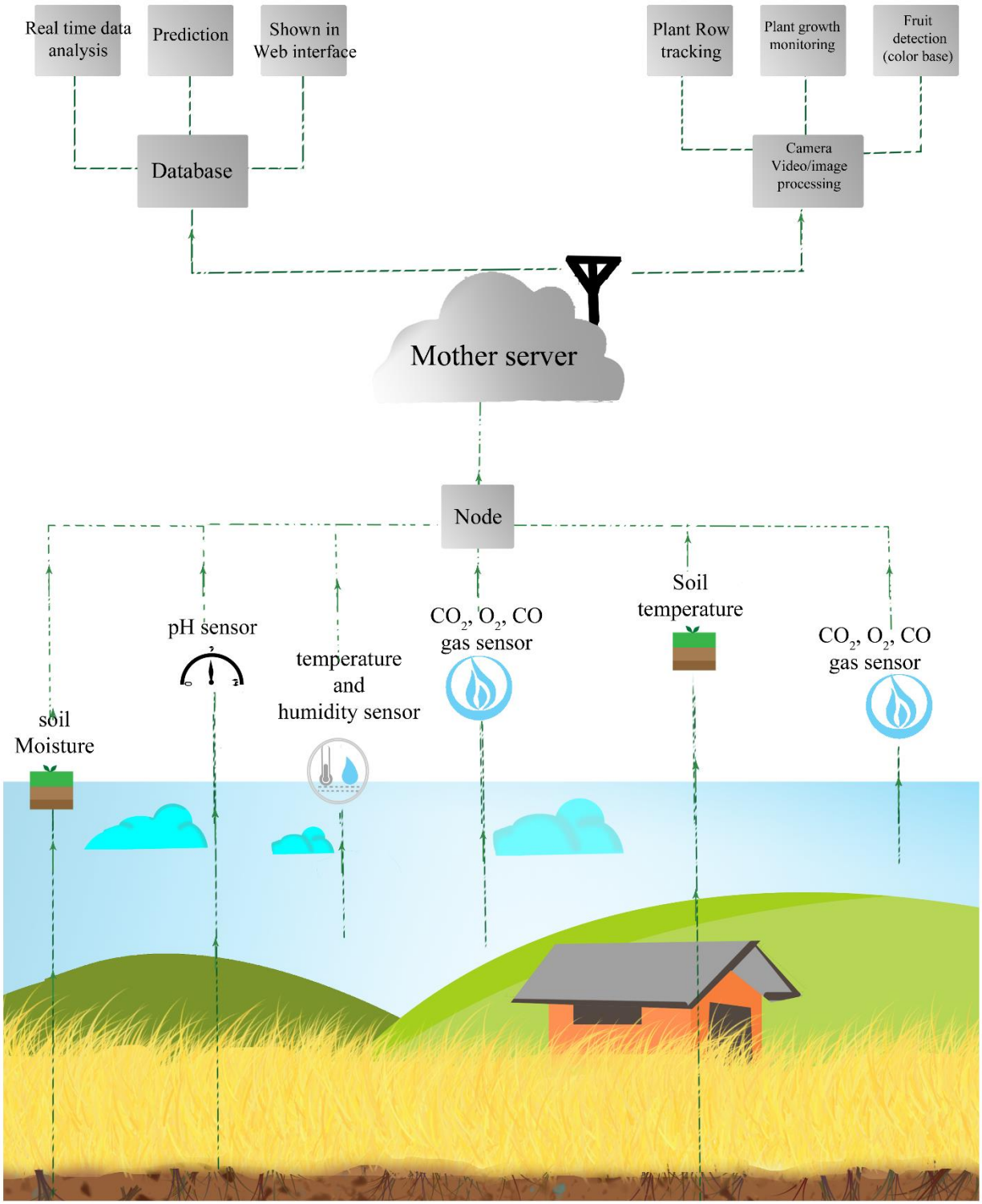


Fig: 1.1 Sensors deployment in the field

1.2 Review of Previous Works on Plant Growth

Some examination works are on the business parts of cultivating age. These papers use the functionalities of IoT to all the more promptly educate the farmers regarding market conditions, for instance, the current free market movement of various yields and tamed creatures [40], and what's more aiding in the organization of the agrarian business itself like in [20]. Eventually in [18] and [31] make a highlight on the transportation side of agribusiness division, despite everything as of now see, to cut down costs and moreover by virtue of last to decrease spreading of foodborne diseases.

Masters have in like manner based on the general condition of the usage of IoT in various endeavors today close by the future potential this development holds. Makers have furthermore made a point on the present obstructions on the usage of IoT, environmental applications and furthermore developing applications in the agrarian territory [19], [32]. All in all, there has been a couple of papers which uncover the scattered state of country data that exists today. An extraordinary approach is taken from [37] which utilize UAVs to create another method to manage different remote framework devices in IoT net-works as a sort of helpful sink with the true objective to cut down power use.

There are furthermore many research works that have been driven only on the monitoring of plant lands with the point of view of better exhorting the farmers with progressing data [40] so they can take more proactive measures and as such make more capable usage of advantages. These structures can screen the water treatment to make green adroit city [4], temperature, light, sogginess and moistness level [11].

Achieving capability to the extent plant advancement and agriculture when all is said in done is an important part of research for any country as a result of the need of sustenance and the creating all out masses. Accordingly, there has been much work done on the basis of upgrading the viability of cultivating sustenance age [39]. This can be practiced in various courses, among which is the better man-agreement of the authentic developing condition. Through IoT it is achievable for residence to much better examination their property and watch changes in it, allowing the maximization of gather and improvement as saw in [9], and a near application ought to in like manner be conceivable by methods for the usage of nurseries, for instance, [41].

There are in like manner various other research works which somewhat based on data amassing, something that farmers starting at now do, yet utilizing IoT, conveyed capacity and remote sensor organizes the methodology of data gathering has been made verifiably more extraordinary with the system being set up to do despite aiding in the essential administration technique of agriculturists, for instance, we have seen in [38], [15], which are habitually used for profitable resource the administrators likewise [29], [10]. Diverse works have focused on utilizing the limits of IoT to automate the country to an explicit degree. In article [8] it applies colossal data examination to consider the developing organic framework when in doubt to develop better practices for the future, while [3] guides the evaluation of farmland for the sensibility of building up specific items.

1.3 Motivation

Climate change and environmental monitoring and management have received much attention recently, and an IoT base dissecting framework is considered very significant. The utilization of sensors for the checking of a given situation aligned with the Internet as a methods for correspondence is prominently known as Internet of Things (IoT). Internet of Things (IoT) impacts the modern era of agriculture through its digitalization. The measure of data created in this condition has prompted an extraordinary increment in information accumulation. The demand of this kind of research and analysis has increasing day by day. This sector has attracts the modern agriculture to the next level. Our motivation gets in this agriculture sector for plant and crops monitoring excites for the welfare of nation. One of the real difficulties for its advancement lies in the capacity and the handling of this immense volume of information into worthy estimations and investigation parameters. This paper talks about an observing framework which gives data about natural conditions and quickly contacts the technological headways by using sensors in observing the plants and drawing out the new extension in observing the present condition issues. This research means to investigate the fundamental structures for both batch and stream sensors handling and to use them for the development of a Big Data condition.

1.4 Objective of the Thesis

The main contribution of this chapter is to present a discussion about the proposed system models in the IoT environment. The connected sensor devices have been tested to collect data in practical experiment. We further analyze the data in plant growth and environment applications in case study of the Bangladesh scenario. Finally, we highlight the important factors (i.e., air and soil quality) for improvements in existing plant environments. We tried to give a proposal of monitoring the plants and prediction analysis for advance steps. Moreover, we focused on energy efficient system for the proposed model of this paper for eco-friendly country.

Organization of the Thesis

This thesis is organized in five chapters as follows

Chapter-1 is all about introduction of this thesis which also includes the research works that has previously done on this field. It also contains the motivation of our research and objectives of our work.

Chapter-2 contains three sections. In the first part, our full proposed system architecture has been introduced. It is sequentially described how each and every parts has been setup the proposed device. In the second part, communication link has been described which shows how the environmental parameters are transferring to data base and working procedure. Last part of this chapter includes the energy harvesting system. The power distribution of this device is being explained.

Chapter-3 contains our result and data analysis of the collected parameters of air and soil. It provides an overview of the characteristics of our systems based on collected data As a result our prediction system has reached a step to observe future consequences.

Chapter-4 concluded this paper alongside describes how we can improve the device in future with more extra ordinary features.

Chapter 2

Proposed Plant Growth Model Using IoT

2.1 System Architecture and Design

Our proposed system model introduced the IoT in total system with wireless sensors modules. The whole system works on its own power. Combination of sensor are setup in a single node called Sensor node. For the agriculture plant monitoring sensor nodes will be deployed at a certain distance. So that it can cover as maximum condition as it can. This sensor nodes are powered with solar panel which ensures its' run time to whole day. These sensor nodes provide environmental parameters to the mother server through Wi-Fi. From the cloud our prediction analysis will be done to give prediction as a feedback.

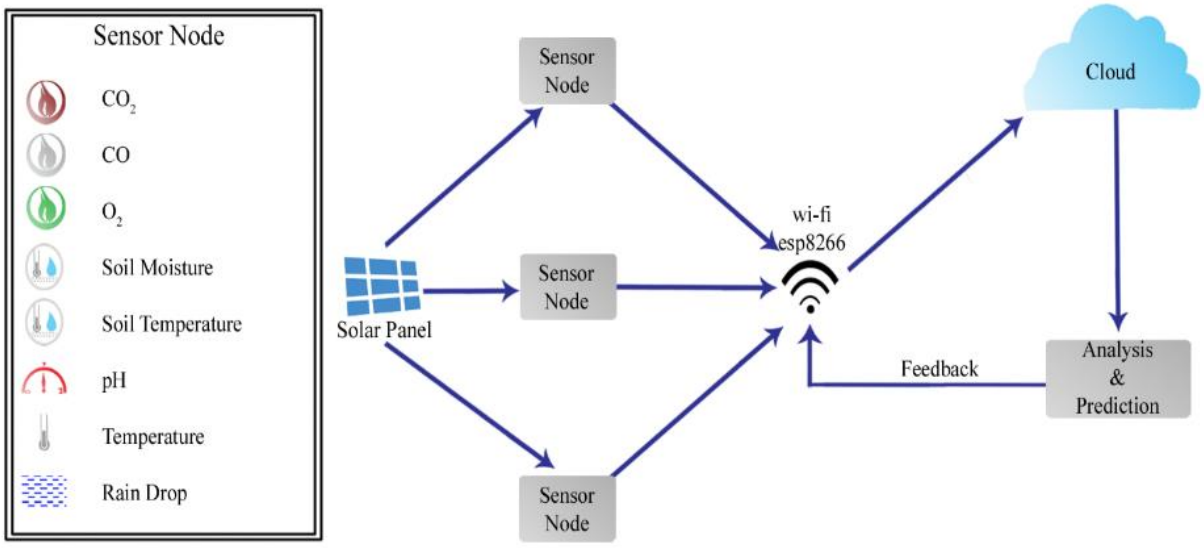


Fig. 2.1: Proposed network architecture model

Device is planned to be as space gainful as could be normal the situation being what it is. Remarkably created circuit has been orchestrated so it will in general be to a great inch

decreased in size. Eight sensors have been executed in this circuit, the sensors were chosen for both air and soil quality estimation, and have been interfaced with Arduino Mega 8560. Environmental air sensors are DHT22, MQ135, MQ09 and Groove gas (O2). From DHT22 contraption get the air temperature and humidity regard. From MQ135 sensor contraption gas CO2 regard in ppm. Same estimation system has been associated for both MQ9 and Groove Gas sensor to get the estimation of CO and O2 separately.

Moreover, for soil measurement Gravity analog pH meter (Model: TOL-00087) is been introduced to get the soil pH status. Digital Temperature Sensor (Model: DS18B20) for soil is setup to measure the soil temperature. In addition, Grove moisture sensor (Model: SEN-00035) has been used for the soil moisture condition. This device provides real time values straight to the Arduino in a time interval basis. All the data were collected from sensors in a packet form.

Device communication has been done using the Wi-Fi module (e.g., ESP8266). It is cheap among the available modules. This is the latest Wi-Fi module available till now. This communication link is the important part of our work which introduces IoT. All the sensor parameters are sent via internet to the main mother cloud database, which stores a record of all received data. A machine learning based algorithm has been introduced which uses to carry out the key function analysis and future predictions based on our cloud database.

In terms of energy efficiency our device has been developed to make it most efficient as could be possible. Various renewable energy sources were tested in practical. Among the different source testing we finally come at the point that solar power has been the most efficient and reliable system. The energy generating system has been divide in two parts (i.e., day time and night time) for operating the device for 24 hours. Solar power has been tested according to the irradiation point in a day in the perspective of Bangladesh. Then solar efficiency has been measured through testing in field area and we concluded that solar power is the most suitable option in Bangladeshi continent.

This device has been created with respect to the welfare of our nation's kin. Remembering that, the aggregate expense of the framework has been decreased to such a sum, to the point that it turned out to be entirely moderate. What's more, device setup has been planned so that it tends to be installed effortlessly by anybody.

2.2 Sensor Modules Configuration

2.2.1 DHT22

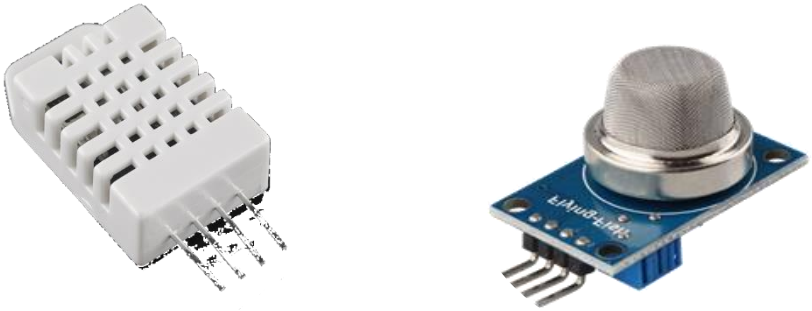
DHT22 (Fig 2.2.1.a) is a dual sensing module which features both environmental air temperature and air humidity. This sensor measures both temperature and humidity at a same time in single line. This module is the equivalent module of AM2302. This temperature and humidity sensor gives digital output. We have chosen this sensor module on the basis of some key features. This module is calibrated as it gives digital signal. It has the stability longer than the other modules. The circuit of this module is designed in such a manner that we do not need any extra pins for functionalizing it. The total number of pin is only 4.

Table 2.2.1: Pin Diagram of DHT22 [65]

Operation	Pin Number
VCC (3.3V-6V)	1
Signal (Sensing Pin)	2
Null	3
Ground (0V)	4

The key function of this sensor is to take very low space on the other hand it gives long transmission distance. So it is a very great advantage to use this sensor. In terms of power, it is very low power consuming. DHT22 uses the digital signal collecting technique which is connected to computer of 8 bit chip. The main communication in between MCU and DHT22, single bus data is used which costs only 5ms for each time. Information is involved number and decimal part, coming up next is the equation for information.

DHT22 convey higher information bit right off the bat! When DATA=8 bit essential RH data+8 bit decimal RH data+8 bit vital T data+8 bit decimal T data+8 bit registration If the data transmission is correct, registration ought to be the last 8 bit of "8 bit vital RH data+8 bit decimal RH data+8 bit fundamental T data+8 bit decimal T information". [65]



(a) (b)

Fig 2.2.1. (a) DHT22 , (b)MQ135

2.2.2 MQ135

MQ135 is a gas sensor of MQ series sensor modules. It detect CO2 of a certain area. Fig 2.2.1.b shows the module we have used in this project. Reason behind using this module is it has some key features which is suitable for determining the gas easily. This module has the longer life durability among the other models. As it is highly sensitive, it is easier for us to detect the gas. It response very fast according to the data sheet. MQ135 module is built in such a way that its driver circuits becomes very simple. The diagram of sensor module is given on fig. 2.2.3

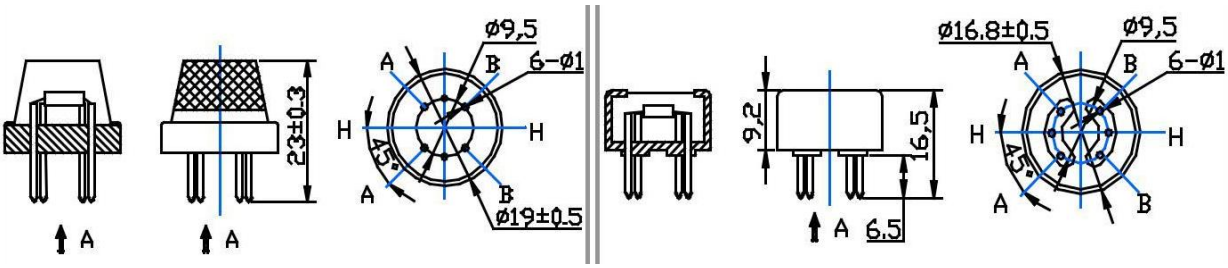


Fig 2.2.3: Sensor Module Configuration [62]

Structure and setup of MQ-135 gas sensor is appeared as Fig. 2.2d. Sensor made by miniaturized scale AL2O3 clay tube, Tin Dioxide (SnO2) delicate layer, estimating terminal and radiator are settled into a hull made by plastic and hardened steel net. The radiator gives fundamental work conditions to work of delicate parts. The encompassed MQ-135 have 6 pins, 4 of them are utilized to get signals, and other 2 are utilized for giving warming current. Electric parameter estimation circuit is demonstrated a Fig.2.2.4. The materials which are used in the different parts of the module is enlisted in the Table 2.2.2.

Table. 2.2.2: Materials list [62]

No.	Parts	Materials
1	Gas sensing layer	SnO_2
2	Electrode	Au
3	Electrode line	Pt
4	Heater coil	Ni-Cr alloy
5	Tubular ceramic	Al_2O_3
6	Anti-explosion network	Stainless steel gauze (SUS316 100-mesh)
7	Clamp ring	Copper plating Ni
8	Resin base	Bakelite
9	Tube Pin	Copper plating Ni

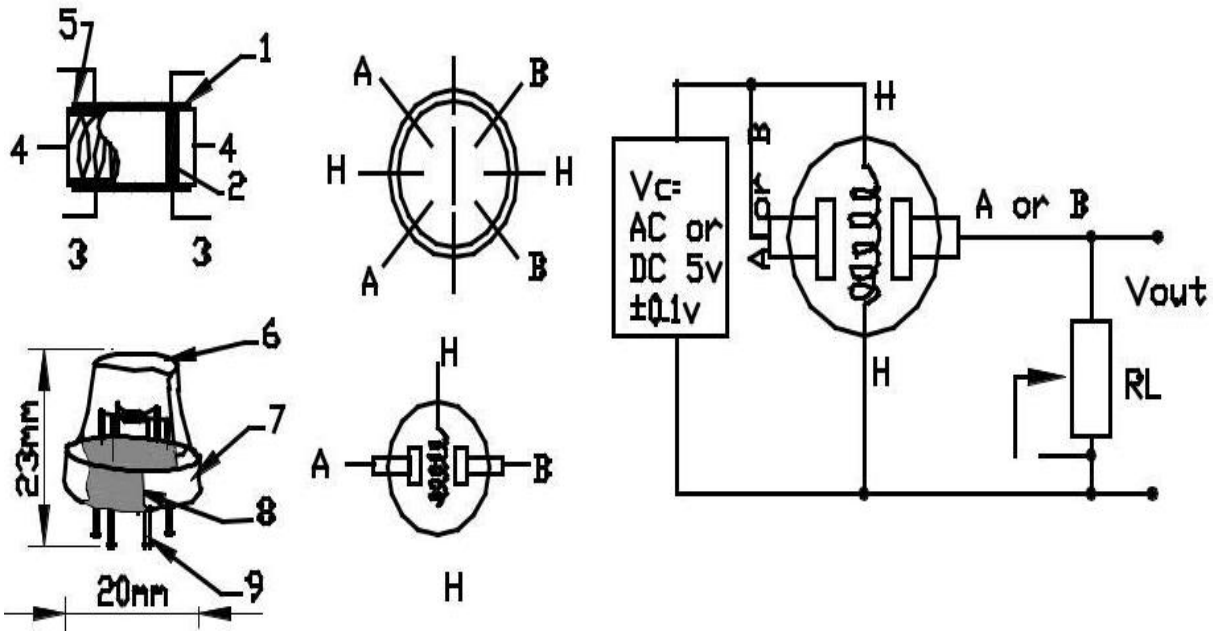


Fig: 2.2.4: Circuit of mq135 module [62]

This MQ135 sensor measures the Carbon Di Oxide gas parameters by varying the resistance values and voltage depending on the current weather situation. This values gives the output in PPM in the serial monitor to the database. The database analysis observes the changes of the CO2 parameter in the environment. This MQ135 sensor is very sensitive to environment. The sensitivity characteristics of the module is given in the fig 2.2.5.

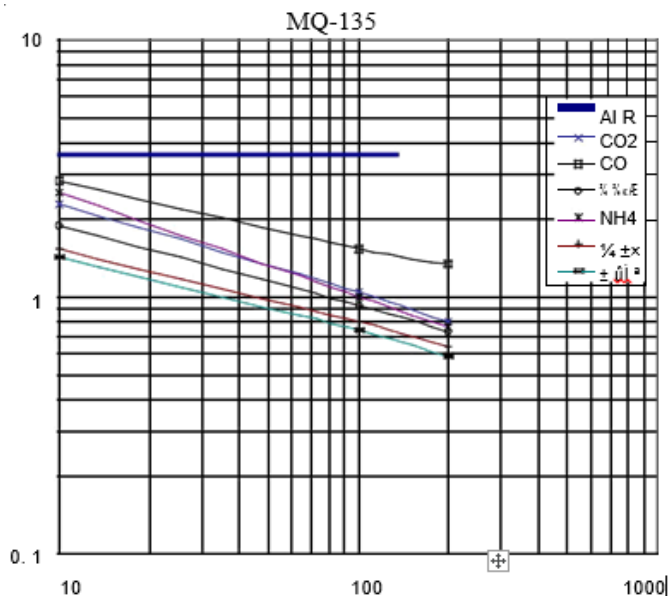
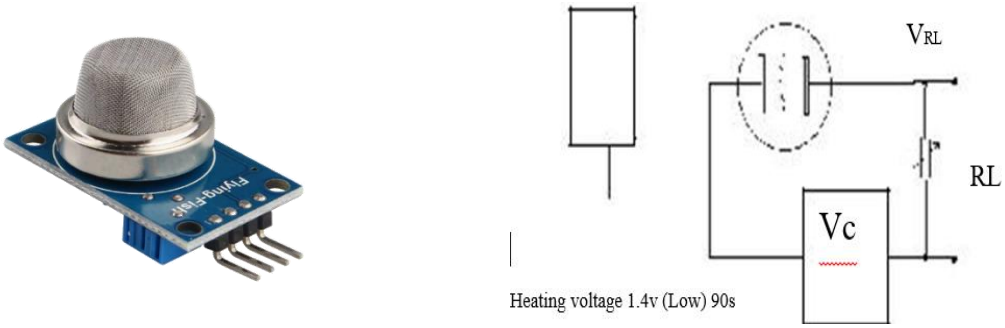


Fig 2.2.5: Sensitivity Characteristics of MQ135 [62]

2.2.3 MQ09

MQ09 (Fig 2.2.6.a) is a gas sensor especially for Carbon Mono Oxide gas detection. It is highly sensitive to Carbon Mono Oxide than Methane and LPG. This sensor is very long lasting and stable among other. We determined this sensors parameters in PPM in our output. So that we can get the overview of Carbon Mono Oxide.



(a) (b)

Fig:2.2.6. : (a) MQ09, (b) Electrical Parameter Measurement Circuit [63]

Ideal estimating circuit of MQ-9 gas sensor sensitive segments comprises of 2 sections. One is warming circuit having time control work (the high voltage and the low voltage work circularly). The second is the flag yield circuit, it can precisely react changes of surface opposition of the sensor which is shown in fig2.2.6.b.

The sensitivity characteristics graph is shown below in fig 2.2.7. This graph shows the ratio between the other gas parameters and their changes in ppm. We can observe the difference between the gas parameters and also the compare to the ideal cases whether it is giving the accurate values or not. The values firstly varies through voltage level than it algorithm in code changes in to ppm which also shows the variance of resistance for gaining the measurement. This table shows the gas sensors LPG, CO, methane line breakdown in 0 to 10000 ppm and the upper axis shows the changes in between 0 to 10.

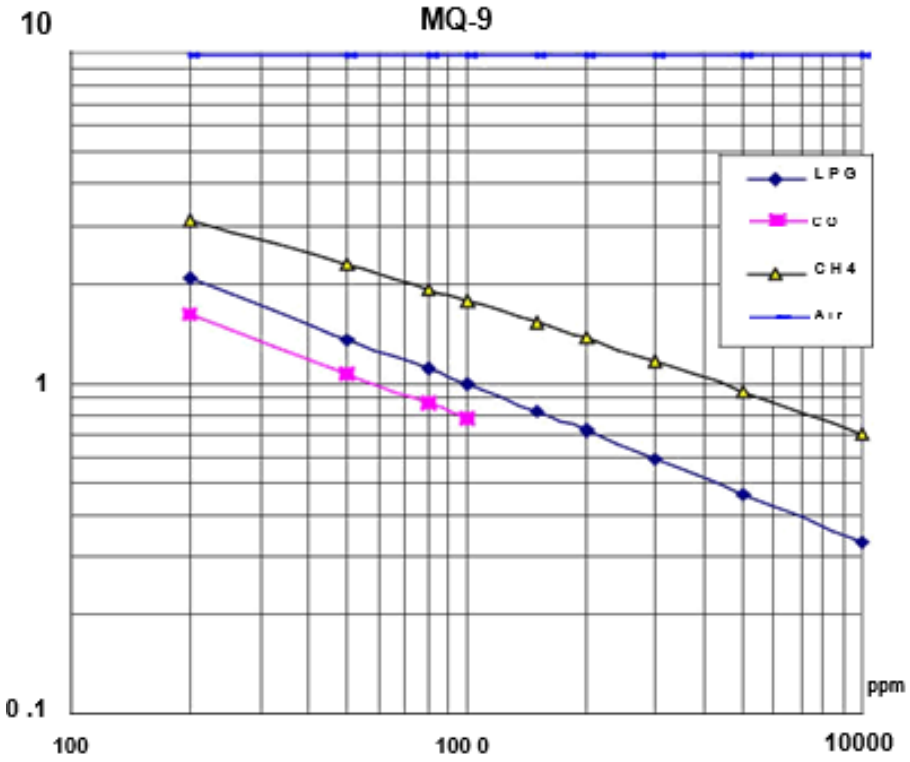


Fig 2.2.7: MQ09 Sensitivity Characterstics Curves [63]

2.2.4 MQ06

To get environmental air parameters one of the sensors we have used is MQ06(Fig 2.2.10.a) to get the oxygen measurement. This sensor response very fast. This is also good for its stability and life durability is longer. It has a very simple circuit. First we had calibrate the detector to get the accurate result. When clear measuring proper alarm point is determined by considering temperature and humidity.

(a) (b) (c)

Fig 2.2.10.: (a) MQ06 , (b) Soil Temperature DS18B20 , (c)Soil Moisture SEN-00035

2.2.5 Soil Temperature DS18B20

The DS18B20 Digital Thermometer sensor (Fig 2.2.10.b) gives 9 to 12-bit (configurable) temperature readings which show the temperature of the module.

Data is sent to/from the DS18B20 over a 1-Wire interface, with the goal that just a single wire (and ground) should be associated from a focal microchip to a DS18B20. Power for perusing, composing, and performing temperature changes is gotten from the data line itself with no requirement for an outside power source.

Since each DS18B20 contains an interesting silicon sequential number, different DS18B20s can exist on only 1-Wire transport. This takes into consideration setting temperature sensors in a wide range of spots. Applications where this element is helpful incorporate HVAC ecological controls, detecting temperatures inside structures, gear and process checking and control.

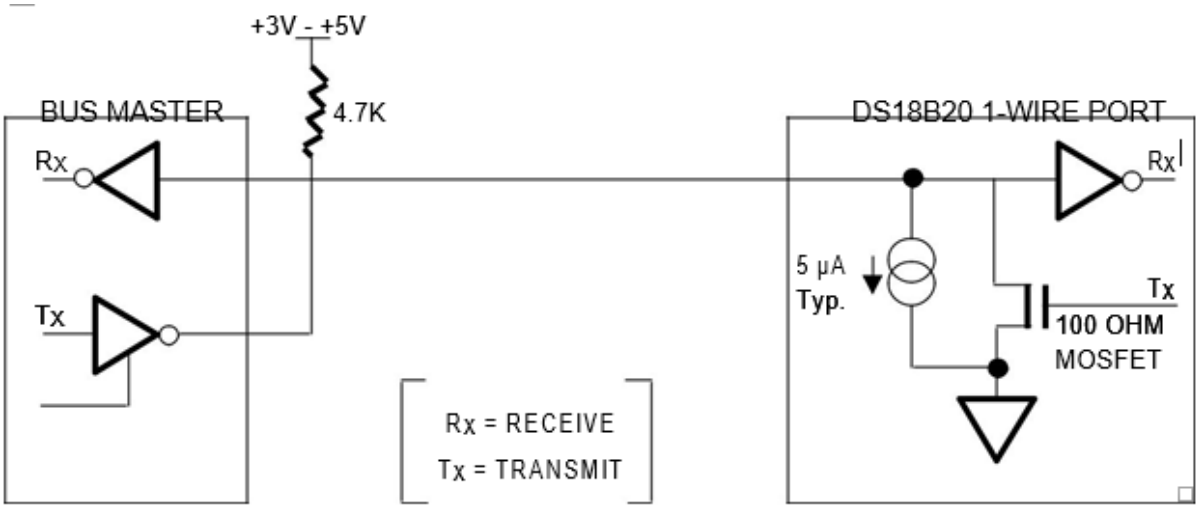


Fig2.2.11: Hardware configuration of DS18B20 [67]

The 1-Wire bus has just a solitary line by definition; it is essential that every module on the bus have the capacity to drive it at the suitable time. To encourage this, every part connected to the 1-Wire transport must have open deplete or 3-state yields. The 1-Wire port of the DS18B20 (DQ stick) is open deplete with an inside circuit identical to that appeared in Figure 2.2.11. A multi-drop bus comprises of a 1-Wire bus with numerous slaves appended. The 1-Wire bus requires a draw up resistor of roughly 5 kω.

2.2.6 Soil Moisture SEN-00035

For taking soils moisture parameter we have used SEN-00035 module (fig 2.2.10.c) which is a groove moisture sensor for surface soil wetness. They is very easy to use, we have just insert SEN-00035 module into the soil and then take reading of it which shows in our database. With the assistance of this sensor, it will be realizable to make the plant remind us that how wet the surface is and how regularly we have to supply water. Table 2.2.3 shows the specification of this module.

Table 2.2.3: Specification of SEN-00035 Module [68]

Item	Condition	Min	Typical	Max	Unit
Voltage	-	3.3	/	5	V

Current	-	0	/	35	mA
Output Value	Sensor in dry soil	0	~	300	/
	Sensor in humid soil	300	~	700	/
	Sensor in water	700	~	950	/

2.2.7 pH sensor TOL-00087

This is groove analog pH sensor (fig 2.2.l2) we have used which Model number is TOL-00087. We have used this sensor for measuring soil's pH. Sensor measure the pH at first in voltage in the dusty soil. The voltage variance mainly shows the pH level. According to the chart of pH level it is measured in between 0 to 14 level. Above 7 is considered alkaline and less than 7 is considered as acidic. We have certain analysis on the pH level to the plants growth. There is a comparison and research that pH level is significantly create impact on the plants health.

The pH enhancer inside the handle is a circuit which permits the standard blend pH terminal to be observed by a lab interface. The link from the pH speaker closes in a BTA plug. The pH Sensor will create a voltage of around 1.75 volts in a pH 7 support. The voltage will increment by about 0.25 volts for each pH number decline. The voltage will diminish by about 0.25 volts/pH number as the pH increments. The Vernier gel-filled pH Sensor is intended to make estimations in the pH scope of 0 to 14. The gel-filled reference half-cell is fixed; it cannot be refilled.

Table 2.2.4: Specification of pH sensor [66]

Type	Sealed, gel-filled, epoxy body, Ag/AgCl
Response time	90% of final reading in 1 second in a buffer
Temperature range	5 to 80°C (readings not compensated)
Range	pH 0–14

Fig 2.2.l2: pH sensor TOL-00087

This pH sensor has been implemented by examining its specifications. The specification table has been shown in table 2.2.4.

2.3 Communication & Analysis Method

2.3.1 Communication Link using ESP8266

Wireless technology is used in the recommended device where the entire system is assembled based on IoT concept. The device is capable of evaluating air and soil quality and delivering all the accumulated information (i.e. data) in real time to the data server via internet. To connect the device with internet to transmit the acquired data a Wi-Fi network is required. To address this issue ESP8266 Wi-Fi microchip appears as a promising solution. To begin with, ESP8266 is a 3V Wi-Fi module that is the most very popular device for Internet of Things applications [41].

The ESP8266 is proficient in hosting an application. Besides, all Wi-Fi networking functions from another application processor can be offloaded using ESP8266 [43]. Moreover, an AT command set firmware is attached with ESP8266 module where AT stands for attention. The AT command set is a command language which supports a series of short text strings [48]. A string is a data type used in programming where it indicates a sequence of characters as a literal constant or as a variable. In addition to, a string is called anonymous string when it shows up in source code [53]. Moreover, multiple AT commands are attached together within a sting that enables the modem to dial out. At present days, AT command set specification is very

popular in most of the personal computer modems. Furthermore, the AT command allows the ESP8266 to get connected with the Arduino device with the best possible WiFi-ability.

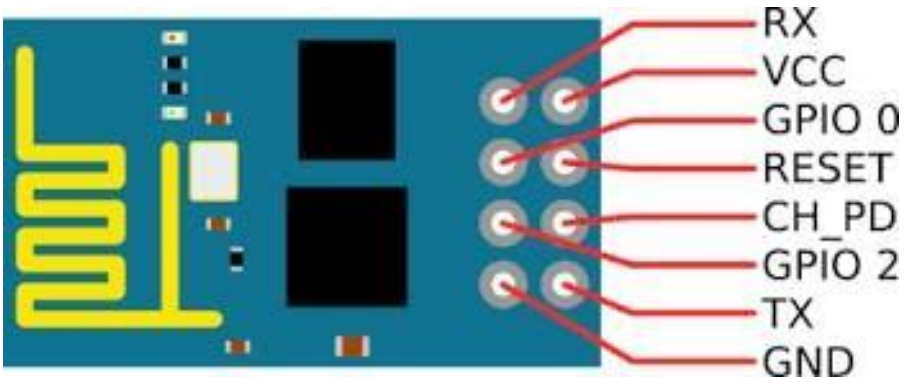


Fig. 2.3.1: ESP8266 Wi-Fi module [41]

Besides, on-board data processing and storage capability of the module makes it enable to get integrated with the sensors as well as with other devices through its general purpose input/output (GPIO) pins. On the other hand, because of the self-calibrated RF, the module can work under any operating conditions [54].

The following useful features of ESP8266 makes it more useful for communication purpose [44].

- 802.11 b/g/n protocol
- Wi-Fi Direct (P2P), soft-AP
- Integrated TCP/IP protocol stack
- Integrated TR switch, balun, LNA, power amplifier and matching network
- Integrated PLL, regulators, and power management units
- +19.5dBm output power in 802.11b mode
- Integrated temperature sensor
- Supports antenna diversity
- Power down leakage current of < 10uA
- Integrated low power 32-bit CPU could be used as application processor
- SDIO 2.0, SPI, UART
- STBC, 1×1 MIMO, 2×1 MIMO
- A-MPDU & A-MSDU aggregation & 0.4μs guard interval
- Wake up and transmit packets in < 2ms
- Standby power consumption of < 1.0mW (DTIM3)

ESP8266 is basically known as Wi-Fi SoC (system on chip). This Wi-Fi module has integrated TCP/IP protocol stack that enables any microcontroller to achieve access of our Wi-Fi network [55]. Basically, Transmission Control Protocol/Internet Protocol (TCP/IP) is a language used by computer to gain the access of the internet. Moreover, within it there are several number of protocols that is mainly designed to initiate a network of networks to provide the internet connection to a host. Furthermore, TCP/IP provides well developed data connection. On the other hand, by providing various major functions such as addressing, mapping and acknowledgement, TCP/IP protocol transmits the data end to end.

In communication part, two things are more important. Firstly, a message to transmit. Secondly, the technique to transmit the message securely. The message part gets handled by the TCP layer. At first, the message gets divided into smaller units. Each and every unit is known as packets. After that the transmission procedure of the packet gets stared over the network. In the receiver, corresponding TCP layer received the packet and reassembled the packets into the original message. On the other hand, the transmission portion gets handled primarily by the IP layer where every individual active recipient on the network gets assigned with a unique IP address. Besides, TCI/IP protocol provides newly made connection to each client [56].

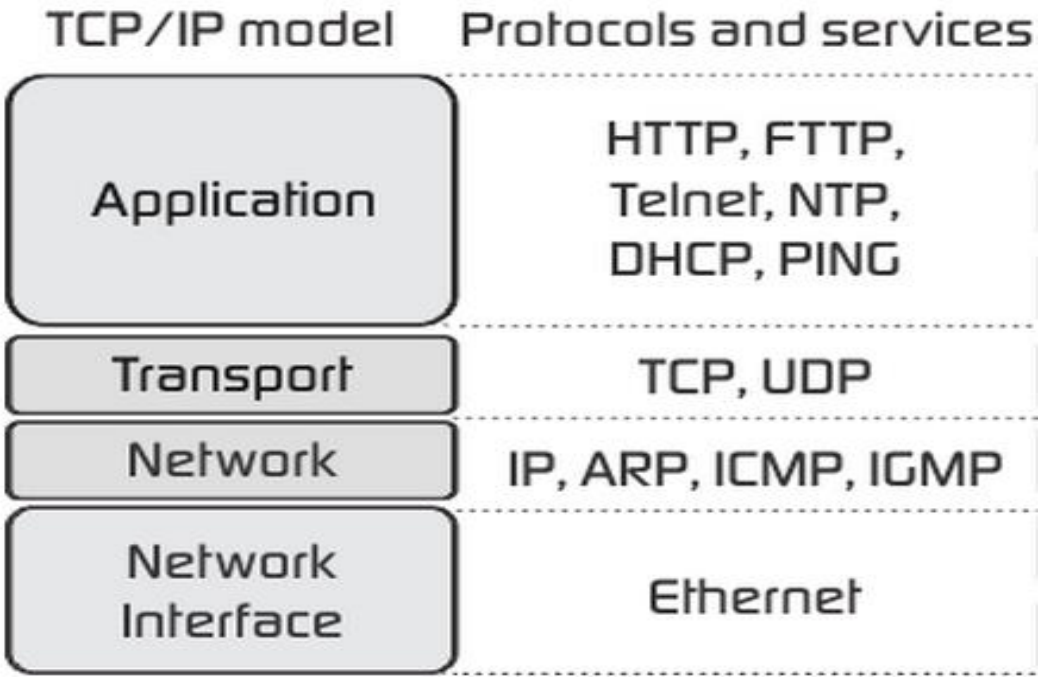


Fig. 2.3.2: TCP/IP architecture model [47]

The Application layer is the top most layer of TCP/IP model. TCP/IP application protocols are illustrated in this layer. Besides, this layer explains the procedure of interfacing between host programs and Transport layer services to use the network. Moreover, all the higher level protocols such as DNS (Domain Naming System), HTTP (Hypertext Transfer Protocol), Telnet, SSH, FTP (File Transfer Protocol), TFTP (Trivial File Transfer Protocol), SNMP (Simple Network Management Protocol), SMTP (Simple Mail Transfer Protocol) , DHCP (Dynamic Host Configuration Protocol), X Windows, RDP (Remote Desktop Protocol) etc. are present in application layer [45].

Transport layer is in between Application layer and Internet layer. Transport layer allows to carry on a conversation between devices on the source and destination hosts. Besides, the condition of the connection during transporting data is illustrated in the Transport layer. Moreover, two major protocol TCP (Transmission Control Protocol) and UDP (User Datagram Protocol) are included in transport layer [45].

Internet layer is present in between Network Access Layer and Transport layer. Data gets converted into data packets in Internet layer and the data packets are called IP datagrams. The most important fact of IP datagram is it carries the information about source and destination address. Besides, the information is also used for delivering the datagrams between hosts and across networks. Moreover, the IP datagrams gets routed as well through the Internet layer. Furthermore, Internet layer contains important protocols such as are IP (Internet Protocol), ICMP (Internet Control Message Protocol), ARP (Address Resolution Protocol), RARP (Reverse Address Resolution Protocol) and IGMP (Internet Group Management Protocol) [45].

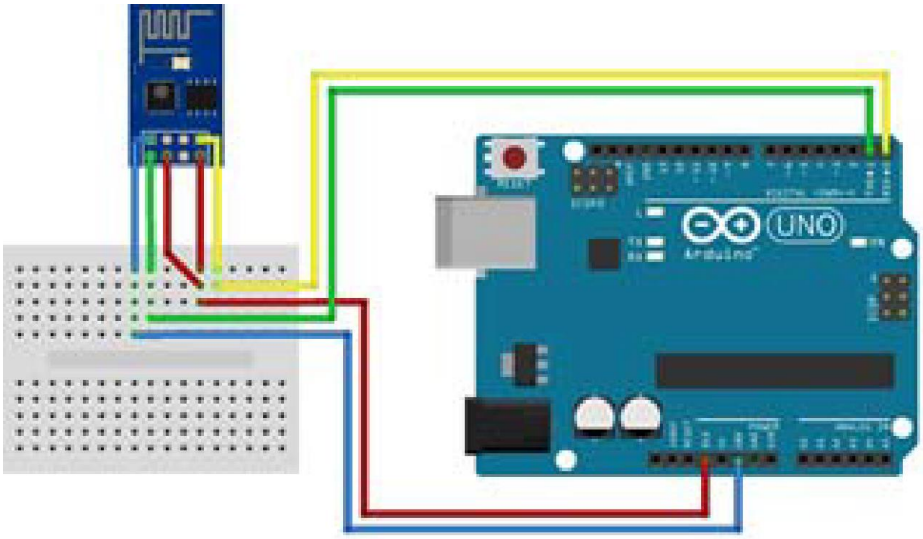


Fig. 2.3.3: Communication link between ESP8266 and Arduino (prepared from open source software: Fritzing) [54]

The first layer of TCP/IP model is Network Access Layer. The main purpose of this layer is to illustrate the procedure of transmitting data physically through the network. Besides, this layer indicates the process of signaling the bits by hardware devices either electrically or optically that interacts with transmission mediums such as optical fiber, coaxial cable or twisted pair copper wire [45].

ESP8266 is the most effective and low cost to connect 'Things' to internet via Wi-Fi. In our proposed communication model the Wi-Fi module is attached with Arduino along with other sensors. The connection diagram of ESP8266 and Arduino is shown in Fig. 2.3.3 that indicates the establishments of an internet connection where operating frequency is 2.4 to 5 GHz with a data rate of 11 to 54 Mbps [34]. Sensors collect data from the surroundings and the device receives the collected data from the sensors. Moreover, the collected values are placed in uniform resource locator (URL) format to access the information of the data using various protocols with the data server's IP address. Basically, Internet protocol (IP) address provides a unique identity of a device using numerical level for communication. After that a hypertext transfer protocol (HTTP) request is sent from the device using the URL and the URL gets handled by a PHP backend code. Basically, HTTP Request is nothing but a packet of Information that is used for communication purpose between two computers. Data gets transmitted from client to server through HTTP request. An HTTP Request gets divided into the following parts [46] :

*Request Line

*Headers, 0 or more Headers in the request

*An optional Body of the Request

Request Line : A Request Line indicates the type of the Method such as GET, PUT and so on that is being used by the Request URI the HTTP Protocol [46].

Request Header: There might be zero or more Request Headers in a HTTP request. Basically, whatever is followed by the Request Line till before the Request Body is known as a Header in this request section. The main purpose of the headers are to transmit additional information to the server about the request [46].

Request Body: Request Body is mainly used for sending additional content such as a file type of JSON or XML to the server [46].

After sending the HTTP request the URL is divided for each column and sent to the MySQL data server via PHP backend programming. Therefore, in the database all the sensor data in real time gets stored.

2.3.2 Data Analysis and Prediction

Data analysis and prediction plays a vital role for better plant growth. To begin with, the data prediction system allows to predict the potential future sensor data. As a result, early decision can be taken to achieve the best plant growth. Soil and air quality needs to be monitored for better plant growth. To predict the future values for analyzing the difference in soil and air quality autoregressive integrated moving average (ARIMA) technique is applied on the stored data in the data server.
Autoregressive Integrated Moving Average (ARIMA) uses not only the linear combination of past values but also a series of errors to predict future values of a time series [52]. ARIMA model is useful for stationary, non-stationary and univariate data type with any type of data pattern such as level, trend, seasonality and cyclicity.

An ARIMA model consists of the following components as follows [49] :

- Auto regression (AR*)*: It indicates the changing variable that regresses on its own delayed, or prior, values.

- Integrated (I): It allows the time series to become stationary by indicating the differencing of raw observations.
- Moving average (MA) *:* it assimilates the reliance in between an observation and a residual error from a moving average model that is applied to lag observation.

Besides, the data from Non-seasonal algorithm can be categorized as ARIMA (a, m, i) where 'a' indicates the numbers of auto regression parts (AR), 'm' refers the number of moving average (MA) terms and 'i' refers the number of non-seasonal differences [50].

The prediction system requires clean data to obtain better accuracy and performance. Therefore, it is required for the attained dataset to undergo through preprocessing stage where the raw data gets converted into clean data. However, in this process the dataset gets converted into a data frame. Hence, the process allows to ignore not only the missing data but also noisy and inconsistent data which reduces the accuracy. Moreover, differencing technique is used to assure the dataset is in stationary using the following equation [51] :

$$y_t - y_{t-1} = arma\,(g, h) \;=\; y'_t \quad (2.3.1)$$

Where y_t indicates the non-stationary data and y'_t indicates the stationary data.

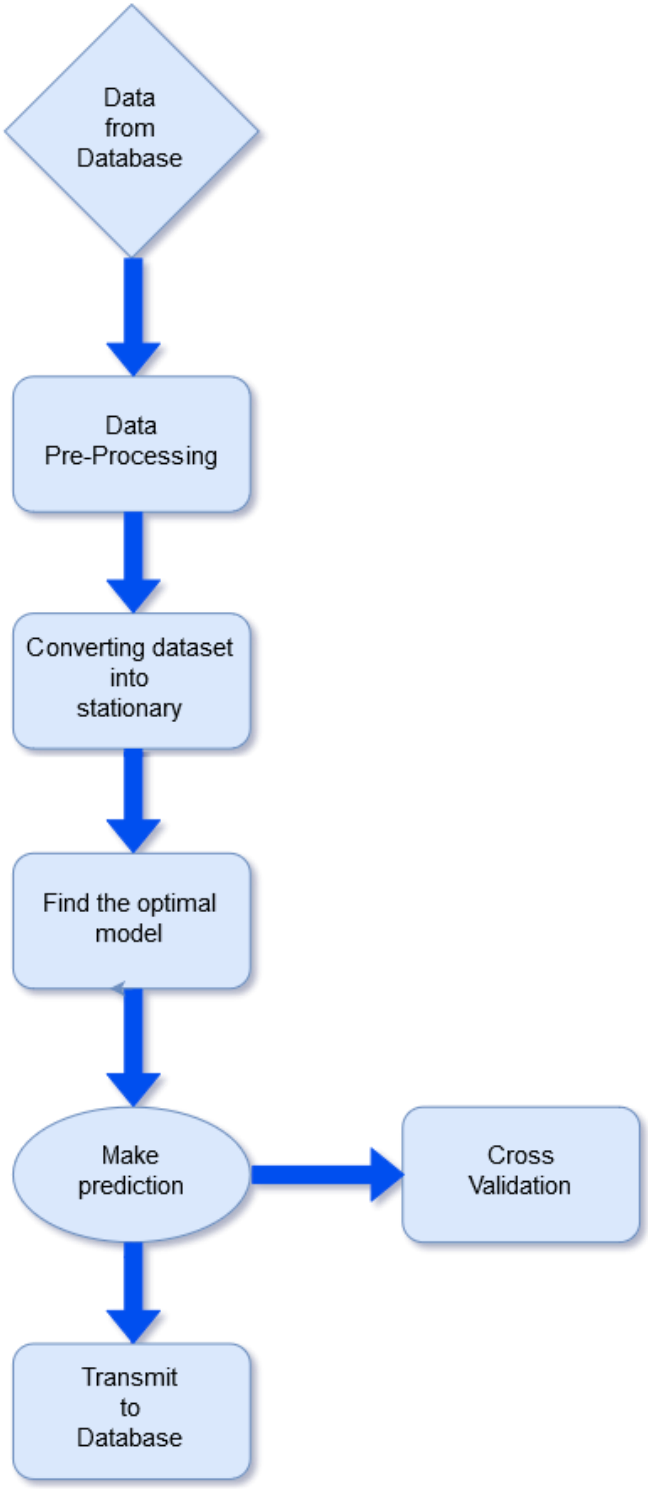


Fig. 2.3.4: Proposed ARIMA based prediction model

The accuracy of the result obtained from ARIMA depends on the stationary form of the data. According to [16] the accuracy of the result in ARIMA may vary on data for being or not being

stationary. To obtain consistent, reliable results, it is necessary to convert the non-stationary data into stationary data .Because of the consistency of Stationary dataset values such as variance, mean, autocorrelation with respect to time, accurate result is achieved. Stationary data form can be achieved either by differencing the data until it appears stationary or by unit root test [12].

To remove the effect of non-stationary data by differencing, the integrated term is proposed in ARIMA model. The forecasting equation is constructed in equation (2.3.1) because the order of difference varies according to different datasets. In the following equation x is the i^{th} difference of X [17].

$$If\ i = 0: x_t = X_t$$

$$If\ i = 1: x_t = X_t - X_{t-1}$$

$$If\ i = 2: x_t = (X_t - X_{t-1}) - (X_t - X_{t-1}) = X_2 - 2 * X_{t-1} + X_{t-2}$$

Based on the above expressions, a general equation of x can be generated [50]:

$$\hat{x} = r + b_1 x_{t-1} + \cdots + b_k x_{t-k} - c_1 d_{t-1} - \cdots - c_z d_{t-z} \qquad (2.3.2)$$

Here b indicates the slope coefficient, c indicates the average moving parameters, x_{t-1} ... ... x_{t-k} refers to autoregression term and d_t is error terms. To resolve the coefficients of the regression model, the optimal parameter is selected for fitting procedure. However, based on Akaike Information Criterion (AIC), and Bayesian information criterion (BIC) values, the best fit model gets selected, [36], [30], [2], [33] and [6]. Here, the main goal is to select a model with minimum AIC and BIC values. Moreover, to achieve the best model, auto. ARIMA function is a promising solution to complete the mentioned process. Besides, to select the best model for ARIMA both the manual and automated modes are compared. Furthermore, to obtain the prediction for the next 30 hours of data, not only the training and testing sets are divided but also more than 300 hours of data is trained. At last, to obtain the accuracy of the m model both the predicted values and testing data are compared.

2.4 Energy Harvesting from Solar

Our purpose was to design an IoT based green device that uses green communication system and also use a green energy source. By green energy it means that energy which can be collected from the environment which can be easily accessed and also emit low carbon di oxide as well as do minimum damage will collecting the energy. There are many green energy sources such as wind power, hydroelectric energy, biomass, hydrogen and fuel cell, geothermal energy, energy from tides.

There are various kinds of renewable power source. The larger part of these manageable power sources depend by one way or another on sunlight. Solar based imperativeness is the quick difference in light using sheets or gatherers. Biomass essentialness is secured sunshine contained in plants. Other economic power sources that don't depend upon sunlight are geothermal imperativeness, which is an eventual outcome of radioactive decay in the covering joined with the main warmth of collecting the Earth, and tidal essentialness, which is a difference in gravitational imperativeness.

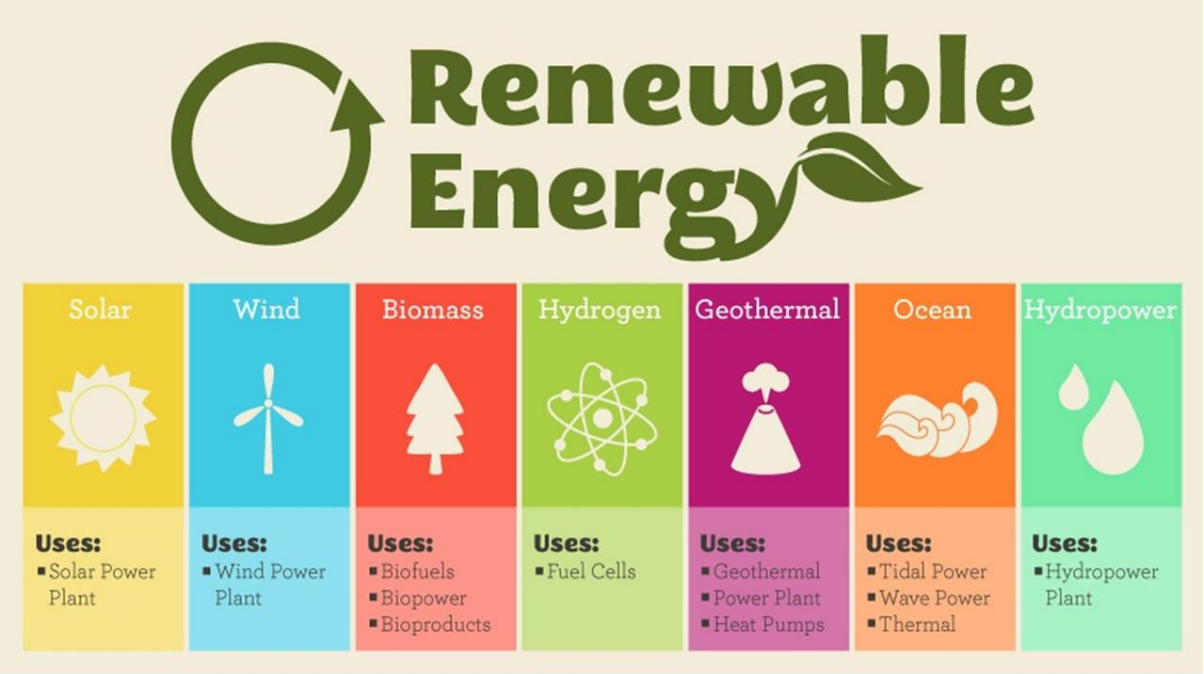


Fig 2.4.1: Seven renewable energy source [74]

Solar energy harvesting imperativeness relies upon the nuclear mix control from the focal point of the Sun. This imperativeness can be assembled and changed over in two or three different

ways. The range is from sun fuelled water warming with sun based specialists or storage space cooling with sun based second story room fans for neighborhood use to the stunning progressions of direct difference in sunshine to electrical imperativeness using mirrors and boilers or photovoltaic cells. Amazingly these are correct now lacking to totally control our propelled society.

Wind Power is the improvement of nature is driven by differentiations of temperature at the World's surface due to fluctuating temperatures of the World's surface when lit by light. Wind essentialness can be used to siphon water or make control, yet requires wide areal incorporation to convey basic proportions of imperativeness.

Hydroelectric energy harvesting uses the gravitational ability of raised water that was lifted from the oceans by sunlight. It isn't completely feasible since all stores at last finish off and require extraordinarily exorbitant uncovering to end up accommodating afresh. Starting at now, a vast segment of the available zones for hydroelectric dams are currently used in the world.

Biomass is the term for essentialness from plants essentialness in this shape is normally used all through the world. Deplorably the most outstanding is the expending of trees for cooking and warmth. This technique releases broad proportions of carbon dioxide gases into the air and is an imperative supporter of awful air in various zones. A bit of the more present day kinds of biomass essentialness are methane age and age of alcohol for vehicle fuel and stimulating electric power plants.

Hydrogen and vitality units are moreover not by any means maintainable power source resources but instead are to a great degree bounteous in openness and are low in pollution when utilized. Hydrogen can be burned as a fuel, ordinarily in a vehicle, with simply water as the start thing. This flawless expending fuel can mean a basic decline of tainting in urban networks. Or then again the hydrogen can be used in vitality parts, which resemble batteries, to control an electric motor. In either case basic age of hydrogen requires endless power. In view of the prerequisite for imperativeness to make the hidden hydrogen gas, the result is the movement of tainting from the urban zones to the power plants. There are a couple of promising procedures to convey hydrogen, for instance, daylight based power that may change this picture certainly.

Imperativeness left over from the primary gathering of the planet and augmented by warmth from radioactive spoil spills out continuously all finished, customary. In explicit regions the

geothermal slant (augment in temperature with significance) is adequately high to attempt to make control. This credibility is obliged to several territories on Earth and various specific issues exist that limit its utility. Another kind of geothermal imperativeness is Earth essentialness, an eventual outcome of the glow storing on the planet's surface. Soil wherever will when all is said in done stay at a reasonably consistent temperature, the yearly ordinary, and can be used with warmth guides to warm a working in winter and cool a working in summer. This kind of imperativeness can decrease the prerequisite for other ability to keep up pleasing temperatures in structures, yet can't be used to convey control.

Daylight based energy is any sort of imperativeness made by the sun. Daylight based essentialness is made by nuclear blend that occurs in the sun. Blend happens when protons of hydrogen atoms violently crash in the suns inside and circuit to make a helium molecule. This strategy, known as a PP (proton-proton) chain reaction, releases a massive proportion of imperativeness. In its middle, the sun consolidates around 620 million metric gigantic measures of hydrogen reliably [72]. The PP chain reaction occurs in various stars that are about the range of our sun, and gives them relentless imperativeness and warmth. The temperature for these stars is around 4 million degrees on the Kelvin scale (around 4 million degrees Celsius, 7 million degrees Fahrenheit) [72]. In stars that are about 1.3 events more prominent than the sun, the CNO cycle drives the arrangement of imperativeness. The CNO cycle moreover changes over hydrogen to helium, anyway relies upon carbon, nitrogen, and oxygen (C, N, and O) to do thusly. At present, under 2% of the sun's imperativeness is made by the CNO cycle. Nuclear mix by the PP chain reaction or CNO cycle releases gigantic proportions of essentialness as waves and particles. Sun controlled imperativeness is continually gushing a long way from the sun and all through the close-by planetary gathering. Sun situated imperativeness warms the Earth, causes wind and atmosphere, and proceeds with plant and animal life. The essentialness, warmth, and light from the sun stream away as electromagnetic radiation (EMR). The electromagnetic range exists as surges of different frequencies and wavelengths. The repeat of a wave addresses how habitually the wave goes over itself in an explicit unit of time. Waves with short wavelengths reiterate themselves a couple of times in a given unit of time, so they are high-repeat. On the other hand, low-repeat waves have any more drawn out wavelengths. Most by a long shot of electromagnetic waves are subtle to us. The most high-repeat waves released by the sun are gamma pillars, X-bars, and splendid radiation (UV bars). The most ruinous UV pillars are completely devoured by Earth's condition. Less solid UV pillars travel through nature, and can cause sunburn. The sun also releases infrared

radiation, whose waves are much lower-repeat. Most warmth from the sun connects as infrared essentialness. Sandwiched among infrared and UV is the obvious range, which contains all of the tints we see on Earth. The shading red has the longest wavelengths (closest to infrared), and violet (closest to UV) the most restricted [72].

Solar energy is such a sustainable and renewable energy source that converts light into electrical energy where photovoltaic cells known as solar cell is used. For this proposed project solar panel has been selected as the source of energy. Most of the green energy needs a complex process for energy harvesting and also not available in every corner of the world. But solar energy can be harvested from most of the places around the globe. Besides solar energy is easily accessible, maintenance is cheap and easy and also it emits low carbon dioxide in the process of energy harvesting. In case of arrangement in remote area and reusability solar harvesting is more effective [16].

In the proposed project the main goal was to collect as many data as possible for all day long. In the project environment sensing and forecasting is used and as a result the amount of data will influence the analysis much greater. The project collects data and forecast an area based weather report from that. After collecting data the project analysis that and predict the future data for monitoring the plant growth system. For this purpose the device needs to collect environment data 24 hours a day.

In that case the device needs to operate even at night without any solar energy. To solve this problem the project introduce two energy harvesting mode for efficient energy utilize. For the first mode it’s called the day time data collection. At day time the solar radiation is available and from the solar panels we can harvest solar energy directly use it to run the device. In second mode called night mode data will be collected from the built in batteries which stores energy at day time when the solar radiation is available and kept for later use in night time data collection [21].

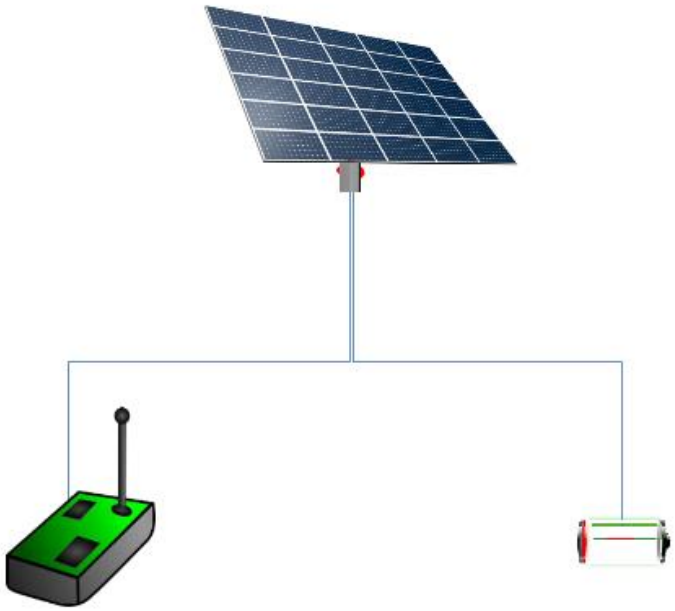


Fig 2.4.2: Solar energy harvesting and storage

Solar radiation is dependent on few parameters and the angle of the solar panel. The main parameters are the sunset time, sunrise time, latitude of the area, available solar radiation. All these can be measured from few equations. Represented at [22] the equations are:

$$\text{Sunset} = 12 + 1/(15°)\ \text{〖cos〗}^{(-1)}(-\sin\varphi\sin\delta/\cos\varphi\cos\delta) \quad (1)$$

$$\text{Sunrise} = 12 - 1/(15°)\ \text{〖cos〗}^{(-1)}(-\sin\delta\sin\varphi/\cos\delta\cos\varphi) \quad (2)$$

$$\delta = \sin(360/365 \times (d-81)) \times 23.45° \quad (3)$$

Keeping the perspective of Bangladesh in mind the solar radiation is calculated from these equations and the project's energy harvesting system is designed. In these equation we can find, declaration angle δ, latitude of the place represented by φ and the date of the year is represented as d.

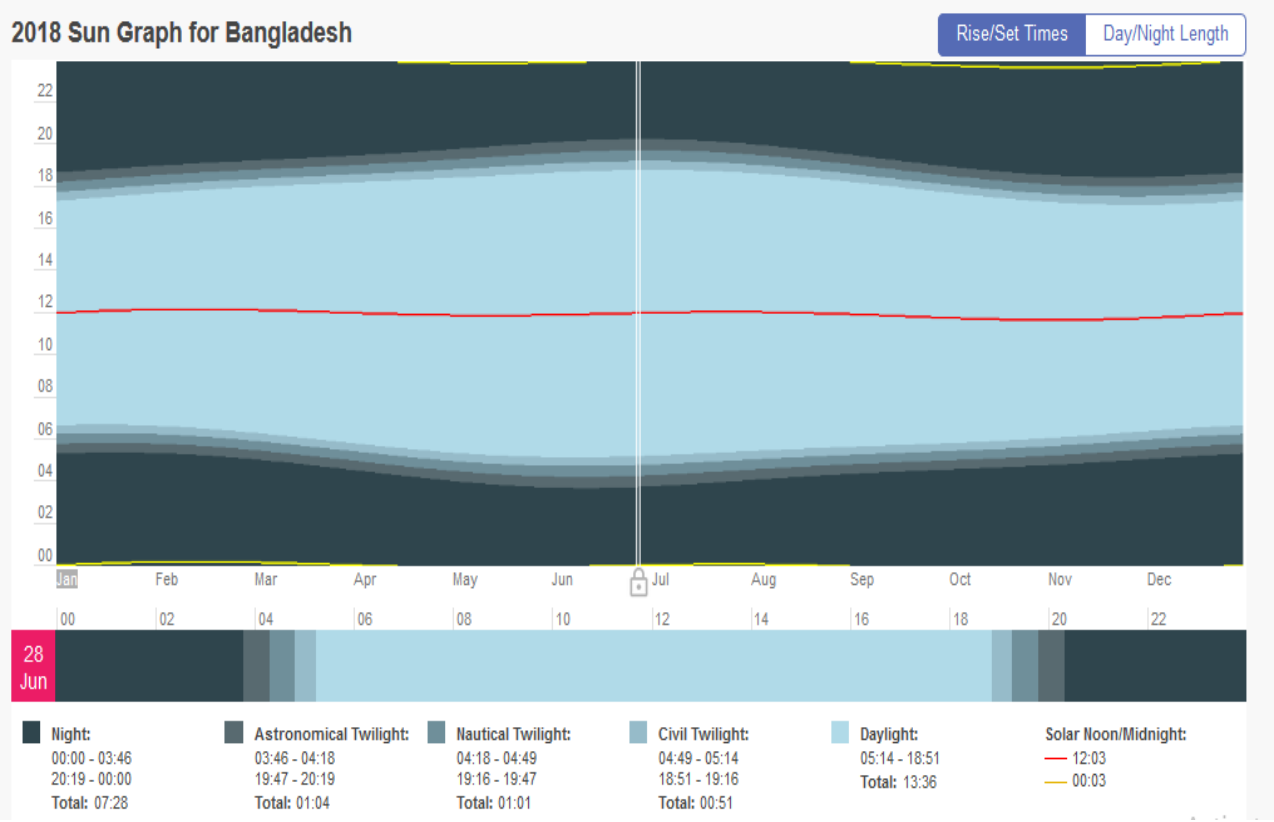


Fig 2.4.3: Solar graph perspective to Bangladesh [73]

Table 2.4.1: Approximate sunrise, sunset and hours of sunlight calculated at the latitude of North 23 degree:

Day	Sunrise	Sunset	Hours of Sunlight
0	6.69	17.31	10.61
5	6.68	17.32	10.64
10	6.66	17.34	10.68
15	6.63	17.37	10.73
20	6.60	17.40	10.79
25	6.57	17.43	10.86
30	6.53	17.47	10.94
35	6.49	17.51	11.03
40	6.44	17.56	11.12

45	6.39	17.61	11.21
50	6.34	17.66	11.31
55	6.29	17.71	11.42
60	6.24	17.76	11.53
65	6.18	17.82	11.64
70	6.13	17.87	11.75
75	6.06	17.93	11.86
80	6.01	17.99	11.98
85	5.95	18.05	12.09
90	5.90	18.10	12.21
95	5.84	18.16	12.31
100	5.79	18.21	12.43
105	5.73	18.27	12.54
110	5.68	18.32	12.64
115	5.63	18.37	12.75
120	5.58	18.42	12.85
125	5.53	18.47	12.94
130	5.49	18.51	13.03
135	5.45	18.55	13.11
140	5.41	18.59	13.18
145	5.38	18.62	13.24
150	5.35	18.65	13.30
155	5.38	18.67	13.35
160	5.32	18.69	13.38
165	5.30	18.70	13.40

170	5.29	18.71	13.41
175	5.29	18.71	13.41
180	5.30	18.70	13.40
185	5.31	18.69	13.38
190	5.33	18.67	13.34
195	5.35	18.68	13.29
200	5.38	18.62	13.24
205	5.41	18.59	13.17
210	5.45	18.55	13.10
215	5.49	18.51	13.02
220	5.53	18.46	12.93
225	5.58	18.42	12.84
230	5.63	18.37	12.74
235	5.68	18.32	12.63
240	5.73	18.26	12.53
245	5.79	18.21	12.42
250	5.85	18.15	12.30
255	5.90	18.10	12.19
260	5.96	18.04	12.08
265	6.02	17.98	11.97
270	6.07	17.93	11.85
275	6.13	17.87	11.74
280	6.19	17.81	11.63
285	6.24	17.76	11.52
290	6.30	17.70	11.41

295	6.35	17.65	11.30
300	6.40	17.60	11.20
305	6.45	17.55	11.11
310	6.49	17.51	11.02
315	6.53	17.47	10.93
320	6.57	17.43	10.86
325	6.61	17.39	10.77
330	6.64	17.36	10.73
335	6.66	17.34	10.68
340	6.68	17.32	10.64
345	6.70	17.30	10.61
350	6.70	17.30	10.60
355	6.71	17.30	10.59
360	6.70	17.30	10.59
365	6.69	17.30	10.61

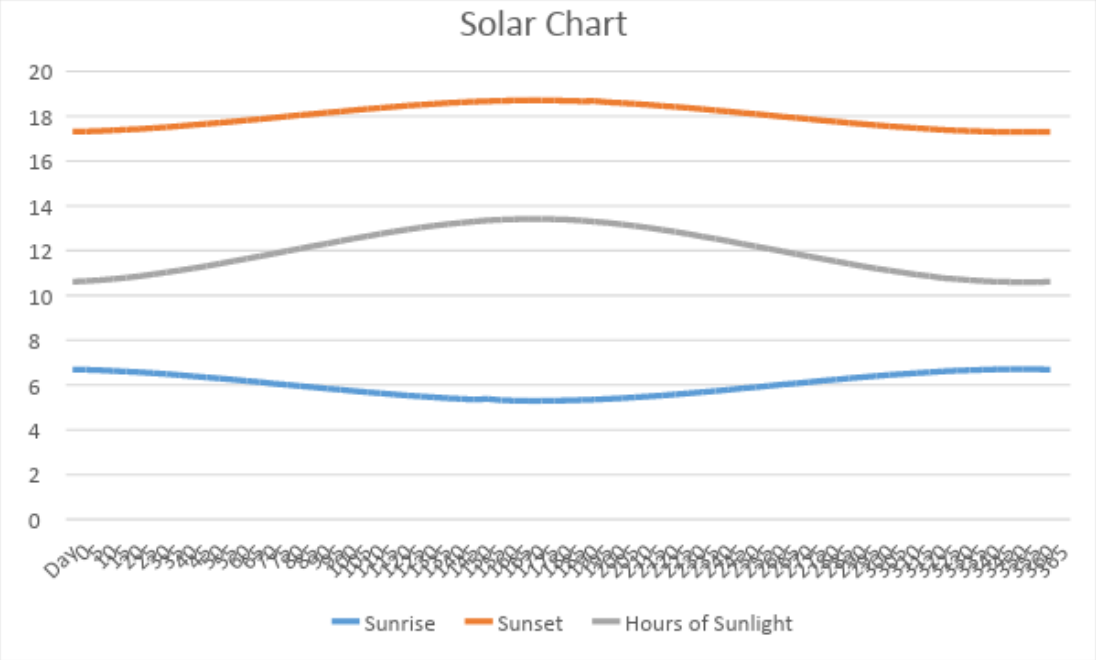


Fig 2.4.4: Approximate calculated graph of solar time

To calculate the sunrise and sunset time we use the (1) and (2) equation and get the value. Using that values we calculate the total sun hour in a day. We can also calculate the sunset, sunset and the sunrise time and the duration of any specific day of the year.

Table 2.4.2: Optimum Tilt Angle for eight divisions of BANGLADESH for one tilt angle System and two Tilt Angle System [21]

	One Tilt Angle for the Whole Year System	Two Tilt Angles for Two Halves of a Year System	
Division	Optimum Tilt Angle (January-December)	Optimum Tilt Angle (April-September)	Optimum Tilt Angle (October-March)
Dhaka	21.40	8.70	37.90
Chittagong	20.20	7.20	36.40

Rajshahi	22.10	9.30	38.50
Khulna	20.70	7.80	37.00
Barisal	20.60	7.70	36.90
Sylhet	22.50	9.80	39.00
Mymensingh	22.40	9.70	38.90
Rangpur	23.30	10.70	39.80

Table 2.4.3: Total Radiation Comparison between One Tilt Angle System And Two Tilt Angle System

Division	Total Radiation for One tilt angle system in Kwh/m^2/year	Total Radiation for Two tilt angle system in Kwh/m^2/year	Difference of Total Radiation between two system in Kwh/m^2/year
Dhaka	3274.72	3382.21	107.49
Chittagong	3291.75	3400.23	108.48
Rajshahi	3267.82	3374.91	107.09
Khulna	3285.34	3393.45	108.11
Barisal	3286.53	3394.71	108.18
Sylhet	3261.80	3368.52	106.72
Mymensingh	3263.47	3370.29	106.82
Rangpur	3251.16	3357.25	106.09

After that the angle θ and air mass (AM) of that particular area or region can be calculated using the sun angle at a vertical axis using equations [16]:

$$\theta = (-\text{ elevation angle}) + 90° \quad (4)$$

$$AM=(\sin\theta\ ^{(-1)}) \quad (5)$$

To report PV cell working processes calculation, a reference spectra is used named AM 1.5 preference also called standard spectra, at SERI and also elsewhere. By the American Society for Testing and Materials, the reference spectra's used by SERI and also others, likewise, which are recognized as unearthly irradiance standards are the "global" moreover, "arrange normal" AM 1.5 spectra [69],[70]. For differentiating the execution of different PV contraptions reference spectra are required and it is also required for delineating execution updates the reason is, as a function of the event spectrum, PV devices are unpleasantly explicit and execution estimations vary. Solar radiation from the sun's plate not withstanding sky and ground-reflected radiation (diffuse) scene on a flat plate device which is suggested by the Global or total irradiance on the PV contraption joins directly. "Facilitate" insinuates only the daylight based radiation from the sun's hover, notwithstanding forward-scattered radiation from around the circle, called circumsolar radiation; "run of the mill" suggests that the sun's bars are inverse (customary) to the tolerant device. Level plate experts utilize overall irradiance, however focusing or cantering specialists utilize the prompt part. The worldwide and direct conventional AM 1.5 spectra have assorted extraordinary disseminations. The diffuse portion of overall irradiance on a bright morning peaks in the shorter (blue) wavelengths and thusly, when summed with the prompt common range, adds short-wavelength irradiance to the ensuing overall range. Air mass implies the relative route length of the immediate sun arranged shaft through the air [71].

At a diffusion of 10%, sun light due to air mass, we determined the direct component of the solar radiation from the air mass which we got using the equations (4) and (5). Using this equation we get the air mass of that area, and using the following equation we calculate the solar radiation:

$$I_D=1.353\times1.1\times(〖0.7〗^{(〖(AM〗^{0.678})})) \quad (6)$$

Using equation (6) visualization and analyzing of the solar radiation as well as the energy harvested through that solar radiation was done from the component of solar radiation. From the following equations [16]:

$$\alpha=〖90〗^{\circ}\text{-latitude angle + declination angle} \quad (7)$$

$$SR=\sin(\alpha+\beta)\times I \quad (8)$$

$$E = r \times SR \times PR \times A \quad (9)$$

In the equations, the tilt angle of the solar panel is represented by β, energy in kWh is presented with E, total area of selected solar panel is represented by A in m^2, the solar panel efficiency is r, solar radiation on tilted panels is assigned as SR and finally represents the performance ratio is represented with PR [23].

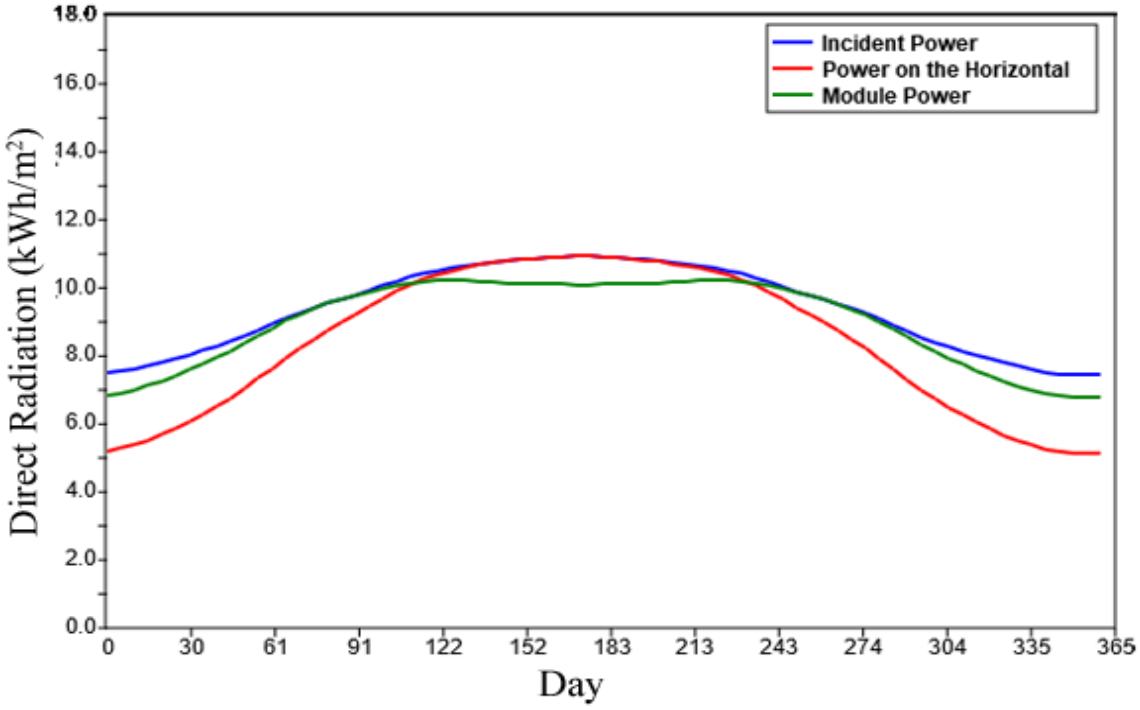


Fig 2.4.5: Solar radiation spectrum [21]

Table 2.4.4: Power consumption off all the modules and devices

Device model	Power consumption	Device model	Power consumption
CARBON MONO OXIDE	750mW	DHT22	1000mW
SOIL TEMPARATURE	500mW	WATER FLOW	1000mW
SOIL MOISTURE	700mW	CARBON-DI OXIDE	800mW
SOIL PH	2000mW	Wi-Fi module	650mW

OXYGEN	900mW	Servo	3500mW

Table 2.4.5: Power calculation of the required solar panel

Power requirement	**Power harvesting**
7(50+500+700+2000+900+1000+1000+800+650+3500)mW = **11.8W** **~12W**	Required power /5 hours irradiance time = 160/5 = **32W**
8Hour per day*12W= **96W**	80% efficiency 32+20%= **40W** (solar)
Loses in power consumption 96+40%= **160W**	Battery (12V*7.5Ah)*2= **180W storage**

Analyzing all of the parts and managing the broad number of issues, we found that we required a 40W sun fuelled board bunch in our proposed model for gathering imperativeness and securing it for later use, while speaking to the structure disasters. We perceived all the setback in the system that can happen that ensures higher execution of the proposed model.

For making the proposed model more capable in importance utilizes, incited programming work has been shown in the base structure where information collection is done in a put off framework. With a definitive target to accomplish higher execution, we assembled a surrender structure in the framework, where information add up to is done after a few depictions of deferral and the proposed modules are turned on precisely when the structure is set up to gather information. For this we used a trade structure which close down most of the modules when no

data is being gathered which spares stacks of essentialness. Subordinate upon the programming we can set the put off time in framework and control it other than for unending gathering of data.

CHAPTER 3

Result & Analysis

3.1 Web Interface & MySql Database:

Our contraption was set up in the accompanying areas: Mohakhali, Gulshan, Old Dhaka and Mirpur in Dhaka city. Every one of the parameters that are gathered from this system module are spared in MySQL database, and a web interface is made to demonstrate continuous information table alongside ongoing table and predicted graphs which have been appeared in Fig 3.1 and Fig 3.2 respectively. These tables shows the real time parameters both in web interface and MySql database in separate rows and columns.

The device detects the air and soil quality dependent on proposed forecast framework. Utilizing that the observing of plant development system can be a lot less demanding and by finding the future qualities, choices can be made early. The sensor esteems are estimated in parts per million (ppm) unit. The adjustments in air and soil quality can be observed from web interface and we would then be able to make fundamental strides dependent on these sensor esteems.

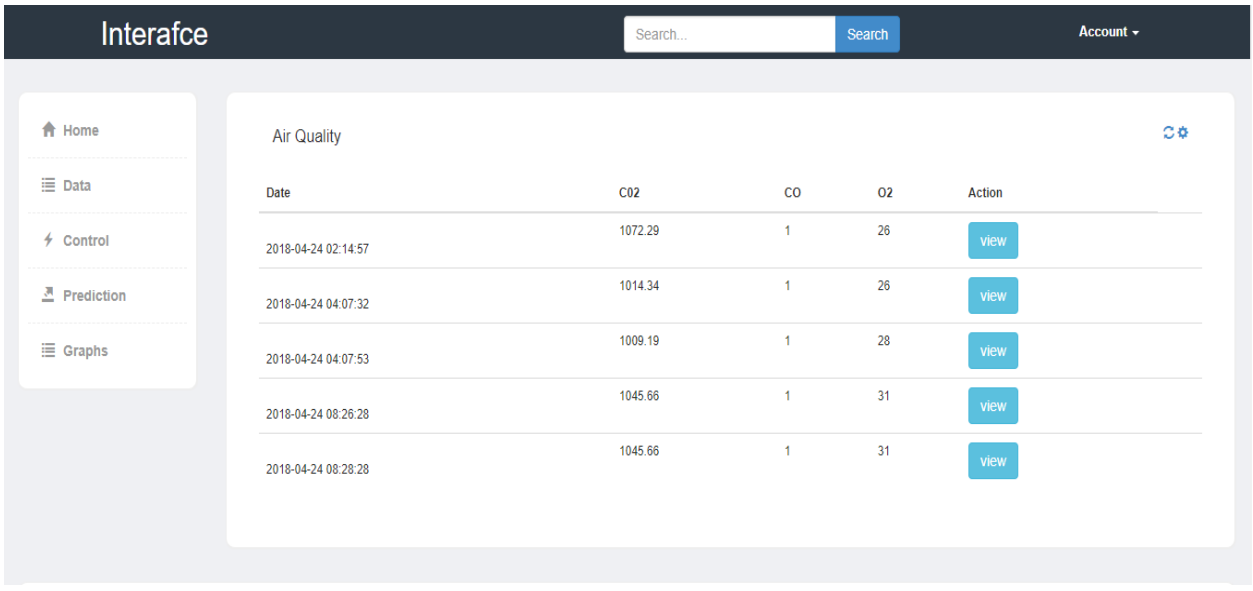
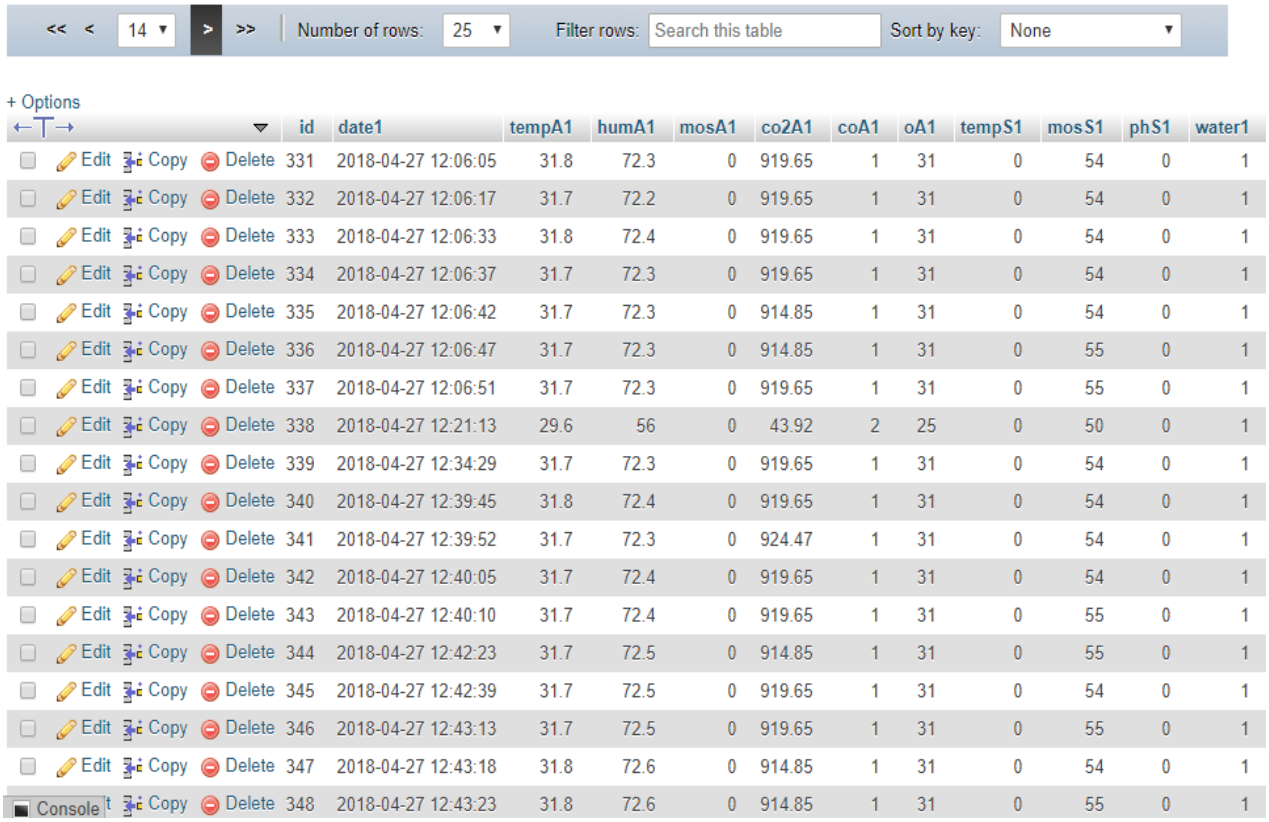


Fig 3.1: Web interface



	id	date1	tempA1	humA1	mosA1	co2A1	coA1	oA1	tempS1	mosS1	phS1	water1
Edit Copy Delete	331	2018-04-27 12:06:05	31.8	72.3	0	919.65	1	31	0	54	0	1
Edit Copy Delete	332	2018-04-27 12:06:17	31.7	72.2	0	919.65	1	31	0	54	0	1
Edit Copy Delete	333	2018-04-27 12:06:33	31.8	72.4	0	919.65	1	31	0	54	0	1
Edit Copy Delete	334	2018-04-27 12:06:37	31.7	72.3	0	919.65	1	31	0	54	0	1
Edit Copy Delete	335	2018-04-27 12:06:42	31.7	72.3	0	914.85	1	31	0	54	0	1
Edit Copy Delete	336	2018-04-27 12:06:47	31.7	72.3	0	914.85	1	31	0	55	0	1
Edit Copy Delete	337	2018-04-27 12:06:51	31.7	72.3	0	919.65	1	31	0	55	0	1
Edit Copy Delete	338	2018-04-27 12:21:13	29.6	56	0	43.92	2	25	0	50	0	1
Edit Copy Delete	339	2018-04-27 12:34:29	31.7	72.3	0	919.65	1	31	0	54	0	1
Edit Copy Delete	340	2018-04-27 12:39:45	31.8	72.4	0	919.65	1	31	0	54	0	1
Edit Copy Delete	341	2018-04-27 12:39:52	31.7	72.3	0	924.47	1	31	0	54	0	1
Edit Copy Delete	342	2018-04-27 12:40:05	31.7	72.4	0	919.65	1	31	0	54	0	1
Edit Copy Delete	343	2018-04-27 12:40:10	31.7	72.4	0	919.65	1	31	0	55	0	1
Edit Copy Delete	344	2018-04-27 12:42:23	31.7	72.5	0	914.85	1	31	0	55	0	1
Edit Copy Delete	345	2018-04-27 12:42:39	31.7	72.5	0	919.65	1	31	0	54	0	1
Edit Copy Delete	346	2018-04-27 12:43:13	31.7	72.5	0	919.65	1	31	0	55	0	1
Edit Copy Delete	347	2018-04-27 12:43:18	31.8	72.6	0	914.85	1	31	0	54	0	1
Console t Copy Delete	348	2018-04-27 12:43:23	31.8	72.6	0	914.85	1	31	0	55	0	1

Fig 3.2: MySql database

3.2 Air Parameters Result & Analysis:

In Fig. 3.3, the blue sinusoidal lines explains the temperature values we get on the other hand the red curve shows the upcoming temperature prediction for next 20 hours. Table 3.1 shows the cross validation of expected and predicted data where the accuracy we get to be 99.13% for the observed hours of data.

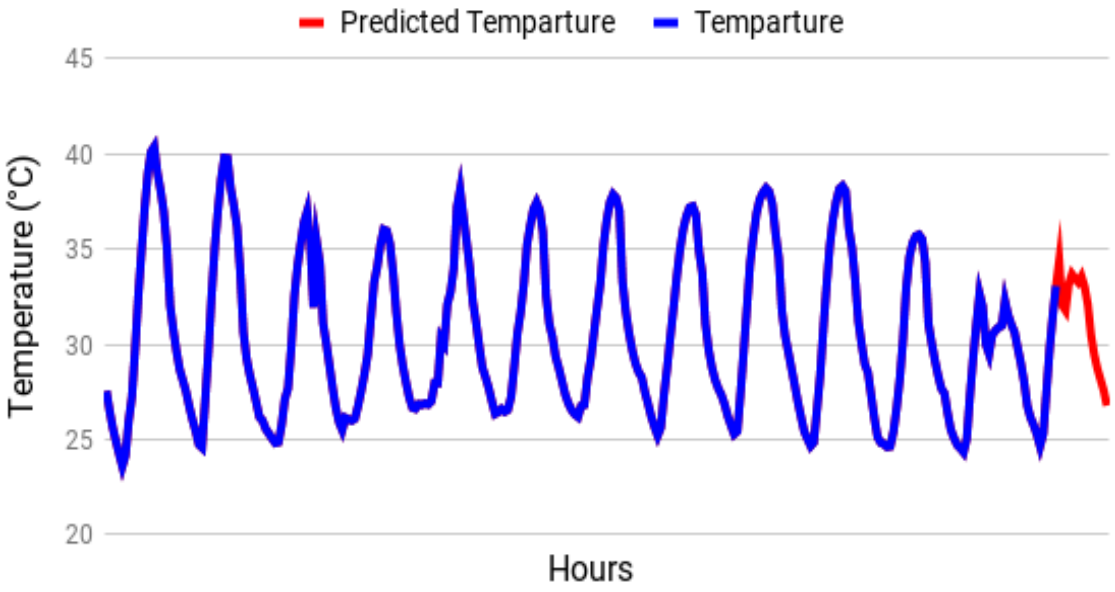


Fig 3.3: Temperature Analysis and Prediction

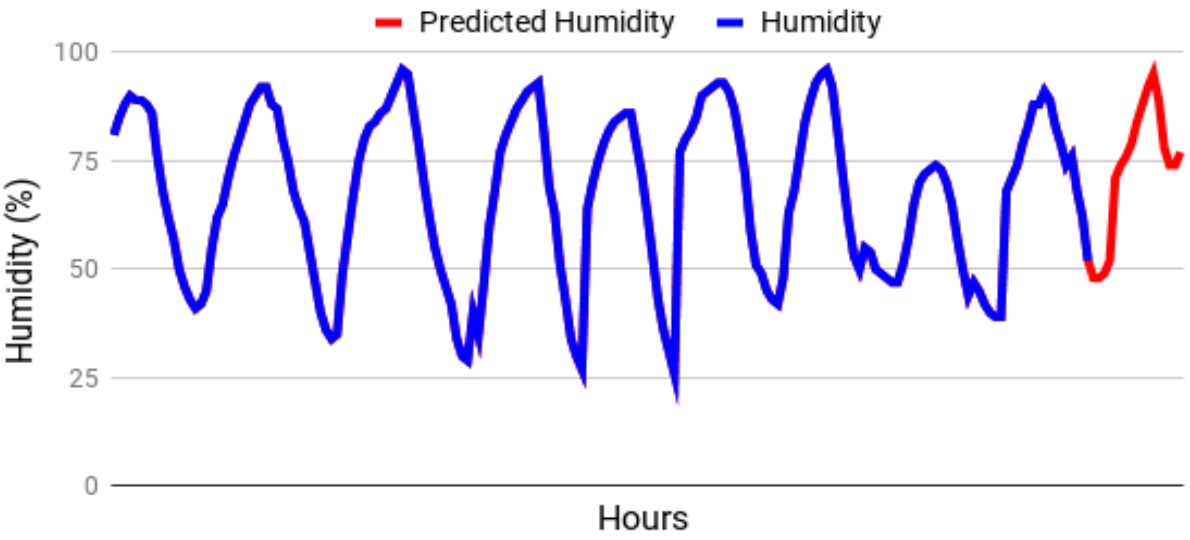


Fig. 3.4: Humidity Analysis and Prediction.

Also the procedure was used on humidity measurement as appeared in Fig 3.4, where the red bend shows the future forecast. Table 3.2 presents the correlation between the two kinds of results. One is what we measured and the other one is what we predict. This methodology has been applied in all other sensor parameters in a similar way.

Table 3.1: Cross comparison of temperature prediction

Expected	Predicated
33.27	33.69
33.27	33.46
33.50	33.57
32.51	32.09
31.70	30.49
30.64	29.47
29.40	28.73
28.15	28.00

Table 3.2: Cross comparison of humidity prediction

Expected	Predicated
70.52	68.00
62.91	62.01
57.16	53.94
48.33	48.00
46.34	48.12
51.08	52.43
55.05	60.38
75.88	74.28

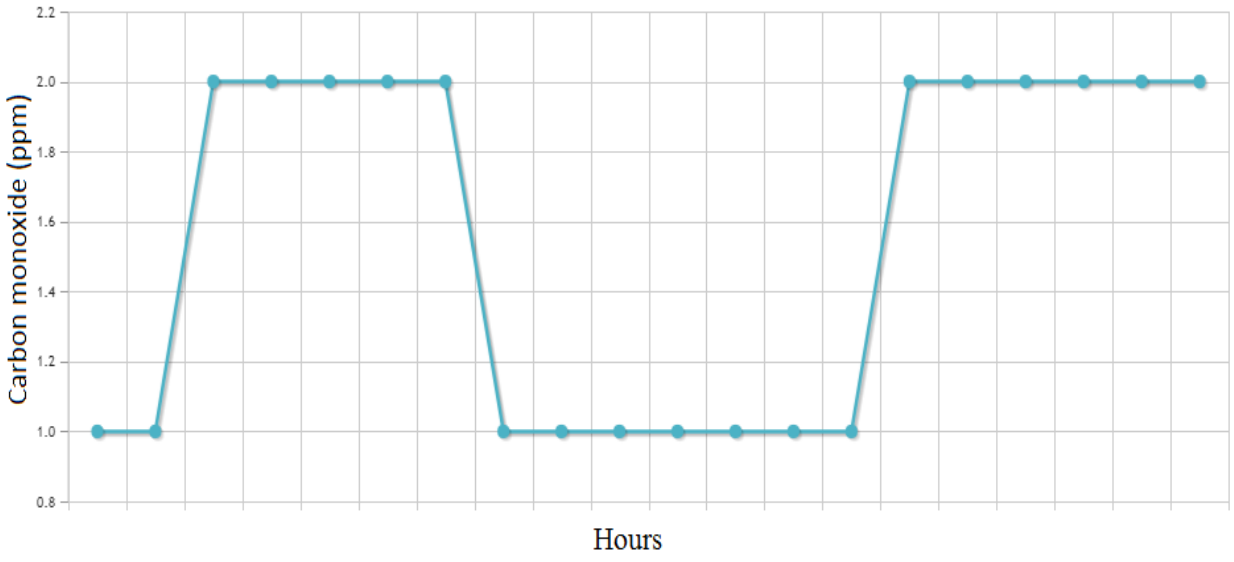


Fig. 3.5: Real time graph of Carbon monoxide (CO).

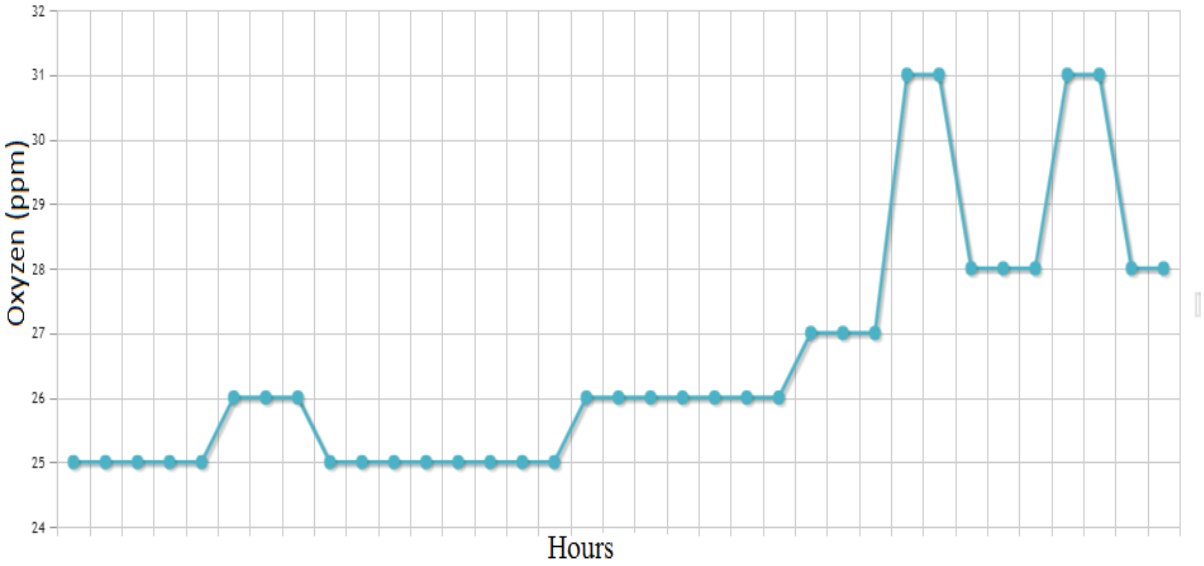


Fig. 3.6: Real time graph of Oxygen (O_2)

Fig. 3.5 and 3.6 demonstrate the resultant chart of carbon monoxide (CO) and oxygen (O2) of various area of Dhaka city. The resultant values of CO changes is somewhere in the range of 1 and 2 ppm relying upon different areas of Dhaka. In suitable CO level, it plays different physiological techniques as a functioning flagging methodology, anyway a strange state of exogenous CO is destructive for plants. It was convincingly definite that exogenous CO gas could apply the critical consequences for managing distinctive physiological occasions including Neurotransmission. In plants, CO has been found to delineate the parts of this perplexing flagging molecule in plant improvement and movement. Social event evidence in plants has exhibited that CO is used for various Inter-cell and Intracellular characteristic capacities. The value of O2 is in 24 to 32 ppm. We require more manor where the range O2 is low. Fig. 3.7 demonstrate the ongoing consequences of CO2 in hourly premise. The resultant values of CO2 is between 960 to 1080 ppm. From the perception of chart, CO2 is high a direct result of substantial number of populace and absence of tree manor.

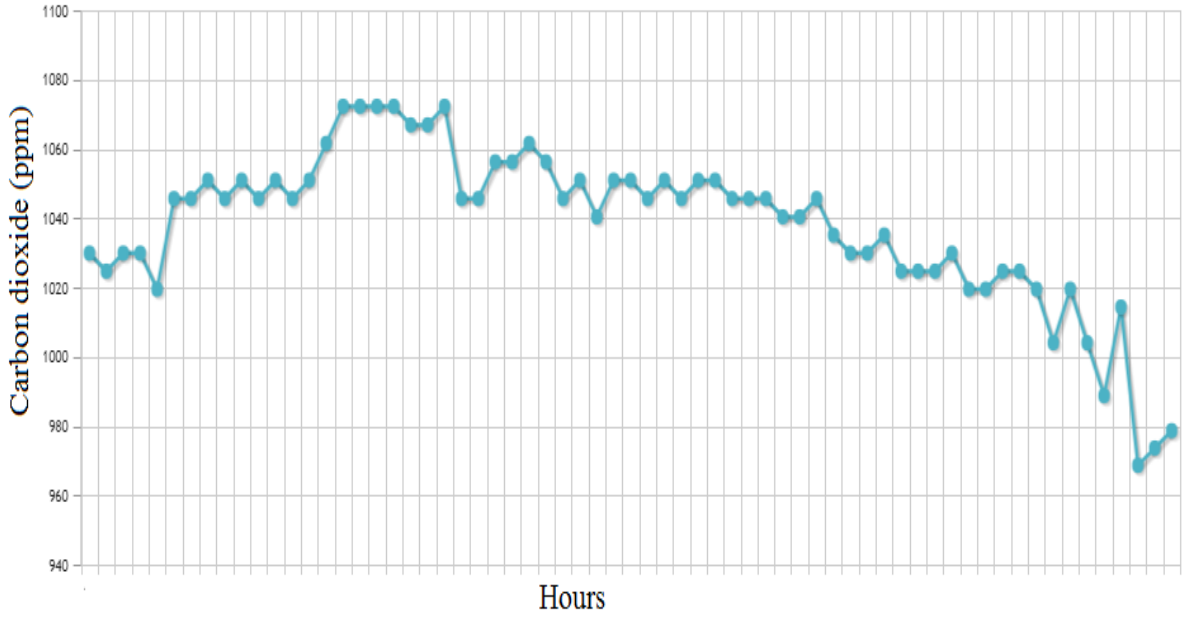


Fig. 3.7: Real time graph of carbon dioxide (CO_2).

3.3 Soil Parameters Result & Analysis:

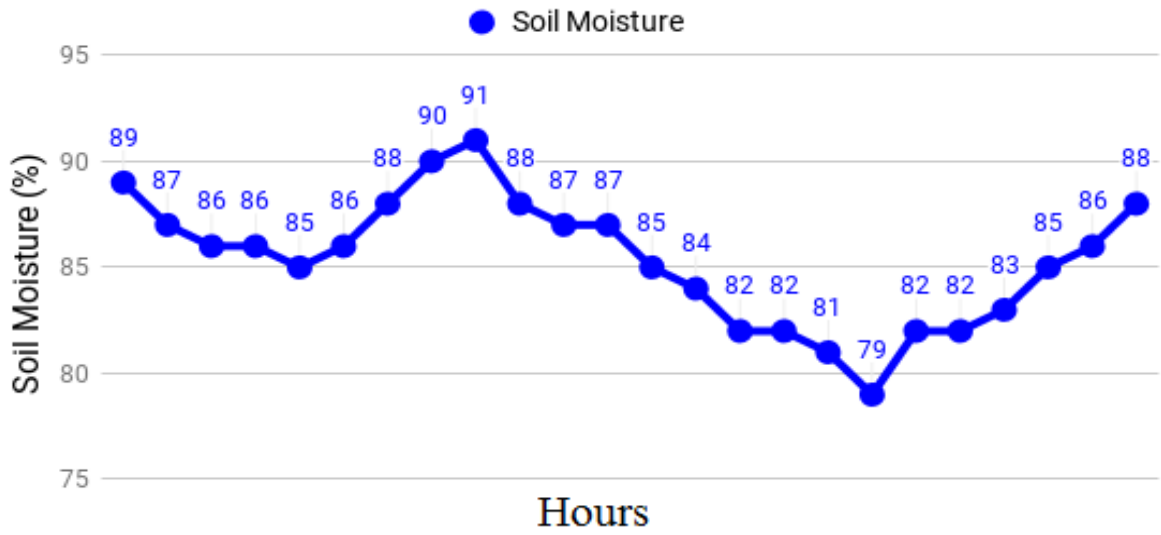


Fig. 3.8: Real time graph of soil moisture

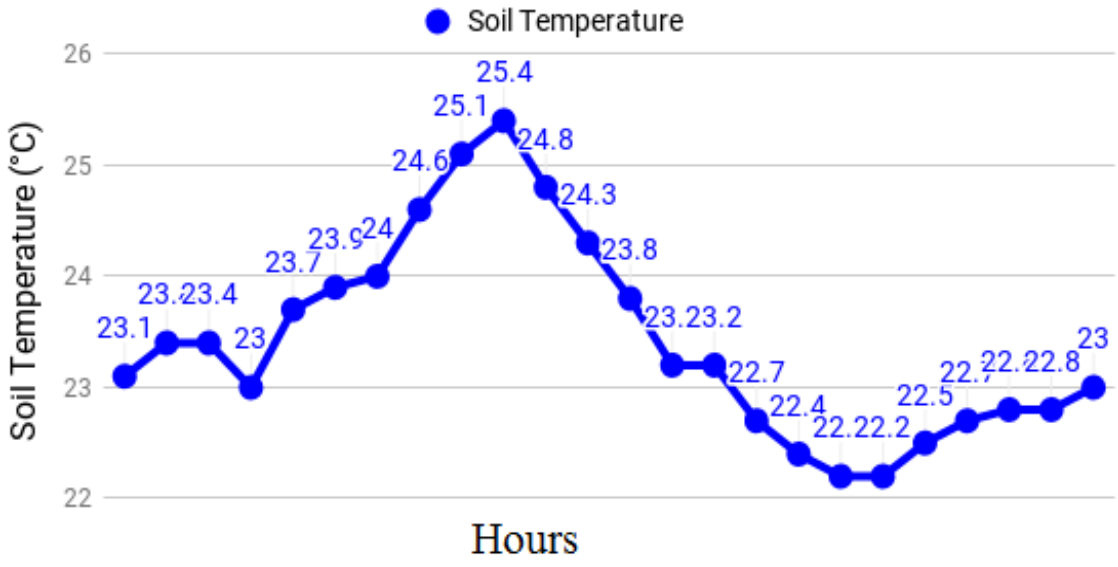


Fig. 3.9: Real time graph of soil temperature

In Fig. 3.8, consistent estimations of soil moistness of various locations in Dhaka are showed up. In the time of April, soil moisture is collected between the ranges of 79 to 91 % from the graph. There are a few area where rain water cannot move and for that reason the soil remain wet for a long time and not suitable for farming most of the crops. This condition of wet soil is considered as long term rain water legging where the soil moisture rate cross the 80% rate. As a result this kind of farmland should be ignored or taken proper steps before irrigation. In case water contains for whole deal than it plant root can get ruined which hampers plants improvement from inside the soil since plant can't get enough oxygen from the earth. Around 50-60% sogginess ensures the trademark clamminess for the plant improvement [27]. In Fig. 3.9, the characteristics soil temperature in the significant lot of April are plotted continuously which exhibits the range is between 22 to 25.4°C. Around each plant backs off its development when soil temperatures go down to 9°C and go up to 50°C [24]. Most outrageous living things' works inside soil thrive between 22-35°C temperatures. Plants, for example, tomatoes, cucumbers and snap peas advantage from soils no under 60°F (16°C.). Sweet corn, lima beans and two or three greens require 65°F (18°C) [35].

Table 3.3: Average soil pH of different locations in Dhaka

Mohakhali	Old Dhaka	Gulshan	Mirpur
4.78	5.82	4.85	5.81

The pH sensors sense the pH regard in hourly preface and Table 17.3, exhibits the ordinary pH of different regions. By and by, Between 7.5 to 8.3 pH insinuates the essential soil and it is suitable for plants like Irish potatoes, sweet potatoes, mints, Blueberries .In the extent of 6.8 to 7.2 rice, peas, wheat, peppers, tomatoes, turnips, corn, garlic, etc grow well and these range demonstrates fair soil [25]. The extent of acidic soil in an extent of 4.6 to 6. More than 8.3 is exorbitantly dissolvable and under 4.6 is too much acidic. Extending of soil sharpness decrease the earth treatment and alkalinity causes nonappearance of iron in soil [35]. Thusly, checking and examining on the pH level from interface, we can make crucial steps like including calcium or limestone raises the pH by executing the acids [26].

The going with philosophy in Fig 3.10, is associated with an extensive scaled dataset of CO2 from recent years to check the gauge. The dataset is default in pandas which is an examination gadget and is used to test the model in a yearly dataset.

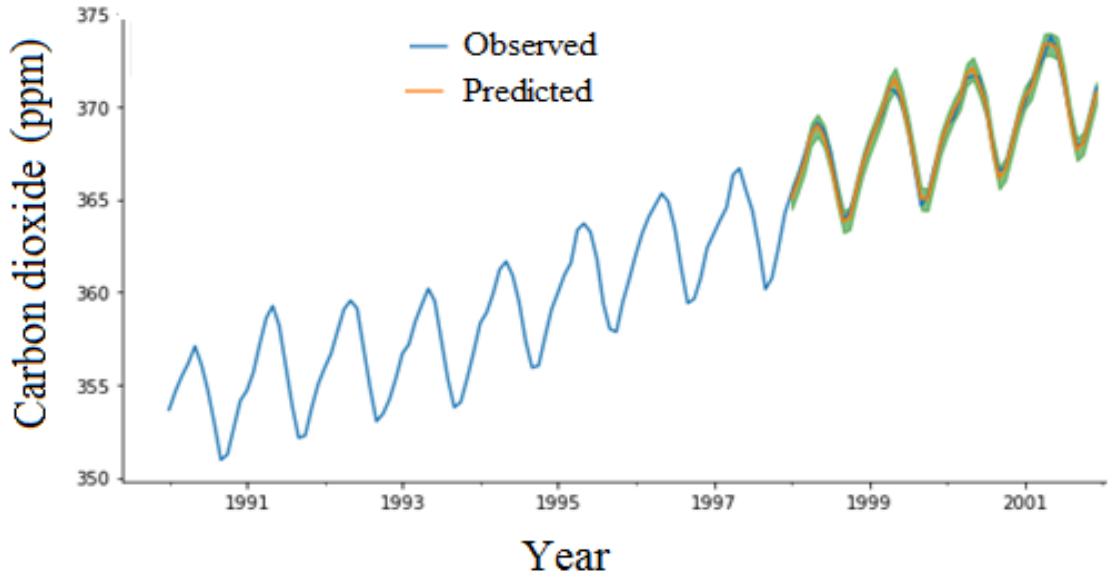


Fig. 3.10: Yearly dataset prediction graph of CO_2

The rain drop sensor sends the status (not down-pouring, sprinkling, generous showering) in the web interface which is showed up in Fig. 3.11 and subject to, it can distinguish it is conceivable that it is raining outside or not and moreover the term of down-pouring of each place figuring the start and end of rain.

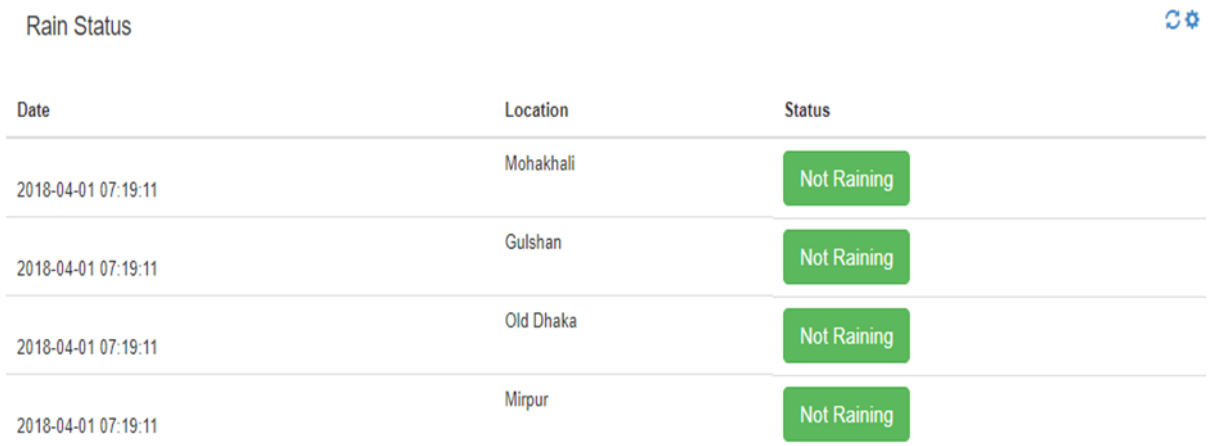


Fig. 3.11: Rain status in web interface

Chapter 4

Conclusion & Future Work

4.1 Conclusion

New innovation and new technology is surrounding the world every passing days. IoT is one of these things that bring all those innovation to another level. IoT is promising new advancement which passes on contraption interoperability and machine to machine to remarkable measurements. These features engages us to tremendously extend the accommodation of any electric contraption used in standard everyday presence or in had some skill in distress by retrofitting IoT abilities to them. In human development and a sustainable global environment, plants plays an essential role and for that a sustainable relation between

environment and plant is required. In the area of agriculture and plant biology, keeping the agriculture sustainable under worldwide climate change is the main topic in modern days. Particularly monitoring the soil and air environment is more essential for plant growth system.

IoT utilize can be unfathomably worthwhile with respect to plant improvement. With the growing rate of about two percent a year, global population is somewhat three billion and it is growing faster than another period of time. As a result population is a vast problem and with population the required productivity of crops are also required. In this state of unstable population and global warming and other environmental problems that are getting worse in every year, monitoring the plant and environment is also very important before it becomes unstable. To reach the highest productivity from the agricultural system, a close and stable monitoring of air, soil, as well as the plant growth is very essential.

The growth of any plant depends on few factors and the environment it is growing is very important as the environment plays a critical role in basis of plant growth. The CO_2, O_2, CO in the air, pH, water level, soil temperature and moisture are the few things that is a must for sustainable plant growth. With micromanagement of our project with different gas and environment sensing modules connected with IoT gives us access to monitor a large farm area creating few segments which allows us to monitor the plant harvesting in terms of plant condition and the environment they are growing. And due to the huge number of data that can be collected from the farmland and process and analyze these in an effective way, prediction of future environment is more accurate.

In the plant growth system taking the right decision at the right moment is more essential. Also using the exact amount of resources in terms of plant growth and reducing the wastage to a certain amount is a challenge for both plant growth industry and also for the global environment. Adding IoT and also all these modules and function implemented in this scale provides the plant growth industries access to potential wastage reduction in a greater level as well as gives the chance of faster decision taking as the analysis and prediction gives advance alert. Also maintenance the device is much easier. As we are using solar energy for the power source its more durable and environment friendly. Solar energy emits less CO_2 in the environment and takes the project to the next level. Keeping all those problems in mind the project is developed to monitor environment, plant, soil and assure a sustainable relation between environment and plant for better world.

4.2 Future Work

In the future there are a few changes we want to make for more effective and more compact design for our device.

First of all, we are using few modules for data collection purpose. We are using Arduino Uno that uses an ATmega328P which has a dimensions of 68.6 mm × 53.3 mm. For a microcontroller board it is much more area than required for only a voltage and over current flow protection. There is also a problem with only one 5V output we get from an Arduino. So for our future device we would like to design a Custom made PCB with all the Sensors. And also for the sensors they are taking a much more area than the requirement. Also few modules requires a certain voltage level to work properly. Few sensors need 5V and few needs 3.3V to work. So proper voltage input is a big problem as over voltage can permanently damage any sensor.

In the future project we will design a PCB and circuit with all the protections. It will provide advantages in two ways. Few modules uses small SMD led for the power indication and data collection statues. Which in many cases is not required as we can easily see the data chart from the server and identify the damaged sensor so easily. But these Led consumes a certain amount of energy which may hamper the power consumption as in a wireless device power is a big factor. Than in a custom PCB design the size will be more compact and easier to deploy and the farmland with smaller battery pack that will last longer. This way we can also collect data from the greenhouses where solar energy harvesting is a problem and also where we cannot get an efficient solar radiation for the device to work properly.

Secondly, as it is a wireless and the device will be planted in the farmland there has to be an image processing system for better plant monitoring. Image processing is a strategy to accomplish a few tasks on a picture, with a goal of getting a developed image, other than that to separate some valuable data from it. Image processing is one kind of a signal processing where output might be picture or attributes related with that picture from inputting an image. Image processing is among the quickly developing advancements these days. It frames center research region inside computer software engineering and electrical engineering disciplines as well. Two sorts of techniques are utilized image processing to be specific, Analog image processing and Digital image processing. In case of analog image processing, it can be utilized

for the printed versions like printouts and photos. Image investigators utilize different essentials of elucidation while utilizing these visual strategies. On the other hand in digital image processing, it procedures help in control of the advanced pictures by utilizing PCs. The three general stages that a wide range of information need to experience while utilizing advanced procedure are pre-preparing, upgrade, and show, data extraction.

So with image processing and using digital image processing we can monitor the plant growth system from anywhere in the world. With image processing, we can also store the plant growth process in a daily basis and compare it with input data. As a result we can find diseases of the plants. With image processing we can also analyze plant health and parasite if there any. So in future upgrade, using image processing is essential in this project. Using image processing in this device not only increase the accuracy of the data analysis and plant monitoring, it also reduce the error and keep it in a fewer amount.

Thirdly, in this device data collection and analysis is the main purpose. But it's not possible without a proper cloud to server communication system. So there has to be a storage system where all the collected data is stored. From there we can access the data using any internet devices such as computer, smartphone, tablet etc. but even it is available in the server and anyone can access it, it's a little complex process to reach the data. In the data base we can see all the data arranged according to time and date. But there is a problem as it is not that much user friendly yet. Analysis of the collected data can be done from the website but it's a bit hard to do so. Also the data is collected in time and date basis, there must be different chart for different area.

To solve this problem we have to come up with a user friendly solution. So we want to build an android app for the users. Now a day's smartphone is available in every corner and most of the people is comfortable with the use of android system. The app can also be easily available from any app store. So it is accessible more easily than the web system. In the app there will be different section for the different devices segmented in the farmland and also section for a full farmland. As a result we can see data in a certain area of the planted device as well as a whole farmland. From these we can see real-time graph of the data and prediction system. So using an android app will give easy access to the users for better understanding.

Finally in future we would like to introduce automatic deployment system of the device. These days all are attracted to automation system and AI. Robotic bots are making our day to day life

more easy and comfortable. So for this future upgrade we would like to introduce a robot for deployment and maintenance of the devices so that manual work not need to be done. The device has a certain area where it can sense the environment and outside this range its not effective. So for effective way of planting the devices a certain measurement need to be followed. For manual work it is a tough work and not precise in many cases. On the other hand with certain calculation and algorithm and also with proper calibration we can achieve the effective way of device deployment system. Also with Artificial Intelligence or AI we can program the bit to store all the device location and if any device become faulty it can collect the device from the exact location for future maintenance or repair. With this we can achieve the maximum utilization of the device and reduce the error in data collection.

With all these future development we can achieve a device with more accurate data collection system, more user friendly operating system, more effective way of the device implementation. For modern agricultural system and effective way of cultivation this device can reduce the wastage and increase the productivity. So with all these development we can market this device from small farmland to industrial agricultural purpose. as there not such device in the market that can forester an area based environment sensing and prediction system, this device can easily be accepted by the user with a user friendly app to monitor their farmland more effective and efficient way.

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