Smart Agricultural System Using LoRa Wireless Technology

By

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Abstract

Contemporary the Internet of Things (IoT) is one of the highest promising application areas in information technology for forthcoming products and services. And the agriculture field is changing expeditiously pointing to the future of automated and embedded systems with a bunch of sensors to monitor and curb the flourishing plants in a way to profit associated with it. The persistent monitoring and controlling of distantly located plants is labor compact and technically tough business. In modern agriculture, a Wireless Sensor Network (WSN) provides a simple cost-effective solution to monitor and control. However, one of the major issues of IoT is still a conversation between devices, notably on long-range. It implies that LoRa is lately accepted as auspicious communication technology, due to its properties such as long-range, two-way communication, and with low cost. It is stated that the communication distance of LoRa is up to 10 km [1], but it is not clear in what measure does. The communication distance is affected by the environmental conditions, parameters of devices, etc. Here we merge the LoRa WSN technology in the agriculture sector for making long-distance, low-cost communication.

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Chapter 1

Introduction

1.1 Introduction

In our modern world, many people are making full use of technology, and because of that, they are doing their job soon and well. But still, many rural farmers cannot use technology more. Also, the demand for food supply is increasing due to an increase in the global population. At that time, IoT(Internet of Things) tends to develop certain techniques in the field of agriculture to increase food production. The farmers can also get useful information regarding the moisture and soil requirements etc. So we are implementing this smart agricultural system for them.

With the help of this system, farmers can examine the temperature, humidity & soil moisture of their farm, which is done by various IOT sensors like DHT, Soil moisture, as well as control various components, like motor, etc. This system is very easy and simple to use, it works wholly on wireless technology. To use this system the farmer has to place the transmitter module in different places in his field and the receiver is put in his home and connected to the server. Now, the farmer can monitor and control the system by the website or mobile application.

As discussed earlier, this system is formed by using wireless technology and we already have a handful of wireless protocols like BLE (Bluetooth Low Energy), Wi-Fi, and cellular, etc. But these technologies are not ideal for IoT sensor nodes, because they needed to transmit information to a long distance without using much power and with low cost [2]. Apart from this LoRa technology plays a vital role in the agriculture sector. That’s why we are using LoRa technology, which can perform very-long range transmission of data or information at low cost and without an internet connection.

The term LoRa stands for Long Range. It is a wireless radio frequency technology introduced by Semtech [1]. LoRa is used to transmitting information in both directions to long-distance and typically LoRa can achieve a distance of 15 to 20 km and can work on battery for a year [1]. The license frequency band for LoRa Technology in India is 865 MHz to 867 MHz [2].

In wireless technology solution, BLE works with low power, but cannot send data to long-distance[1]. While using LoRa we can achieve high distance communication without an internet connection, thus it overcomes the drawbacks of Wi-Fi and BLE communication. The below chart provides a difference between WSN technology.

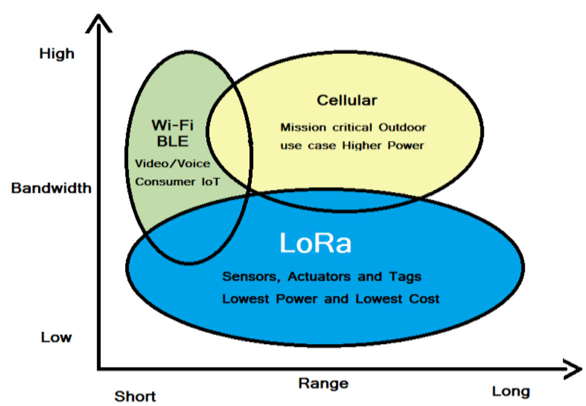


Figure 1.1: WSN Comparison Graph [3].

1.2 Objectives

- The objective of a smart agricultural system using LoRa wireless technology is to observe and control the temperature, humidity, moisture, and motor of the field via website and android mobile application. Field data will transmit using LoRa technology, without an internet connection, and with high distance.

1.3 Outline

- Chapter-2 contains a discussion about the existing literature survey.
- Chapter-3 provides an overview of methods and modules that are used to carry out implementation.
- Chapter-4 shows the results of various experiments performed for a smart agricultural system using LoRa technology.
- Chapter-5 contains a conclusion and discussion about the future scope.

Chapter-2

Literature Survey

In the last few years, researchers have shown a great interest in smart agriculture, WSN (wireless sensor network), and also in the area of LoRa technology. Many researchers used ZigBee and other WSN technology for field data monitoring. This chapter briefly discusses the related research work carried out by different researchers in the area of smart agriculture, and WSN.

Santoshkumar, et al.[4] in their research, select various sensors and methods for precision agriculture such as temperature sensor, humidity sensor, and Arduino (ATMega328) microcontroller board with the wireless sensor network system. The role of WSN is to sense the remote data from the desired location and transmit through the wireless network which can be viewed by the receiver. The earlier monitoring systems had a lot of limitations such as distance and reliability factors. Previously, the wireless networks used RF technology which was replaced by Bluetooth technology, and Bluetooth has replaced by ZIGBEE technology [4]. Santoshkumar, et al.[4] discusses the development of the WSN system for precision agriculture based on the Zigbee wireless sensor network. ZIGBEE is a specification for wireless personal area networks (WPANs), and operating at 868 MHz, 902-928 MHz, and 2.4 GHz [4]. Moreover, WPAN is a personal area network in which the device connection is wireless. The ZIGBEE is used as LR-WPAN i.e. low rate wireless personal area network. According to them, using ZIGBEE devices in a WPAN can communicate at speeds up to 250 Kbps while physically separated by distances up to 50 meters in typical circumstances and greater distances in an ideal environment [4].

M. Dholu, et al.[5] proposed and designed an IoT for precision agriculture application. This proposed system consists of various components like humidity & temperature sensor, soil moisture sensor, and a microcontroller unit (MCU) along with the Wi-Fi module, using the Wi-Fi router uploaded the sensed data on Thingspeak cloud and finally displayed it on the mobile application. According to them, soil moisture measurement has done by using the YL – 69 electrodes. There is two terminal in electrode between which the resistance is measured. With a change in the soil moisture the resistance between these two-point changes. So this change in moisture is the measure of the amount of moisture in the soil. YL–38 is a chip which is used in the proposed work to convert the change in resistance into an analog voltage, it is fed with 3.3 v supply so it gives an output from 0 to 3.3 v. NodeMCU is a microcontroller unit that is used as an MCU, which is development prototyping kit based on ESP8266.

D. Davcev, et al. [6] design an IoT agriculture system based on LoRaWAN. As discussed, RF technology was replaced by Bluetooth technology, and Bluetooth was replaced by ZIGBEE technology, And ZIGBEE has replaced by LoRa technology. D. Davcev, et al. [6] in their paper, discussed LoRa technology. Use LoRaWAN and LPWAN (Low-power Wide-Area Network) as a transmission protocol that was designed by the LoRa Alliance and met the need of the IoT services [6]. LoRaWAN network was specifically designed for IoT applications with the objective of connecting thousands of sensors over a large network [6]. LoRa is the physical layer of the LoRaWAN which is based on CSS (Chirp Spread Spectrum) modulation, which maintains the same low power characteristics as FSK modulation but significantly increases the communication range [6]. According to D. Davcev, et al. [6], LoRaWAN can achieve data transmission range from 2-5 km in urban areas and to 15 km in suburban areas, LoRaWAN's star of stars topology in comparison with ZigBee's mesh network topology does not need additional modules to act as routers, which decreases the overall cost and complexity of the network [6].

Y. Kim, et al. [7] designed remote sensing and control of an irrigation system using a distributed wireless sensor network. In this proposed system [7], communication signals from the sensor network and irrigation controller to the base station were successfully interfaced using low-cost Bluetooth wireless radio receiver [7]. They also developed graphical user interface-based software [7]. Wireless data communication was well described by Y. Kim, et al. [7] in which, Bluetooth module was selected for the wireless data communication from the in-field sensing station to a base station. The key features of Bluetooth technology are low power, low cost, and communication between Bluetooth devices follows a strict master-slave scheme [7]. Y. Kim [7] observed Bluetooth radio transmission at a downloading interval of 15 min, daily total power consumption was 23.8 Wh [7].

A. Hanggoro, et al. [8] proposed and designed a greenhouse monitoring and controlling using an android mobile application, which was a complete system designed to monitor and control the humidity inside a greenhouse. It used an android mobile phone, connected using Wi-Fi to a central server which connects via serial communication to a microcontroller and humidity sensor. According to them, Wi-Fi has been implemented all over the world, and 802.11g was the third modulation standard for wireless LANs. It worked in the 2.4 GHz band (like 802.11b) but operated at a maximum raw data rate of 54 Mbit/s, or about 19 Mbit/s net throughputs. It used wireless G for communication path from android to server and vice versa. A. Hanggoro, et al. [8], in their paper, the hardware system was divided into 3 parts which are microcontroller Arduino, a sensor, and IEEE wireless 802.11g. The microcontroller sends the value from the sensor to the android via computer through serial communication and wireless connection [8].

P. Gangurde, et al. [9] designed a novel approach for precision agriculture using a wireless sensor network. In their research, they propose different topologies for precision agriculture. The development and deployment of WSNs have taken traditional network topologies in new directions [9]. Different WSN topologies are Bus, Star, Ring, and Grid [9]. According to them, delay in star case was much less than the delay in a bus, grid, and ring topology [9]. As per their research, average network delay using the execution for the four cases was 45ms for the star, 71ms for the grid, 81ms for the bus, and 98ms for the ring topology [9]. In star topology, the delay was decreased by approximately 50%. [9].

D. I. Sacaleanu, et al. [10] discussed a data compression on the wireless sensor nodes lifetime for LoRa technology, comparing with ZigBee and Enhanced ShockBurst. According to D. I. Sacaleanu, et al. [10] DASMote node with ZigBee protocol acquires 7 parameters and transmits 14 data bytes without data compression. The average current recorded in the transmission was 27 mA, while the current spend on 58.45 ms transmission timeframe was 1.59 mA, thus resulting in a ~20% energy improvement [10]. For the Arduino nodes with the Enhanced ShockBurst protocol, there were acquired 7 parameters and transmit 14 bytes without data compression, 2 bytes for each parameter [10]. The average current in the transmission was 6 mA [10], while the current spend on a 4.64 ms timeframe was 28.1 µA, thus resulting in a ~7% energy improvement [10]. And the LoPy node with LoRa acquires also 7 parameters and transmits 14 data bytes without data compression [10]. The average current in the transmission was 154 mA, while the current spend on an 1190 ms timeframe was 183 mA, thus resulting in a ~31% energy improvement [10].

Table 2.1 shows a Summary of the Literature Survey

No.	Paper Title	Author name	Journal Name	Method Used	Advantages	Dis-Advantages	Remarks
1	IOT Based Smart Crop field Monitoring and Automation Irrigation System	R. Nageswara Rao, B.Sridhar	Proceedings of the Second International Conference on Inventive Systems and Control (ICISC 2018) [11].	Raspberry PI, Soil moisture sensor, Temperature Sensor, Relay (For controlling AC Motor), Buzzer, MCP3208 (Convert Analog to Digital Signals)	The main Advantage of this work is crop development at low quantity water consumption [11].	Raspberry PI is Expensive, and This should be properly shutdown otherwise there is a risk of file corruption and software problems.	Raspberry PI will replace with Arduino, this just plugs and play device. If power is connected starts running and if disconnect it simply stops.
2	IOT Based Smart Agriculture System	G. Sushanth1 and S. Sujatha2	2018 International Conference on Wireless Communications, Signal	Arduino, Moisture, Humidity, Temperature, and Motion Sensors,	Send suggestions via SMS to the farmer directly on his mobile using the GSM module	Android mobile and, continuous internet connectivity is required.	Only Android application is there (IOS not)

			Processing, and Networking (WiSPNET) [12].	Relay, Water pump, wifi, GSM/GPRS, LCD Display, Power Supply.	instead of the mobile app [12].		
3	IOT Based Intelligent Agriculture Field Monitoring System	Md Ashifuddin Mondal, Zeenat Rehena	2018 8th International Conference on Cloud Computing, Data Science & Engineering (Confluence) [13].	Temperature sensor, soil moisture sensor, Arduino UNO, NodeMCU	The level of water content is low the pump gets ON automatically or the level of water content in land is high the pump gets OFF automatically [13].	NA	Counting accuracy can be more than 95%.
4	Development of WSN System for precision Agriculture.	Santosh kumar, Udaykumar R.Y	IEEE Sponsored 2nd International Conference on Innovations in Information Embedded and Communication Systems, ICIIECS’15 [4].	Arduino UNO, Temperature sensor, Humidity sensor, Zigbee Radio	WSN provides a simple cost-effective solution to monitor and control [4]. ZIGBEE technology is used as WSN [4].	use of different languages can encompass further usage of the model at hand	ZIGBEE technology has a low Range than Bluetooth and other WSN like Wi-Fi and LoRa

5	IOT for Precision Agriculture Application	Manishkumar Dholu, Mrs. K. A. Ghodinde	Proceedings of the 2nd International Conference on Trends in Electronics and Informatics (ICOEI 2018) [5].	MCU, Wifi Module, Temperature & Humidity Sensor, Soil moisture sensor, Wifi router.	Communication with the gateway wirelessly through Wi-Fi module as it gives an advantage over Bluetooth [5].	Wi-Fi has short-range communication, over LoRa WSN	Bidirectional communication is not there.
6	IOT agriculture system based on LoRaWAN	Danco Davcev, Kosta Mitreski, Stefan Trajkovic, Viktor Nikolovski, Nikola Koteli	2018 14th IEEE International Workshop on Factory Communication Systems (WFCS) [6].	Microcontroller, Sensors, LoRaWAN	This system base on the LoRaWAN network for long-range and low power consumption data transmission from sensor nodes to the cloud services [6].	LoRa has a low data rate as compared to other WSN.	NA

Chapter-3

Methodology for Implementation

3.1 Overview of existing workflow:

Santoshkumar, et al. [4] have discussed the development of the WSN system for precision agriculture based on the ZIGBEE wireless sensor network.

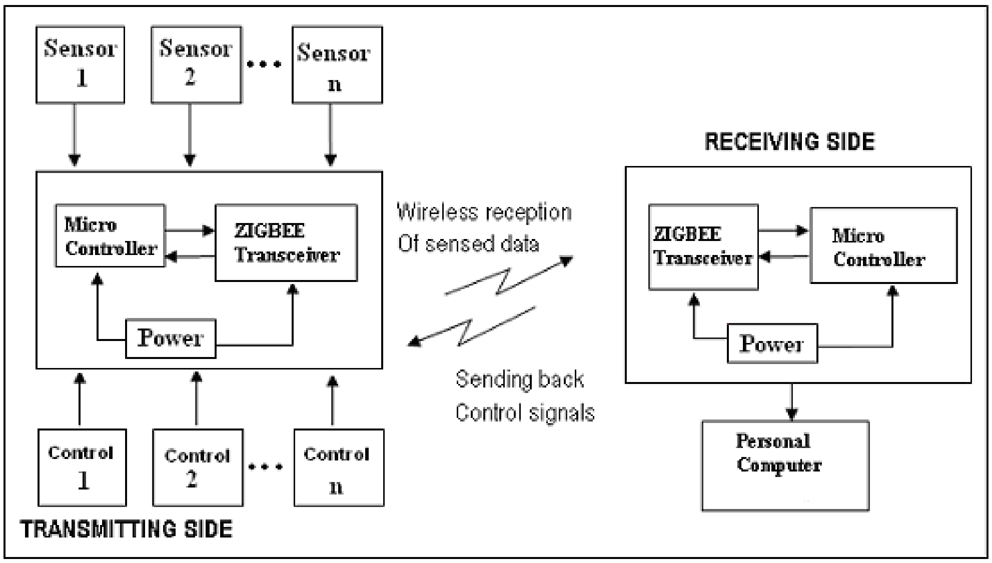


Figure 3.1: Existing workflow [4].

Santoshkumar and Udaykumar R.Y have proposed the WSN node using ZIGBEE. In this model, at the transmitting side, the Microcontroller and ZIGBEE transceiver is power by the external power supply and different sensors are connected with a microcontroller. All the sensor's data are controlled and collected by the microcontroller, and using the ZIGBEE transceiver transmits the sensed data wirelessly. At the receiving side, another microcontroller and the ZIGBEE transceiver are there, it will receive the sensed data and use for the personal computer. They have used WSN as a ZIGBEE, operating at 868 MHz, 902-928 MHz, and 2.4 GHz, and communicate at speeds up to 250kbps while physically separated by distances up to 50 meters [4].

3.2 Implemented Workflow:

One wireless network is formed with the help of LoRa technology which contains a transmitter and receiver. We have divided this technology into two parts, one for field and another for the control hub (farmer's home). Talking about the field area, two transmitters and one receiver are used. One transmitter has a moisture sensor, another has a DHT sensor, and one receiver for the motor control. Both the transmitter generates useful data of farm like the data of temperature and humidity which is generated by the DHT sensor, and the data of available moisture in the soil, generated by a soil moisture sensor. Now moving towards the control hub which contains a transceiver connected to the operating device. The role of the transceiver is to receive the whole data generated by the onfield components and also transmit the command to control the motor whereas the device stores the data and displays on the website and mobile application for remotely monitoring.

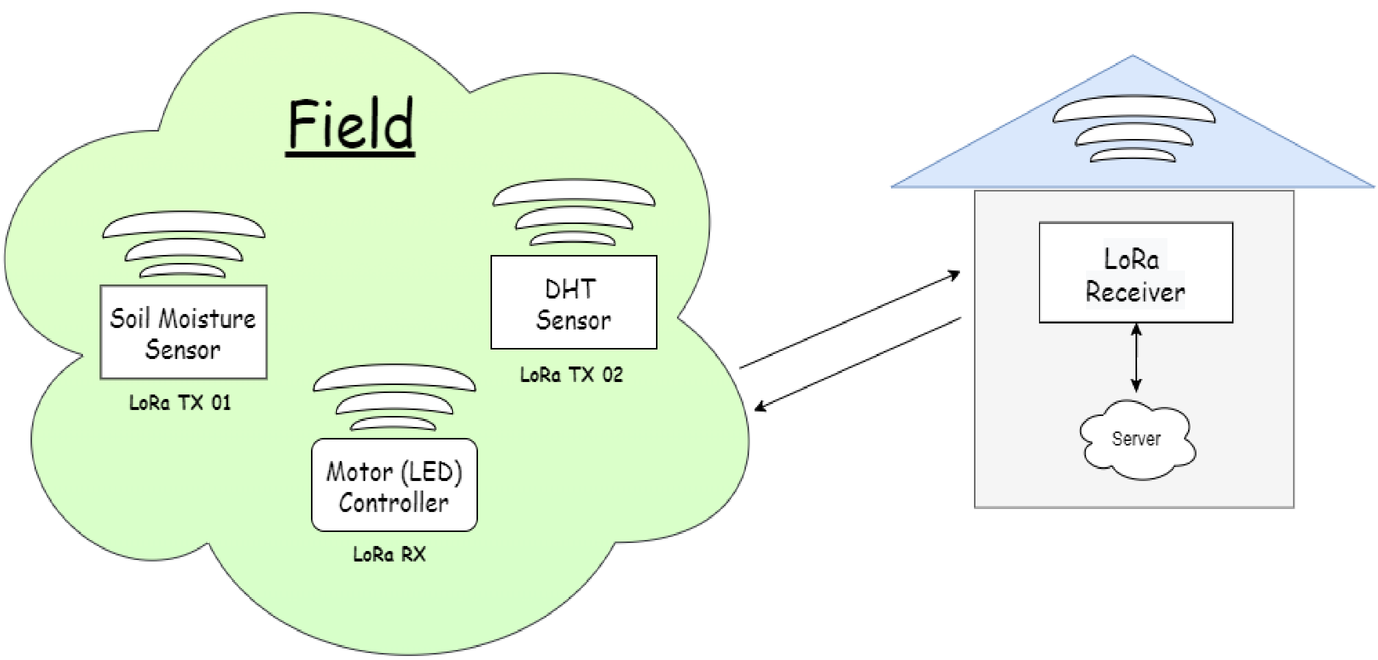


Figure 3.2: Implemented workflow.

3.3 Modules:

A. Arduino UNO:

Arduino is an open-source electronics rostrum [14]. Arduino boards have the ability to read inputs that are light on a sensor, a finger on a button, or a Twitter message and turn it into an output like activating a motor, turning on an LED, publishing something online [14]. For that you need to program your board and do so, you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing [14]. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE via type B USB cable, It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts [15].

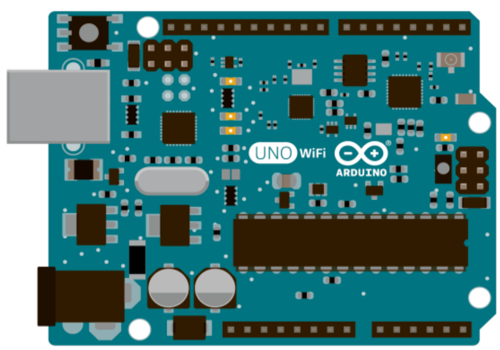


Figure 3.3: Arduino UNO [16].

B. LoRa SX1278 RA02:

The LoRa SX1278 RA02 works with SPI communication protocol so it can be used with any micro microcontroller that supports SPI communication protocol. It is mandatory to use an antenna along with the module else it might damage the module permanently. The module should be powered only with 3.3V, and the operating voltage is 3.3V, and the frequency is 433 MHz and transmits and receives packets up to 256 bytes [1]. Here we are not legally allowed to use the 433MHz frequency module for a long time other than for educational purposes [1].

Figure 3.4: LoRa SX1278 RA02 [17].

C. NodeMCU (ESP8266 Wifi module):

ESP8266 is a low-cost, WiFi Module chip that can be configured to connect to the Internet for the Internet of Things(IoT) and similar technology projects Basically, Your normal Electrical and Mechanical equipment cannot to the internet on their own, because they don't have the in-built set up to do so [18].

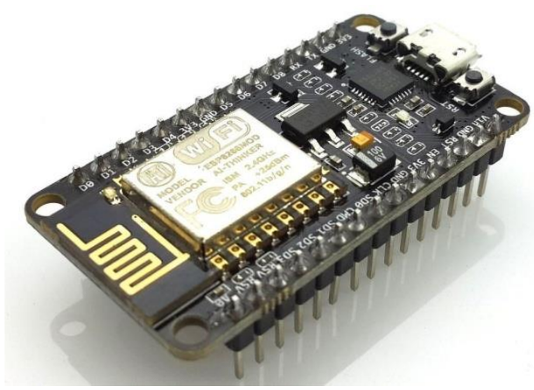


Figure 3.5: ESP8266 (NodeMCU) [18].

D. DHT Sensor:

The DHT provides an easy and inexpensive way to get temperature and humidity measurements with the Arduino. The wiring is very simple – you just need to connect the DHT data pin to Arduino digital pin [19].

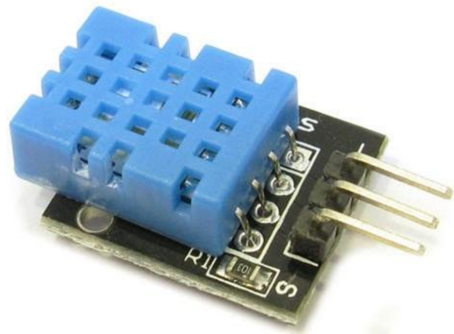


Figure 3.6: DHT Sensor [19].

E. Moisture Sensor:

The soil moisture sensor is basically used to measure the content of water present in the soil. This consists of two conducting probes that act as a probe. The sensor can measure the moisture content in the soil, based on the change in resistance between the two conducting plates [20].

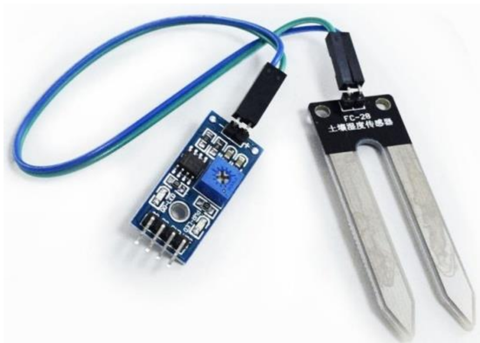


Figure 3.7: Moisture Sensor [20].

3.3 LoRa wireless technology:

In this section, the basic concepts of LoRaWAN, LPWAN, and LoRa technologies will be described. Figure 3.8, characterizes typical parts and architecture of an LPWAN network. The LPWAN sensors, or an end node, collect different measured values and using LoRaWAN to send the data to the gateway. The gateway transmits the data to some internet cloud service. The client can use that collected data from cloud services. The advantage of LoRa lies in technology's long-range capability. A single base station can cover hundreds of square kilometers, but the range is highly dependent on the environment or obstructions [21]. The LoRa modulation can be utilized by many different protocol architectures such as Star, and Mesh.

LoRaWAN ensures data rates from 0.3 kbps up to 50 kbps, which are considered acceptable for transmitting real-time sensor data in the IoT [21]. The bandwidth of LoRa is low, nonetheless, transmitting anything that requires high bandwidth, or transmission of real-time image data, that may not suitable on the LoRa network.

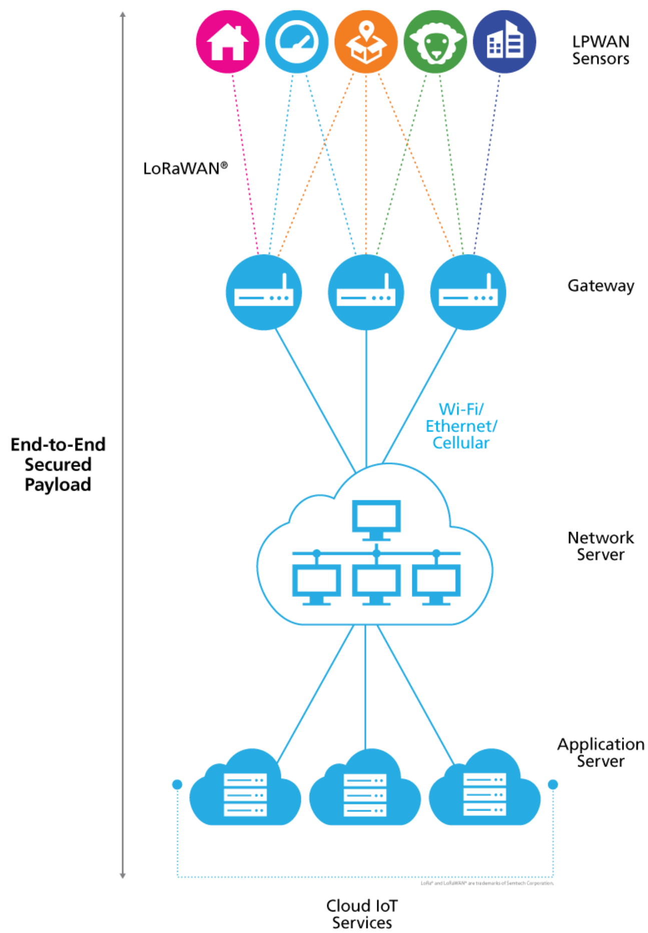


Figure 3.8: Communication protocol and system architecture of LoRaWAN (I) [22].

LoRaWAN defines three classes of devices. These device classes can negotiate network downlink communication latency versus the battery lifetime [21]. These classes are shown in Fig. 3.9 and, depending on the application needs, A, B, or C class can be chosen. Battery-powered devices in "Class A" are intended for low powered devices such as sensors, these are the most energy-efficient class but have the biggest latency time [21]. It also includes devices that do not need to transmit data all the time. All the LoRaWAN-capable devices must support the functionalities of this class [21]. Class B is focused on battery-powered devices such as sensors. These are energy efficient but with a latency controlled downlink. And the C class is used by bi-directional (both direction) with maximal receive slots, which has almost continuously open receive windows, which are only closed when transmitting [21].

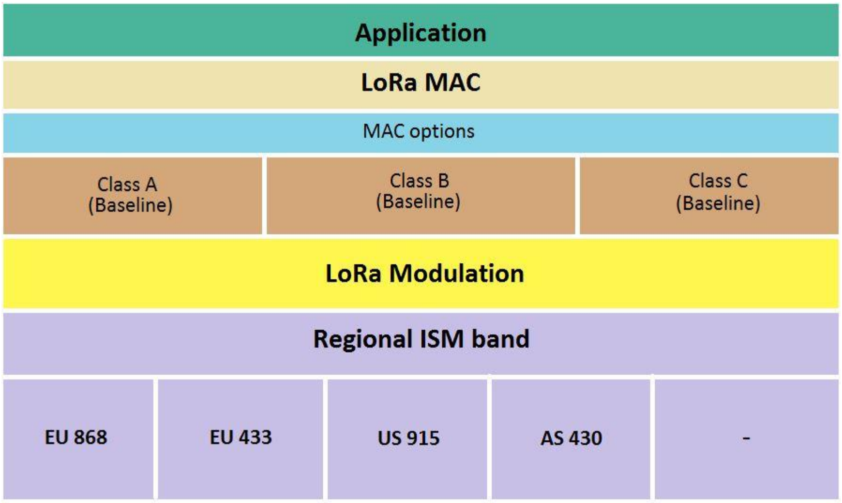


Figure 3.9: LoRa Communication satck (II) [21] [22].

LoRaWAN network protocol security is based on IEEE 802.15.4 and is also extended by using two session keys: a network session key and an application session key. Each LoRaWAN edge node device also has its own 128-bit AES key, known as the AppKey [21].

3.5 Tools and Technology:

A. PHP:

PHP is standing on a "Hypertext preprocessor". PHP is an open-source scripting language, the script is executed on the server. And this language is free to download and use. PHP files can contain text, HTML, CSS, JavaScript, and PHP code and PHP code is executed on the server, and the result is returned to the browser as plain HTML [23]. The extension of the PHP file is ".php". Using a PHP script we are able to create, open, read, write, delete, and close files on the server. And also collect form data from the web page. This language is also helpful for add, delete, and modify data in your database. We are able to run PHP on various platforms like Windows, Linux, Unix, Mac, OS X, etc., PHP is compatible with almost all servers used today (Apache, IIS, etc.), PHP is easy to learn and runs efficiently on the server-side [23].

B. XAMPP:

XAMPP is a cost-free and open-source cross-platform web server developed by Apache Friends, it is the most favored PHP development environment which makes transitioning from a local test server to a live server possible [24]. XAMPP is a collection of Apache distribution, MariaDB, PHP, and Perl [25].

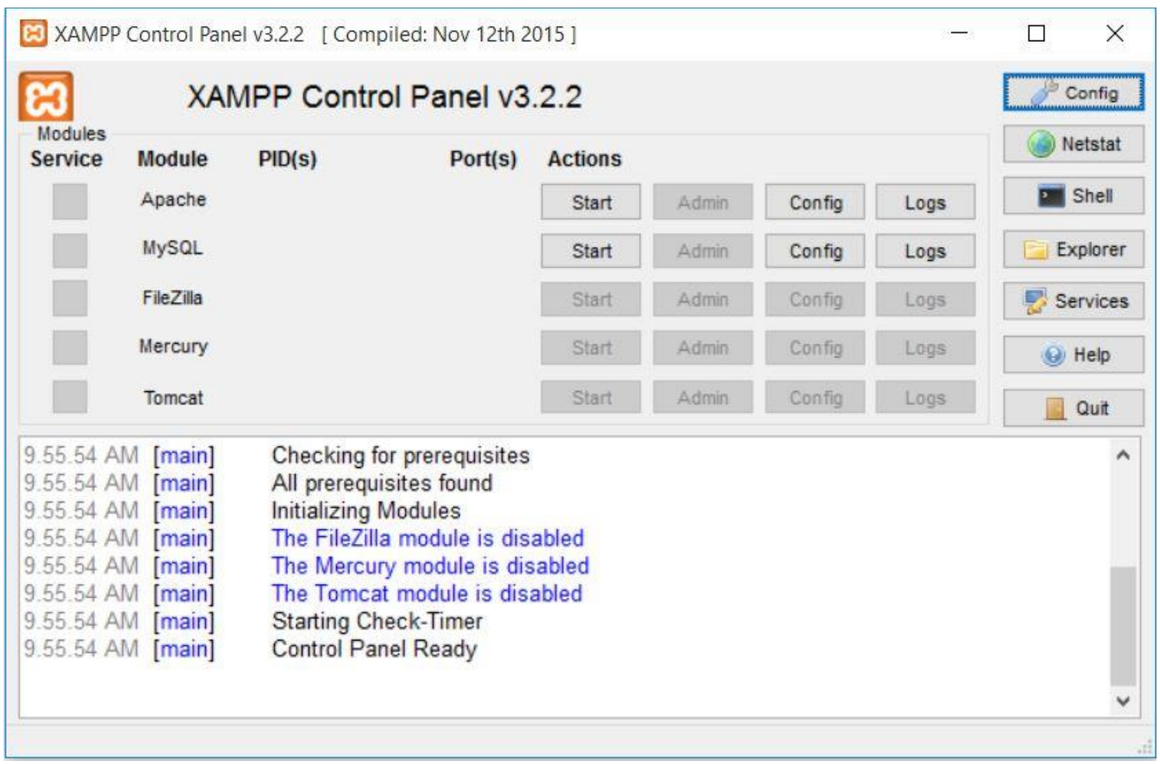


Figure 3.10: XAMPP interface.

C. Arduino IDE:

The Arduino Integrated Development Environment (IDE) encompasses a text editor for writing code, it connects to the Arduino and Genuino hardware to upload programs and transmit with them [26]. The programs are written using IDE are knows as sketches. And the file extension of the program is ".ino". Like other editors, Arduino IDE has also featured for cutting/pasting and for searching/replacing text. The console of IDE provide error messages and other information, and the bottom right-hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor [26].

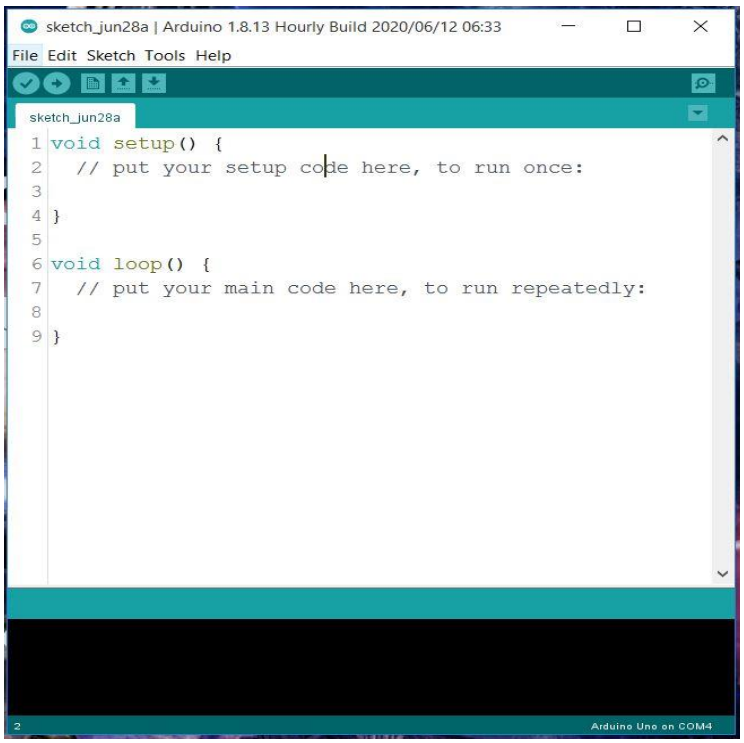


Figure 3.11: Arduino IDE.

D. Android Studio:

Android studio is the Integrated Development Environment (IDE) for android app development. In IDE there are three types of modules a) Android app module b) Library modules and c) Google app engine modules. By default, your project files display in the android project view. In IDE each module contains the following folders.

a) Manifests AndroidManifest.xml file.
b) Java: it contains the java source file.
c) Res: it contains non-code resources, such as XML layouts, bitmap images.

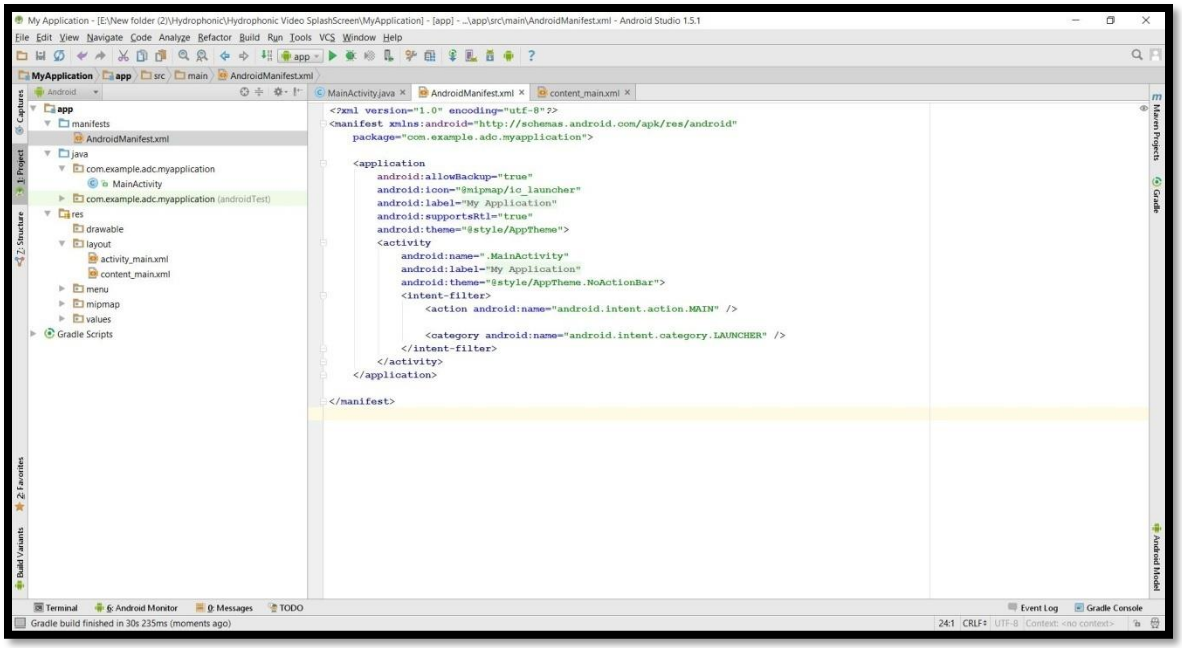


Figure 3.12: Android Studio IDE.

Chapter-4

Implementation Details and Results

After the study in the agriculture sector, fields are mainly available in rural areas. Moreover, the farmers need to control some components like motor, etc. and some basic information about the field like, how much moisture is available in the soil and how much temperature is there? For getting this kind of control and information, they require to use wireless technology. After that, we are starting a survey and study about different wireless technology available in the market like Wi-Fi, Bluetooth, Zigbee, and many more. And finally, we are selecting one best wireless technology for the agriculture sector. We have selected LoRa wireless technology for the agriculture sector. because it fulfills all requirements for making a smart agriculture system.

4.1 Basic LoRa Arduino interaction with Hello World message:

In the first step, we are going to do some basic interaction between LoRa and Arduino UNO. For doing that we require a number of two Arduino UNO, and two LoRa RA02 SX1278 modules. There is mandatory to operate the LoRa module with antenna, else output power will damage the module. Here we are using a 433Mhz LoRa module, so my antenna is also rated for 433Mhz. For doing this interaction, we need to create one transmitter and one receiver.

While using LoRa with Arduino UNO, in the beginning, we need to install a library of LoRa in Arduino IDE via the following steps.
Sketch → Include Library → Manage Libraries → and discover for LoRa, here we are adopting LoRa library by Sandeep Mistry [27].

A. Transmitting side connecting LoRa SX1278 with Arduino UNO [1]:

For the transmitting side, we used an Arduino UNO with our LoRa SX1278 module. The circuit diagram used to connect the Arduino with LoRa is shown below, The LoRa module consists of 16 different pins with 8 pins on both side. Out of these total 16 pins, six pins are used by GPIO pins, ranging from DIO0 to DIO5, and four pins are used by Ground pins. The LoRa module operates in 3.3V, and hence the 3.3V pin on the LoRa module is connected to the 3.3v pin on the Arduino board. Then after we connected the SPI pin of the LoRa module to the SPI pins on Arduino Board as shown below. You can also use the below table to make sure the connection is done correctly.

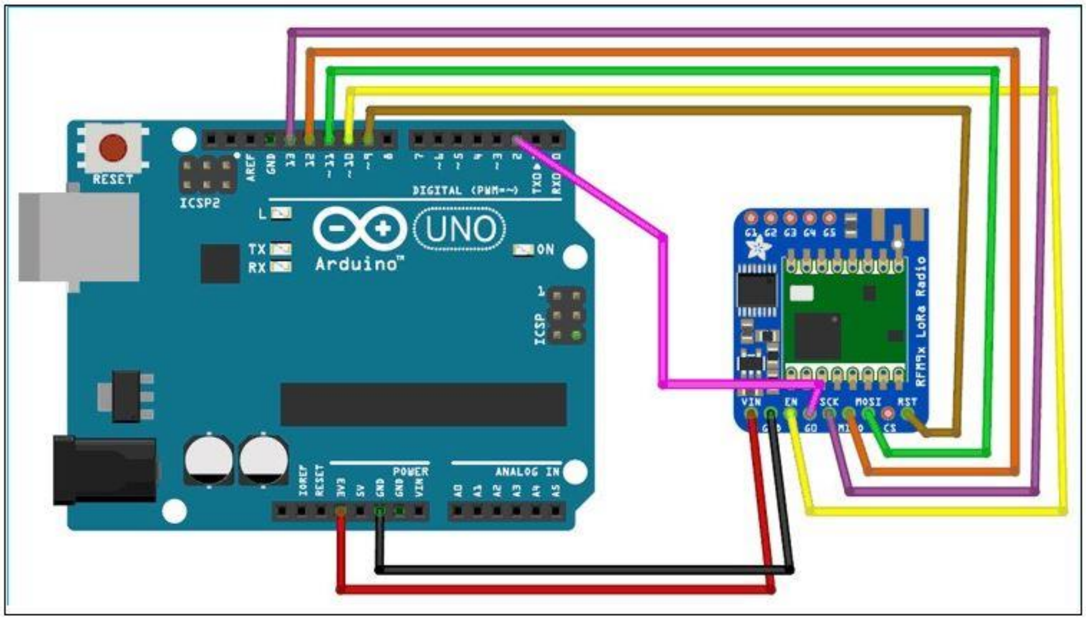


Figure 4.1: LoRa with Arduino UNO Transmitter [1].

Table 4.1: Arduino UNO to LoRa Interaction Tx [1].

LoRa SX1278 Module	Arduino UNO Board
3.3V	3.3v
Gnd	Gnd
Nss	D10
G0/DIO0	D2
SCK	D13
MISO	D12
MOSI	D11
RST	D9

B. Receiving side connecting LoRa SX1278 with Arduino UNO [1]:

For the Receiving side, we used an Arduino UNO with LoRa (Long Range) module. You can use any Arduino board that you have for Receiver and Transmitter, but make sure you, the connection between Arduino and Lora is correct. The circuit diagram between Arduino UNO and LoRa is shown below.

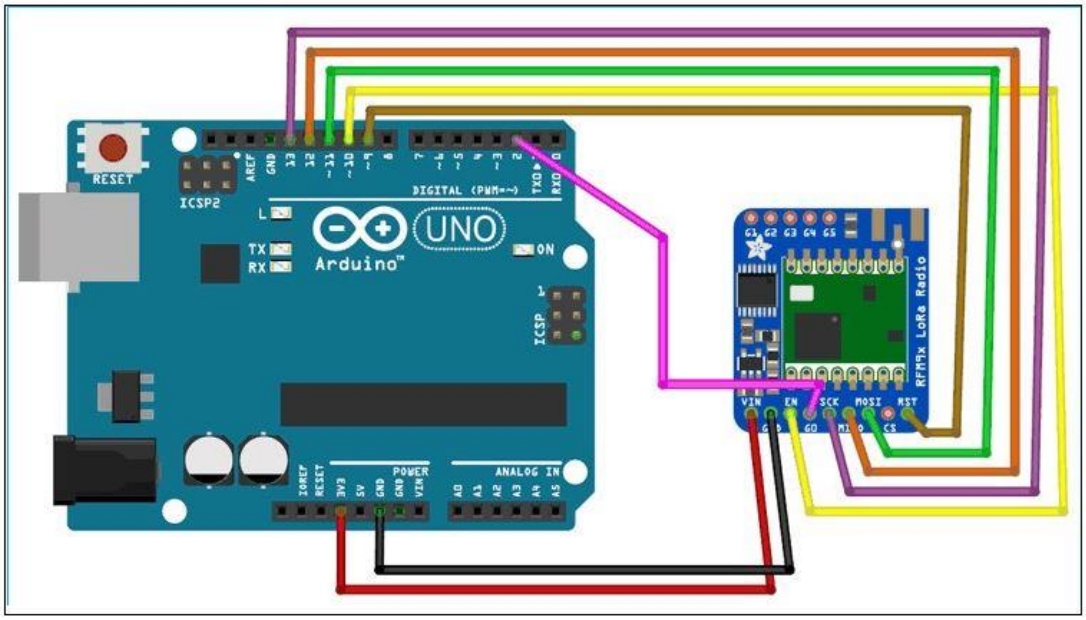


Figure 4.2: LoRa with Arduino UNO Receiver [1].

The connections almost remain the same.

Table 4.2: Arduino UNO to LoRa Interaction Rx [1].

LoRa SX1278 Module	Arduino UNO Board
3.3V	-
Gnd	Gnd
En/Nss	D10
G0/DIO0	D2
SCK	D13
MISO	D12
MOSI	D11
RST	D9

C. Implementation:

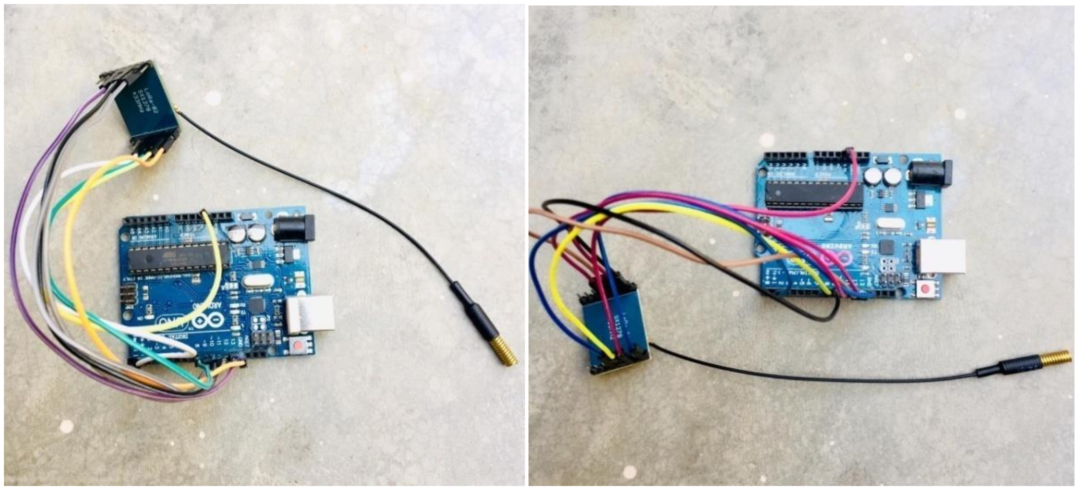


Figure 4.3: Implemented LoRa with Arduino UNO TX and RX.

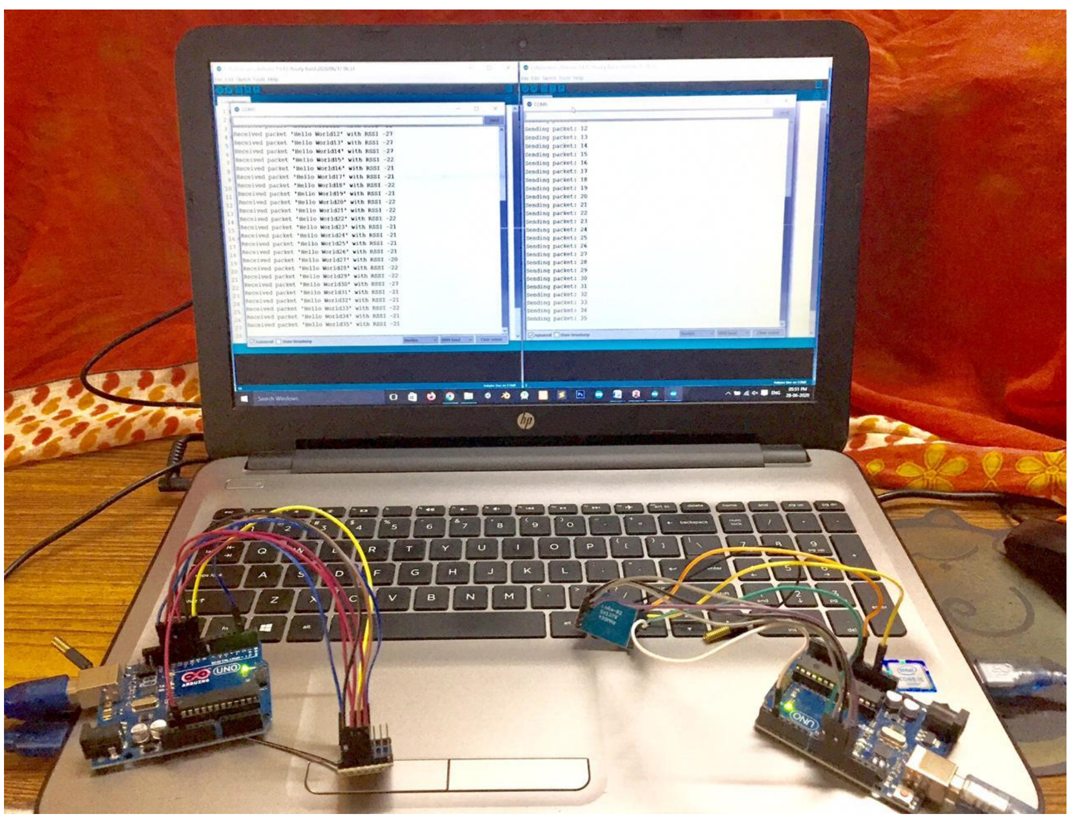


Figure 4.4: Implemented LoRa with Arduino UNO TX and RX Output.

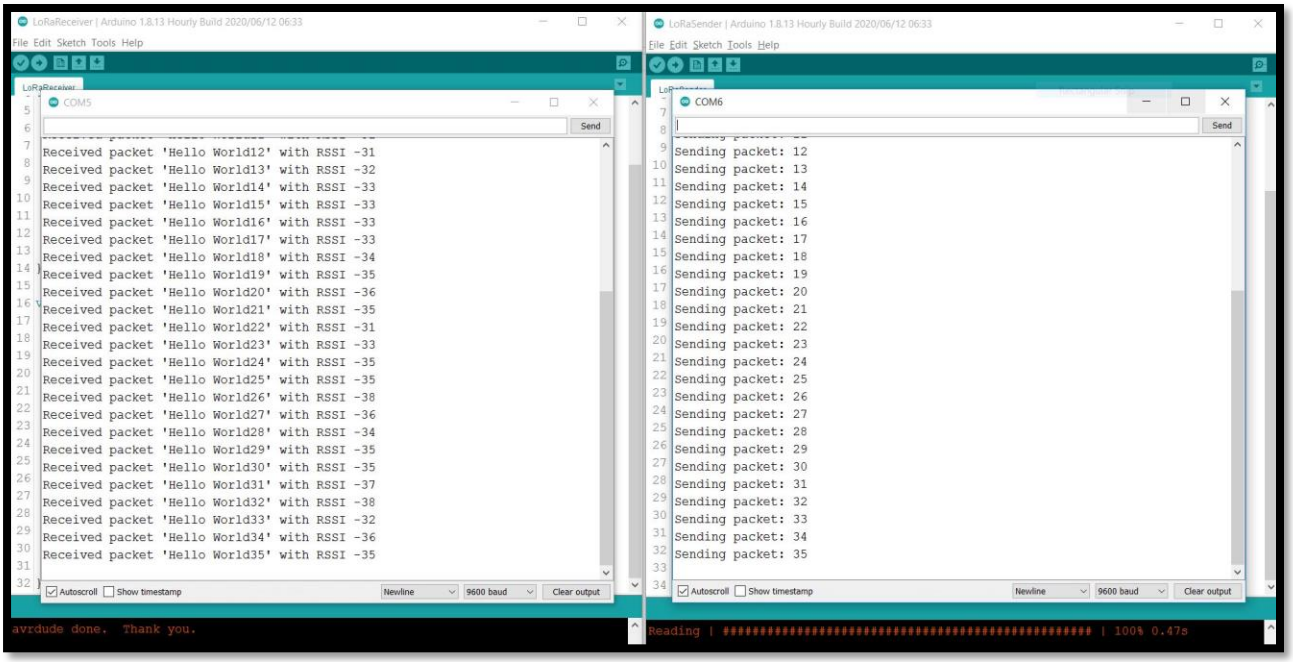


Figure 4.5 TX and RX output via serial monitoring.

4.2 Receiving side replace Arduino UNO with NodeMCU:

In the smart agriculture system, we have to provide remote access to field information for the farmer. When we are using Arduino UNO on the receiving side, we are not able to provide remote access to the farmer. Because Arduino UNO does not connect with Wi-Fi or the internet. The solution to this problem is very simple. In the above basic system at the receiving side, we need to replace Arduino UNO with the ESP8266 (NodeMCU) Wi-Fi module. As we already discussed in chapter 3, ESP8266 is a Wi-Fi chip module. And we easily connect it with Wi-Fi.

For using ESP8266 we need to make the following steps [28]

i) Connect your ESP8266 module to PC
ii) Then open your Arduino IDE.
iii) After that, we need to install ESP8266 board in IDE, Go to File → preferences.
iv) Enter the following URL into "Arduino Board manager URLs" http://arduino.esp8266.com/stable/package_esp8266com_index.json [28]
v) Then go to Tools → Board → Board Manager

vi) Find “ESP8266 by ESP8266 Community”.

Now your board is ready to program. For connecting Wi-Fi with your board, you need to include the library “ESP8266WiFi.h”, and just provide SSID and Password of your Wi-Fi network. After that, you need to initialize that into the “void setup” function. Now your board is ready to connect with your network.

For using NodeMCU with LoRa module, you have to connect NodeMCU with LoRa SX1278.

A. Receiving Side Connecting LoRa SX1278 with NodeMCU (ESP8266) [29]:

Table 4.3: NodeMCU to LoRa interaction [29].

LoRa SX1278 Module	**NodeMCU Board**
3.3V	3.3V
Gnd	Gnd
En/Nss	D8
G0/DlO0	D1
SCK	D5
MISO	D6
MOSI	D7
RST	D0

The LoRa module consists of 8 different pins on both sides. Out of these, six pins are used by GPIO pins, ranging from DIO0 to DIO5, and four pins are used by Ground pins. The LoRa module operates in 3.3V, and hence the 3.3V pin on the LoRa module is connected to the 3.3v pin on the NodeMCU. Then we connect the SPI pin of the LoRa module to the SPI pins on NodeMCU as per the above table.

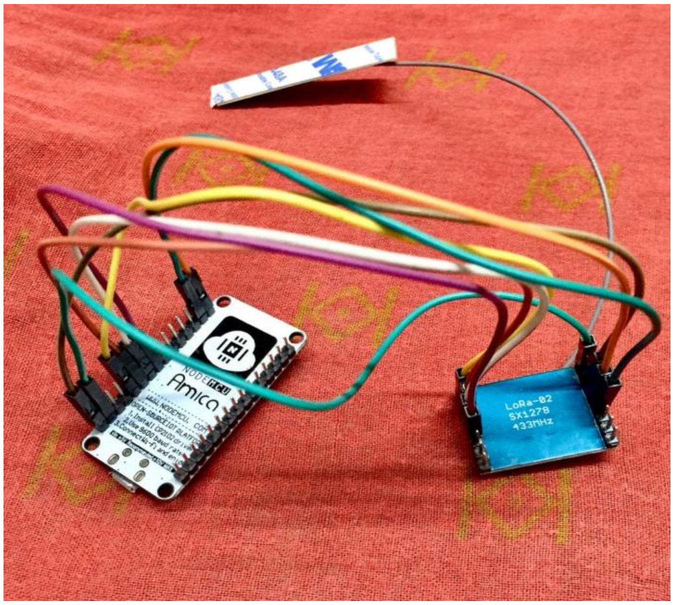


Figure 4.6: Implemented LoRa with NodeMCU.

4.3 Complete node with the DHT sensor:

A. DHT sensor in Transmitting side:

As we discussed in chapter 3, using the DHT sensor, we get temperature and humidity. The measurement of temperature and humidity is very essential for field monitoring. So we have to connect the DHT sensor on a transmitter side. Now our transmitter is a collection of Arduino UNO, LoRa SX1278 with antenna, DHT sensor, and 5V power supply. The block diagram of the transmitter side is as shown below.

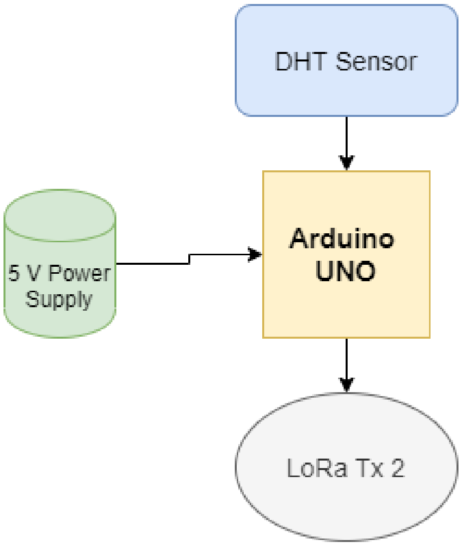


Figure 4.7: Block Diagram of Transmitter With DHT.

DHT sensor has three different pins: a) DATA pin, b) VCC pin, c) GND pin. This sensor works with a 5V power supply, so we just need to connect the VCC pin of the DHT sensor with a 5V pin or VIN pin of Arduino UNO and simply connect the GND pin of DHT sensor with the GND pin of Arduino UNO. The DATA pin of the DHT sensor is connected with any digital pin of Arduino UNO. In my case, I am going to connect the DATA pin of DHT sensor with the D8 pin of Arduino UNO.

Table 4.4: Arduino UNO with DHT sensor interaction.

DHT sensor	**Arduino UNO**
5V	5V / VIN
Gnd	Gnd
DATA	D8

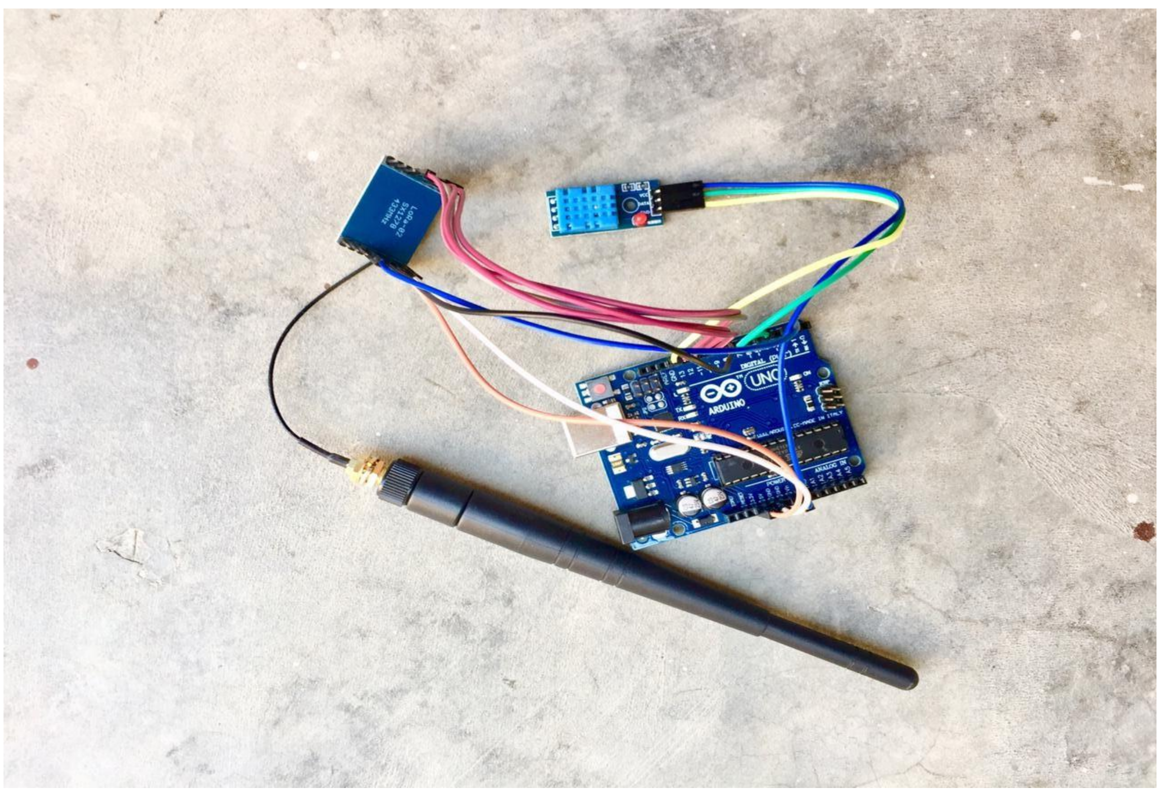


Figure 4.8: Implemented Transmitter with DHT sensor.

After that, we need to program our transmitter. For that, we have to install a library of DHT in Arduino IDE, by going from Sketch → Include Library → Manage Libraries. And search for DHT. Then we are able to program it. At the beginning of the program, including the library, define DHTTYPE, and also define DHT data pin connect with Arduino, and just begin it in void setup.

B. Receiving Side:

As we discussed in chapter 4 topic number 4.2, we used the same thing here. Use the NodeMCU module on the receiving side, so we easily upload and store the received data on the database.

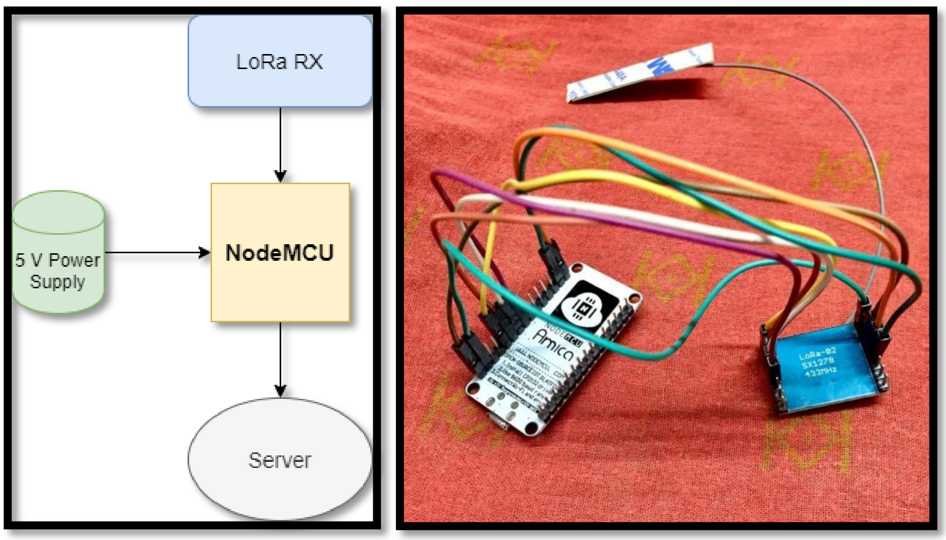


Figure 4.9: Implemented Receiver for DHT sensor.

C. Prepare Database and Web Page:

We want to provide remote access to farmers, so we are created one website by that farmers can easily monitor the temperature and humidity of the field. But first of all, we have to create one database. As we have seen in chapter 3, using XAMPP phpMyAdmin we do that.

In the first step we need to start Apache and MySql from XAMPP:

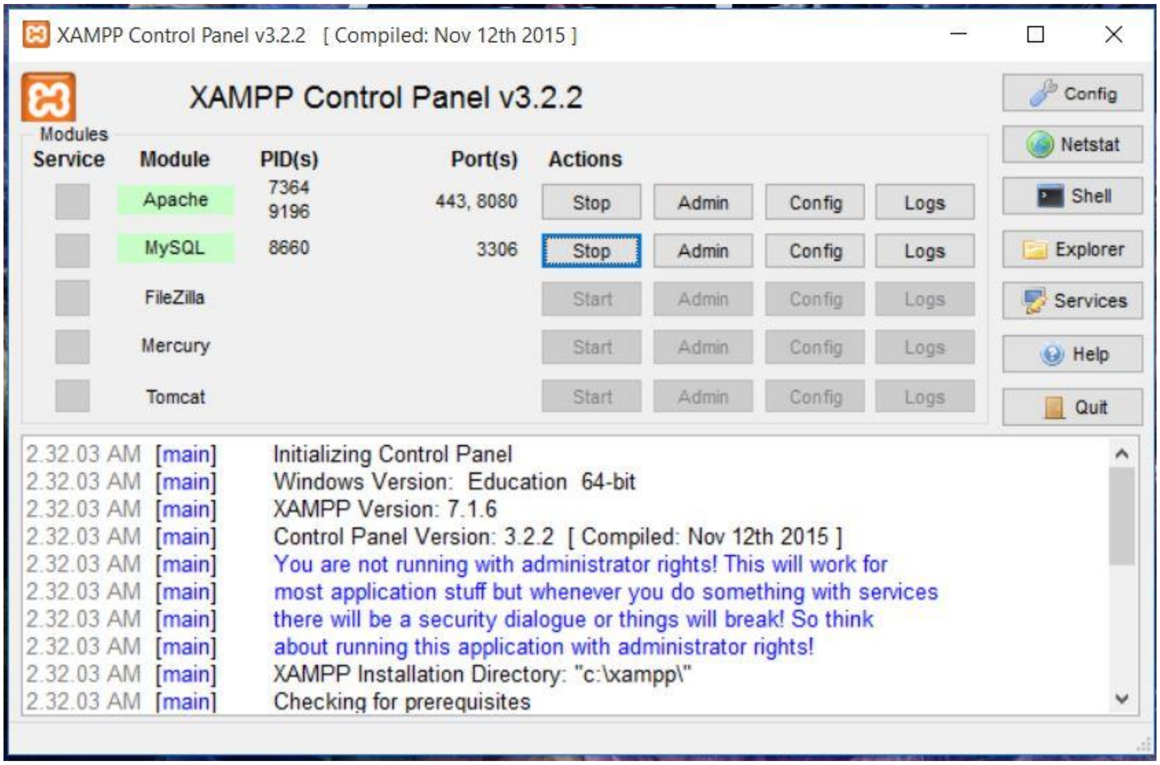


Figure 4.10: XAMPP Control Panel.

Open phpMyAdmin by searching “localhost/phpMyAdmin” on a browser. And create one new database, after that create one table in that database and store the sensor value in that.

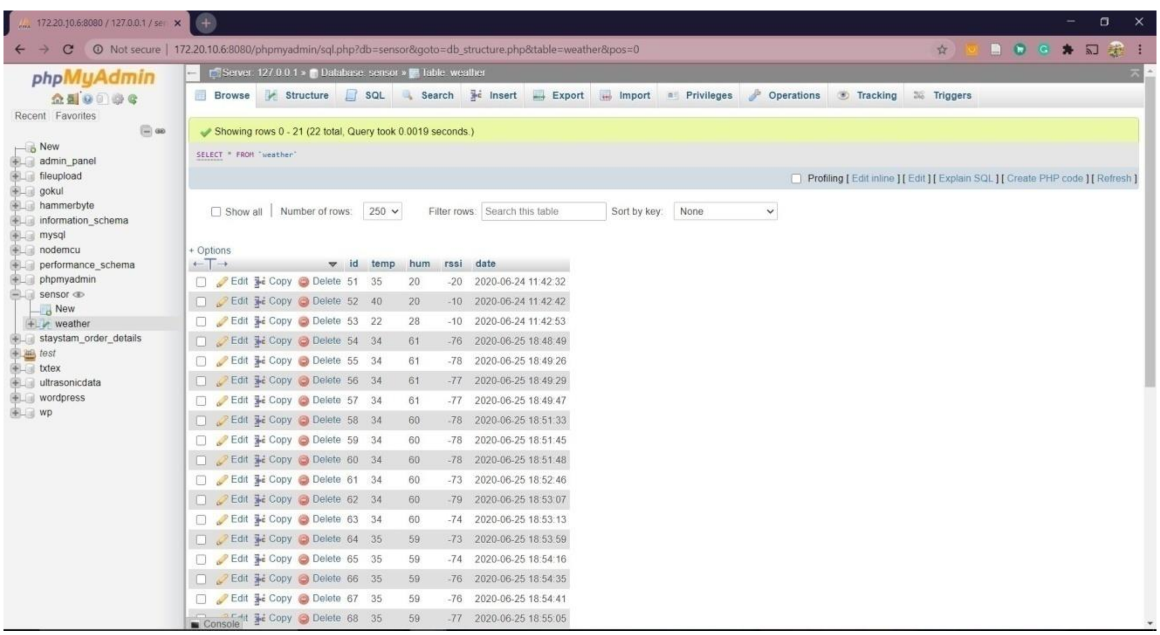


Figure 4.11: phpMyAdmin Database.

Here the database name is a “sensor”, and the table name is the “weather”. In the table we store the id number of data, then temperature, humidity, RSSI value, and date and time.

D. Implementation:

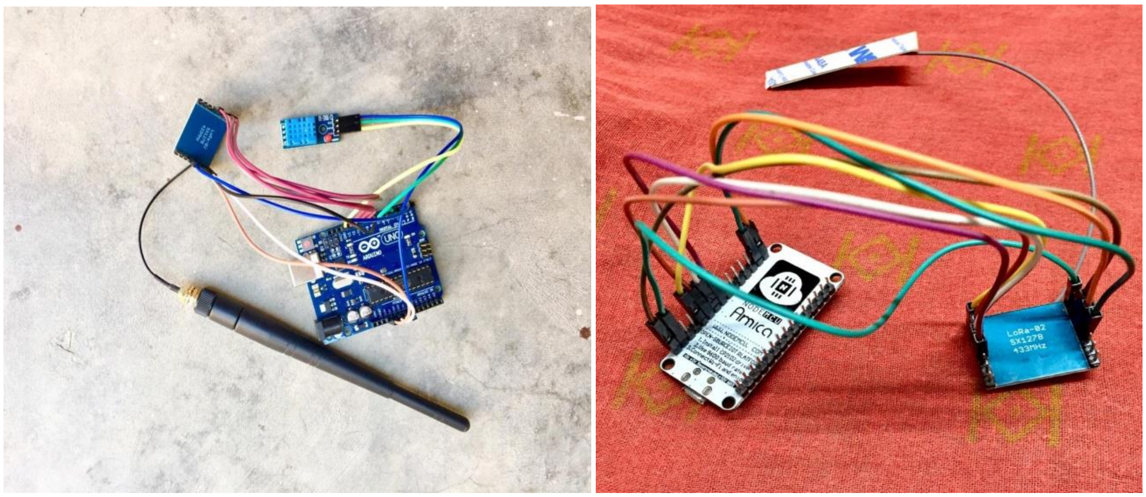


Figure 4.12: Implemented DHT Node TX RX.

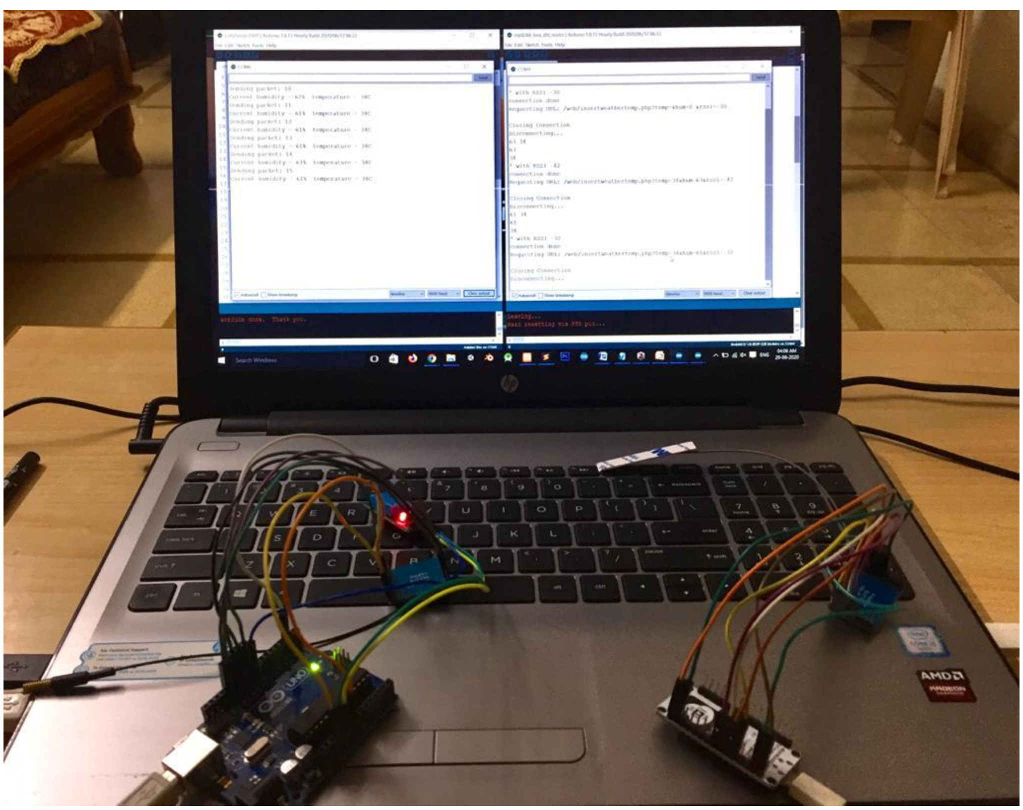


Figure 4.13: Implemented DHT Node TX RX output.

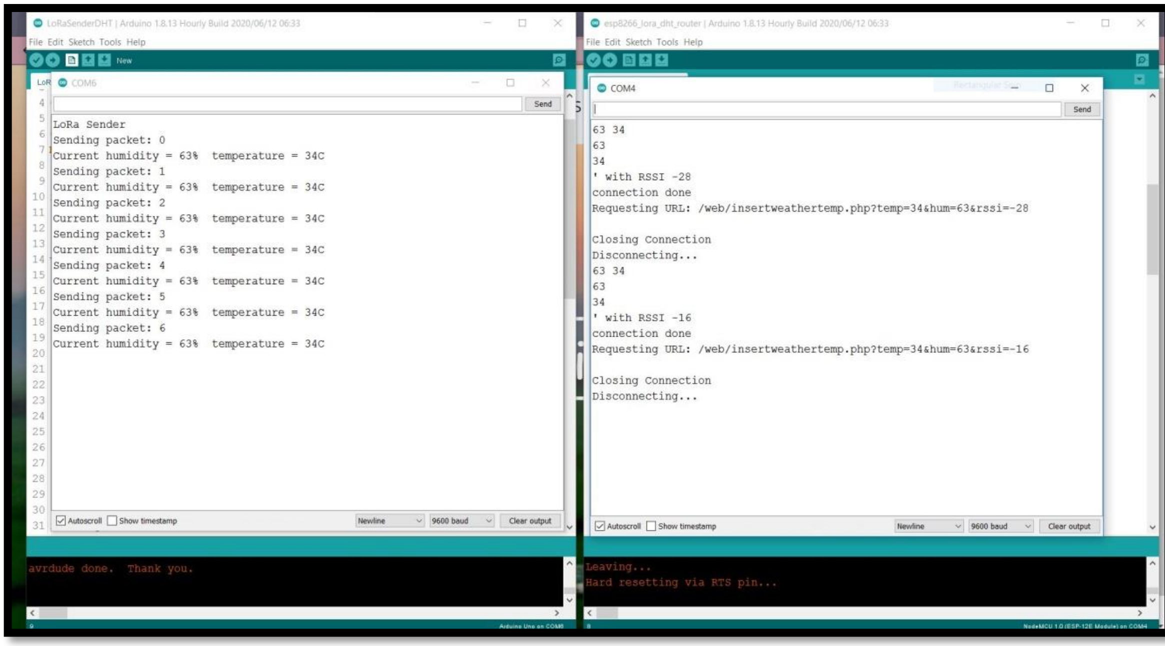


Figure 4.14: DHT Node TX RX With Serial Monitoring.

We fetch the store data from the database and display it in various forms via the web site using PHP and HTML.

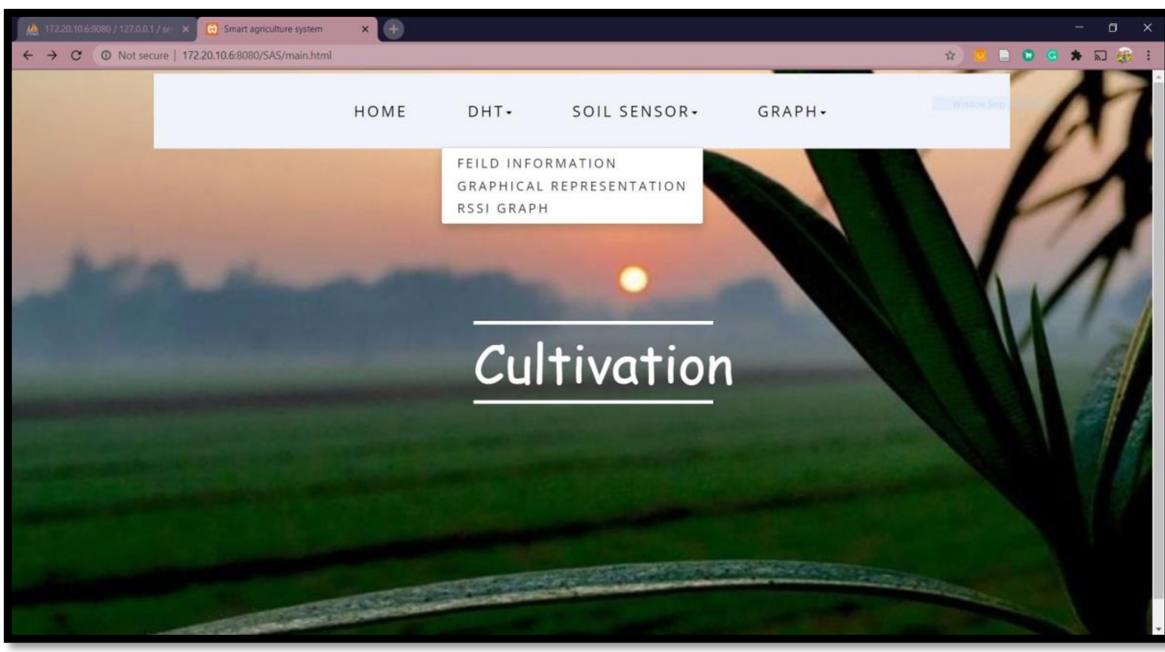


Figure 4.15: DHT Home Page of Web Site.

We display the store data in tabular-form on the website.

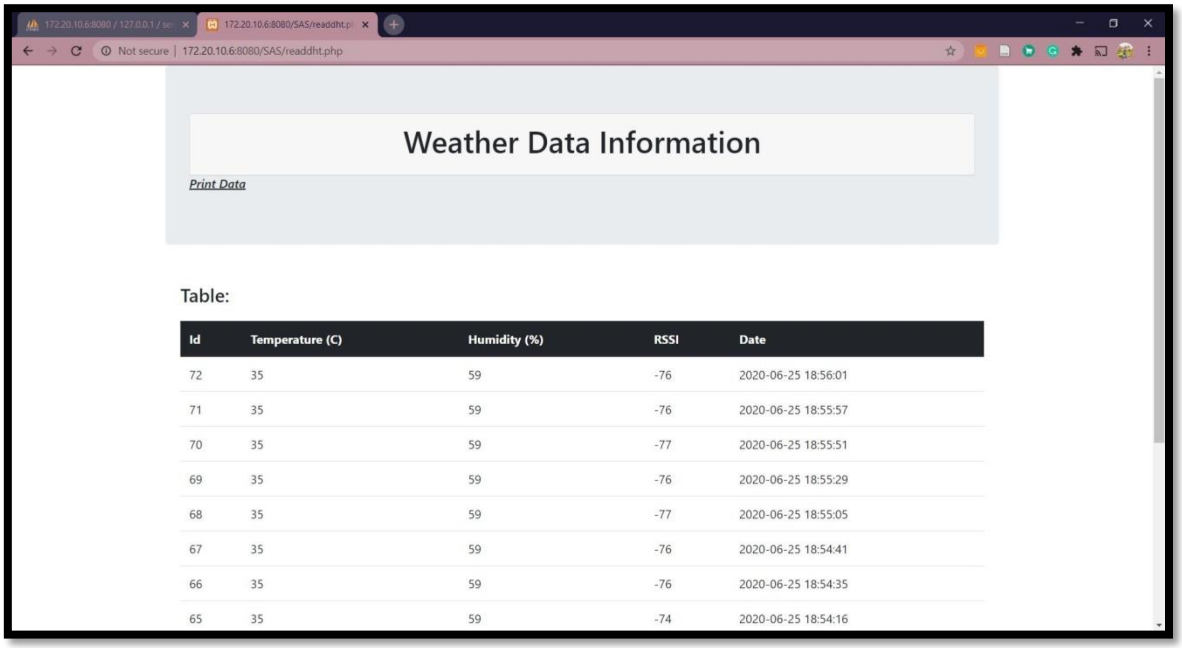


Figure 4.16: Collection of Live DHT data in Table Form on Web Site.

And base on the store data value, we are plot a graph with a good interface. Using that farmers can easily monitor the major and minor changes in temperature and humidity.

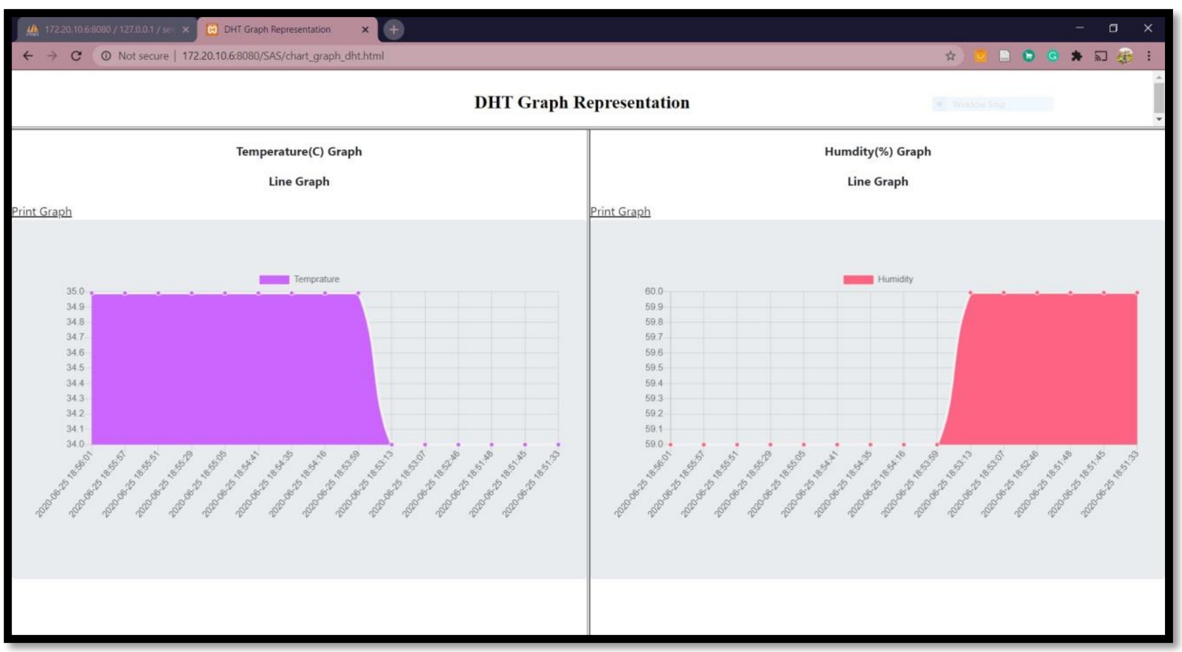


Figure 4.17: DHT Graph Representation.

Here the “temperature graph” is represented in various kinds of graphs using that, farmers can easily monitor and understand field data.

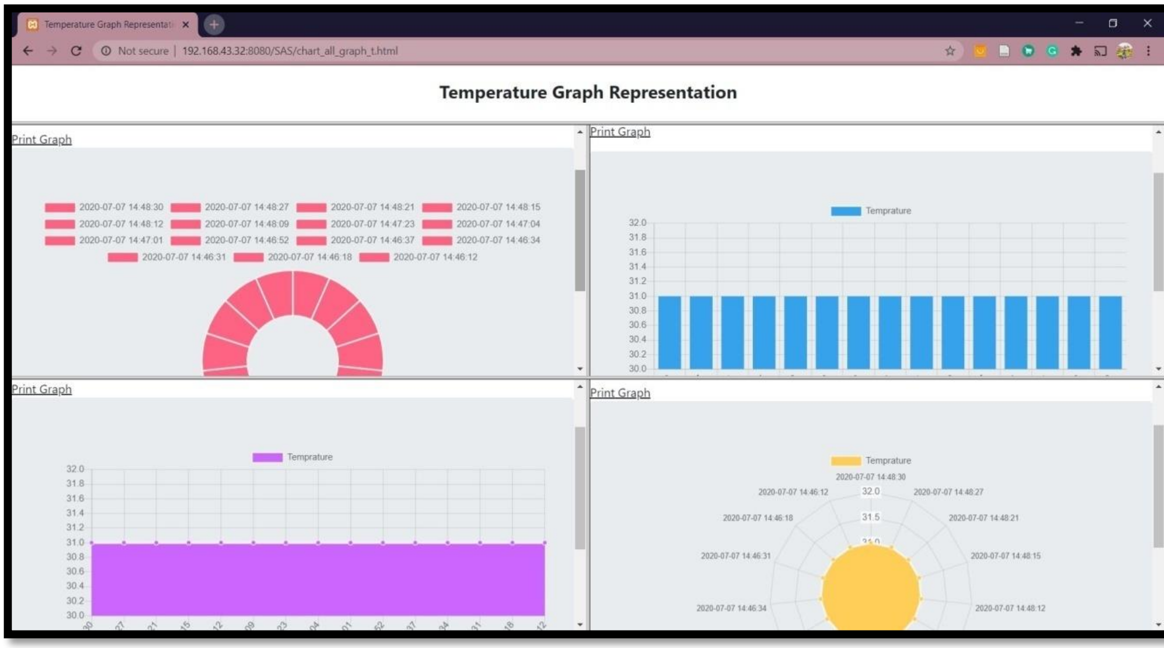


Figure 4.18: Temperature Graph Representation.

Here the “humidity graph” is represented in various kinds of graphs using that, farmers can easily monitor and understand field data.

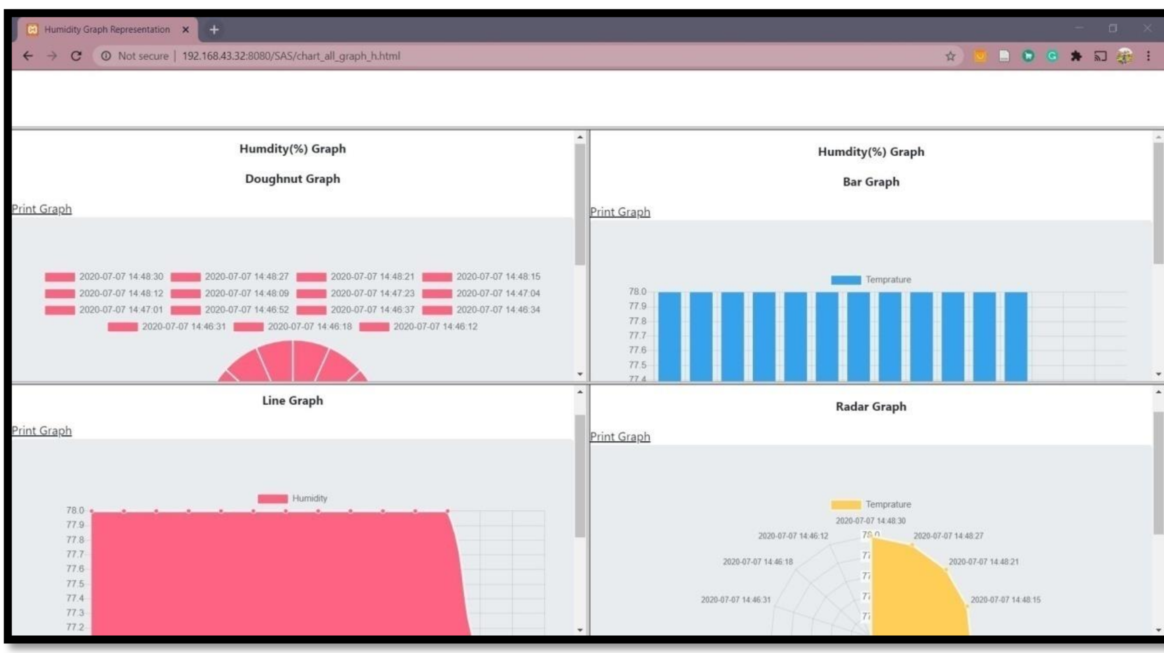


Figure 4.19: Humidity Graph Representation.

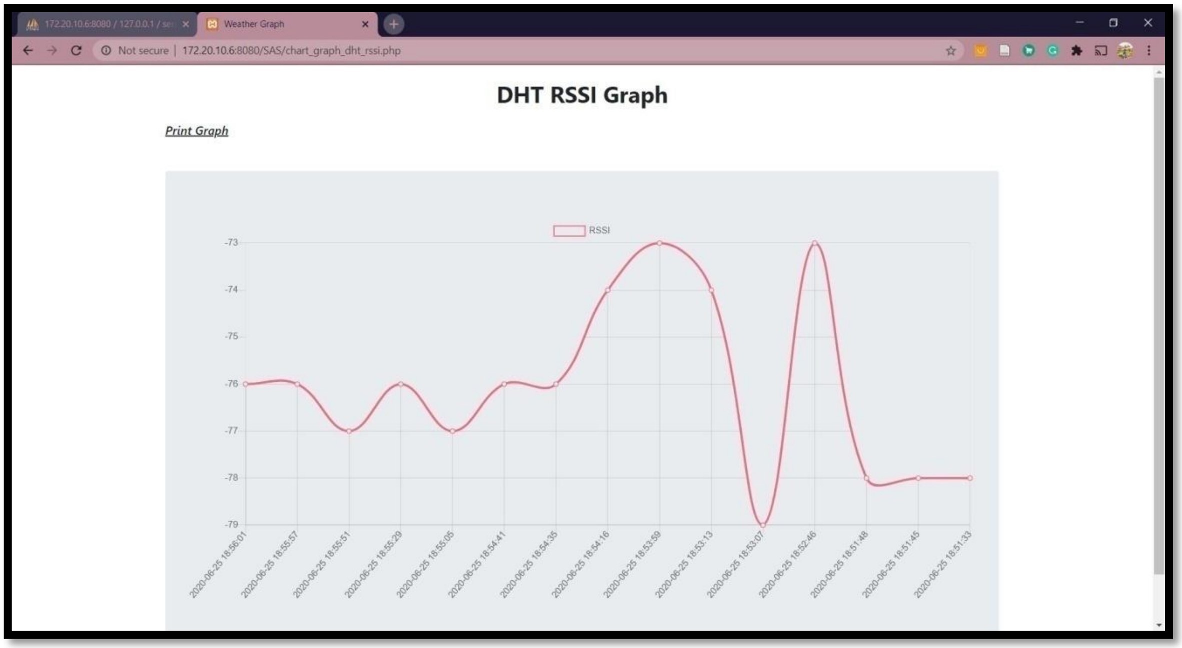


Figure 4.20: DHT RSSI Graph.

Here the RSSI of LoRa signal strength value for DHT transmitter is also monitored using a plotted graph.

4.4 LoRa Range:

The range is one of the major concepts for choosing LoRa wireless technology for making a smart agriculture system. We already know Bluetooth wireless technology is used for short-range data transmission, less than 10 m to up to 100 m [30]. And Wi-Fi wireless technology provides a 50 m range [31]. Zigbee technology also provides some good range of 10 m to 100 m [32]. However, all wireless technology is not satisfied with the required range in the agriculture sector. But LoRa wireless technology claims it provides 2 to 5 km range.

The distance between Lora Transmitter and receiver depends on the environment. The maximum range we obtained in urban areas was about 700 meters. The receiver was placed in open space outside the building. The transmitter was moved away from the receiver side. We obtained a maximum range in rural areas was about 1200 meters.

Table 4.5: LoRa Range

Environment	Range (m)	Tx Power
Urban area (town)	700	5V
Rural area	1200	5V

4.5 Complete node with Soil Moisture sensor:

A. Soil Moisture sensor in Transmitting side:

As we discussed in chapter 3, using the Soil Moisture sensor we measure available moisture in the soil and the measurement of soil moisture is very essential for field monitoring. So we need to connect the Soil Moisture sensor on a transmitter side. Now our transmitter is a collection of Arduino UNO, LoRa SX1278 with antenna, Soil Moisture Sensor, and 5V power supply. The block diagram of the transmitter side is as shown below.

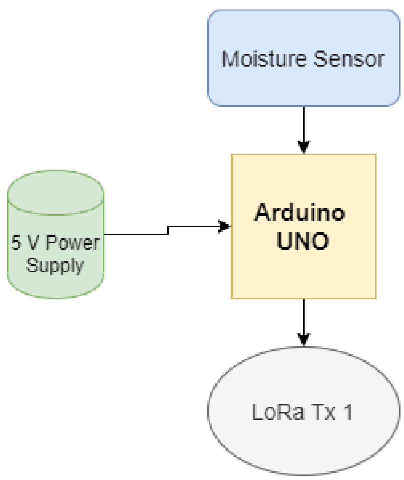


Figure 4.21: Block Diagram Of Transmitter with Soil Moisture.

Soil moisture sensor has four different pins: A) DATA pins: i) one for analog signal, ii) one for digital signal. B) VCC pin, C) GND pin. This sensor works with a 5V power supply, so you just need to connect the VCC pin of moisture sensor with a 5V pin or VIN pin of Arduino UNO. And simply connect the GND pin of moisture sensor with the GND pin of Arduino. The analog DATA pin of moisture sensor is connected with any analog pin of Arduino UNO, in my case, I am going to connect analog DATA pin of moisture sensor with A2 pin of Arduino UNO.

Table 4.6: Arduino UNO with Soil Moisture sensor interaction.

Soil Moisture sensor	**Arduino UNO**
5V	5V / VIN
Gnd	Gnd
A0	A2

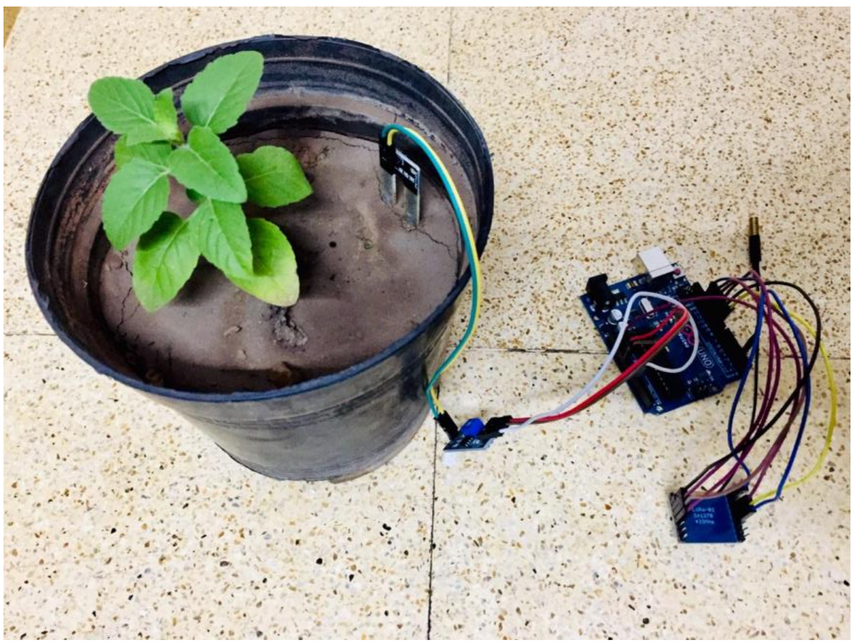


Figure 4.22 Interface of Soil Moisture Tx.

B. Receiving Side:

As we discussed in chapter 4 topic number 4.2, we are using the same thing here. Use the NodeMCU module in the receiving side, so we easily upload and store the received data of soil moisture sensor on the database.

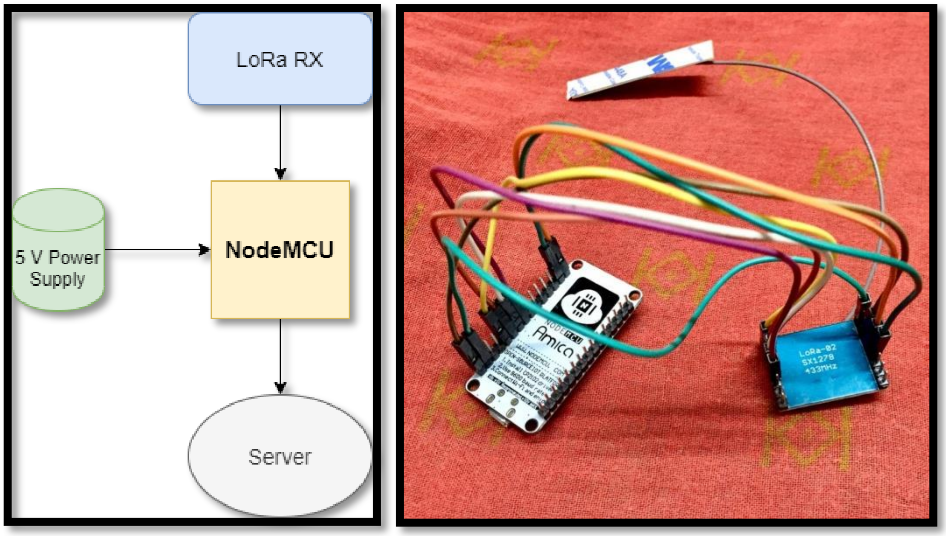


Figure 4.23: Receiver for the Soil Moisture Sensor.

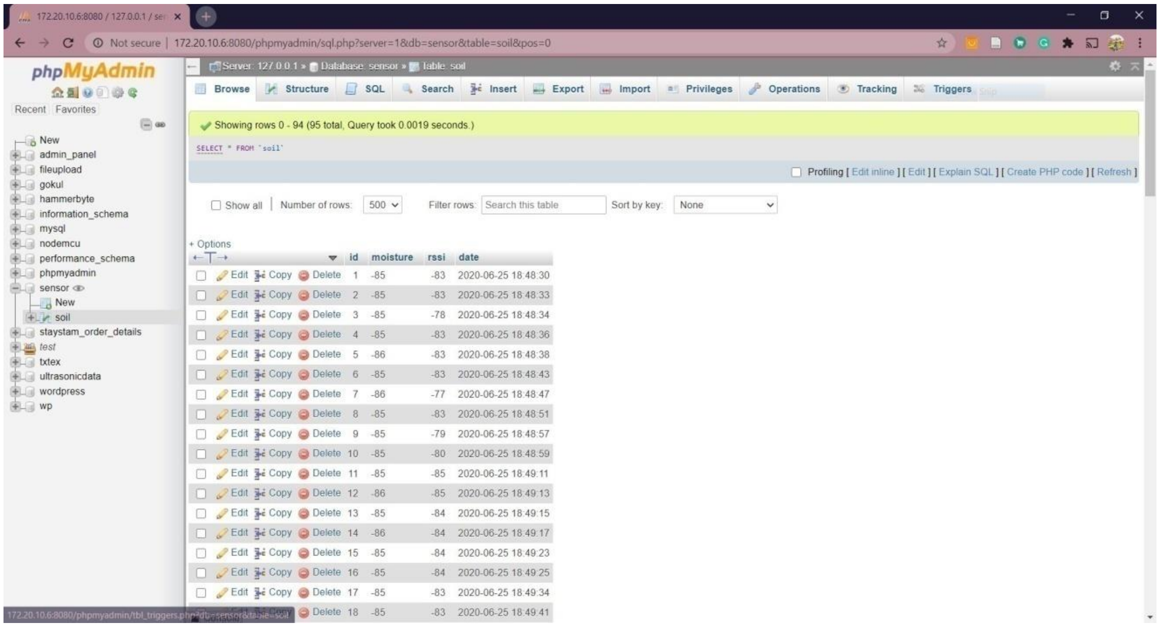
C. Prepare Database and Web Page:

We want to provide remote access to farmers, so we have created one web site. Using that farmers can easily monitor the soil moisture of the field. But first of all, we have to create one database. As we see in chapter 3, using XAMPP phpMyAdmin we do that.

In the first step we need to start Apache and MySql from XAMPP:

Figure 4.24: XAMPP Control Panel.

Open phpMyAdmin by searching "localhost/phpMyAdmin" on a browser and create one new database, after that create one table in that database and store the sensor value in that.



id	moisture	rssi	date
1	-85	-83	2020-06-25 18:48:30
2	-85	-83	2020-06-25 18:48:33
3	-85	-78	2020-06-25 18:48:34
4	-85	-83	2020-06-25 18:48:36
5	-86	-83	2020-06-25 18:48:38
6	-85	-83	2020-06-25 18:48:43
7	-86	-77	2020-06-25 18:48:47
8	-85	-83	2020-06-25 18:48:51
9	-85	-79	2020-06-25 18:48:57
10	-85	-80	2020-06-25 18:48:59
11	-85	-85	2020-06-25 18:49:11
12	-86	-85	2020-06-25 18:49:13
13	-85	-84	2020-06-25 18:49:15
14	-86	-84	2020-06-25 18:49:17
15	-85	-84	2020-06-25 18:49:23
16	-85	-84	2020-06-25 18:49:25
17	-85	-83	2020-06-25 18:49:34
18	-85	-83	2020-06-25 18:49:41

Figure 4.25: Soil Moisture Database.

Here the database name is a “sensor” and the table name is the “soil”. In the table we store the id number of data, then moisture value, RSSI value, and date and time.

D. Implementation:

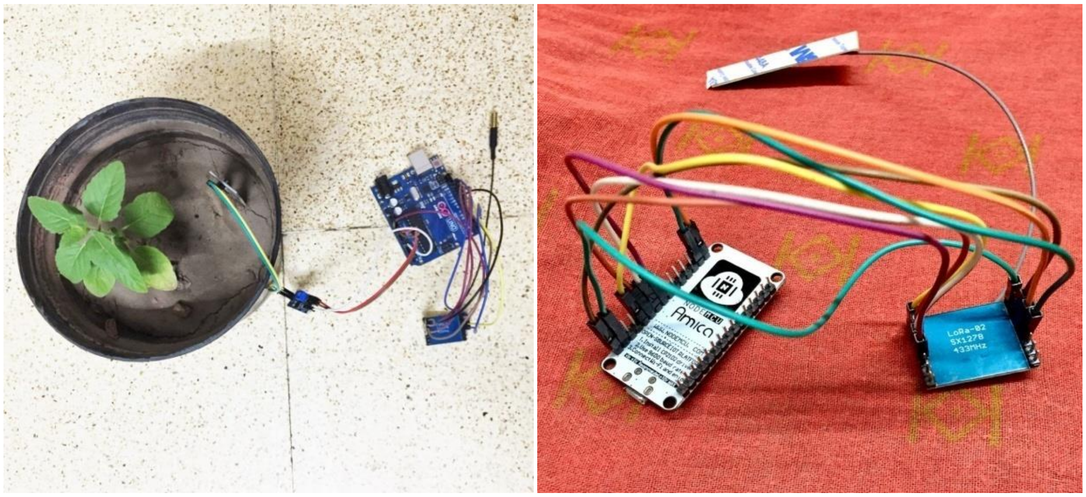


Figure 4.26: Implemented Soil Moisture Node Tx Rx.

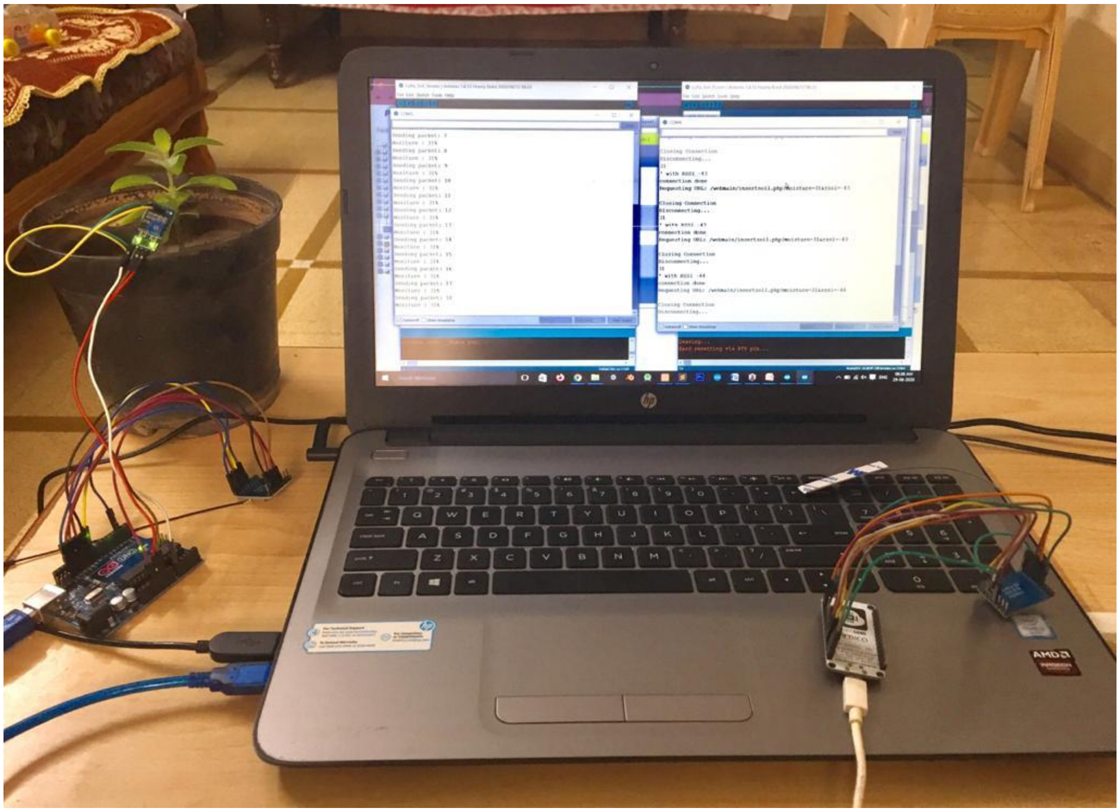


Figure 4.27 Implemented Soil Moisture Node Tx Rx output.

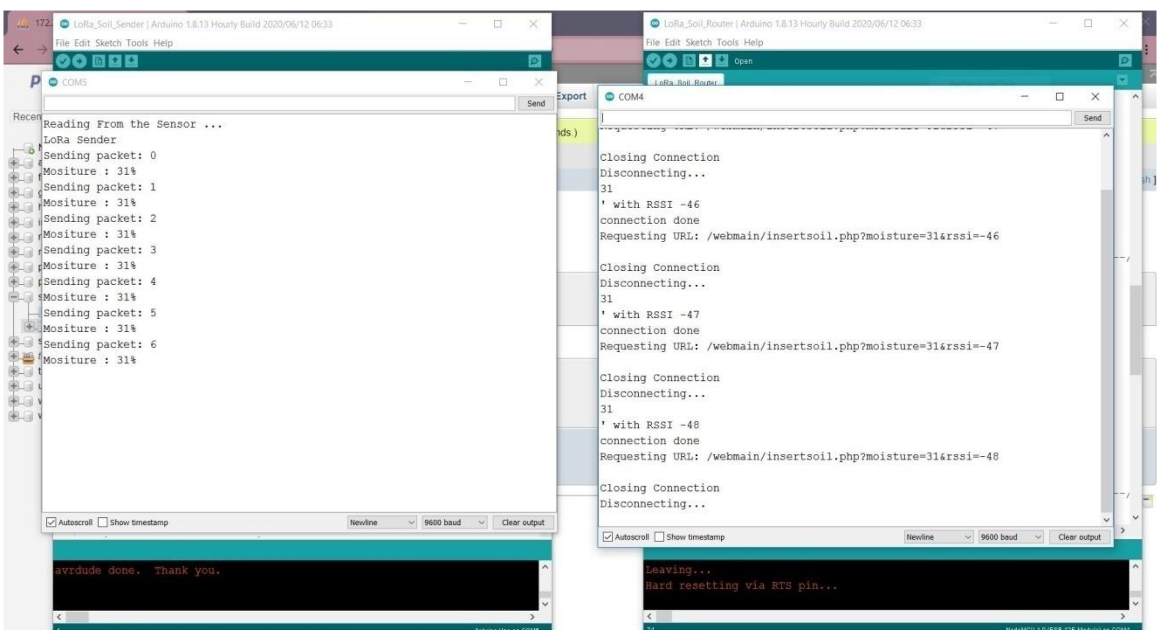


Figure 4.28: Soil Moisture Node TX RX With Serial Monitoring.

We fetch the store data from the database and display it in various forms via the web site using PHP and HTML.

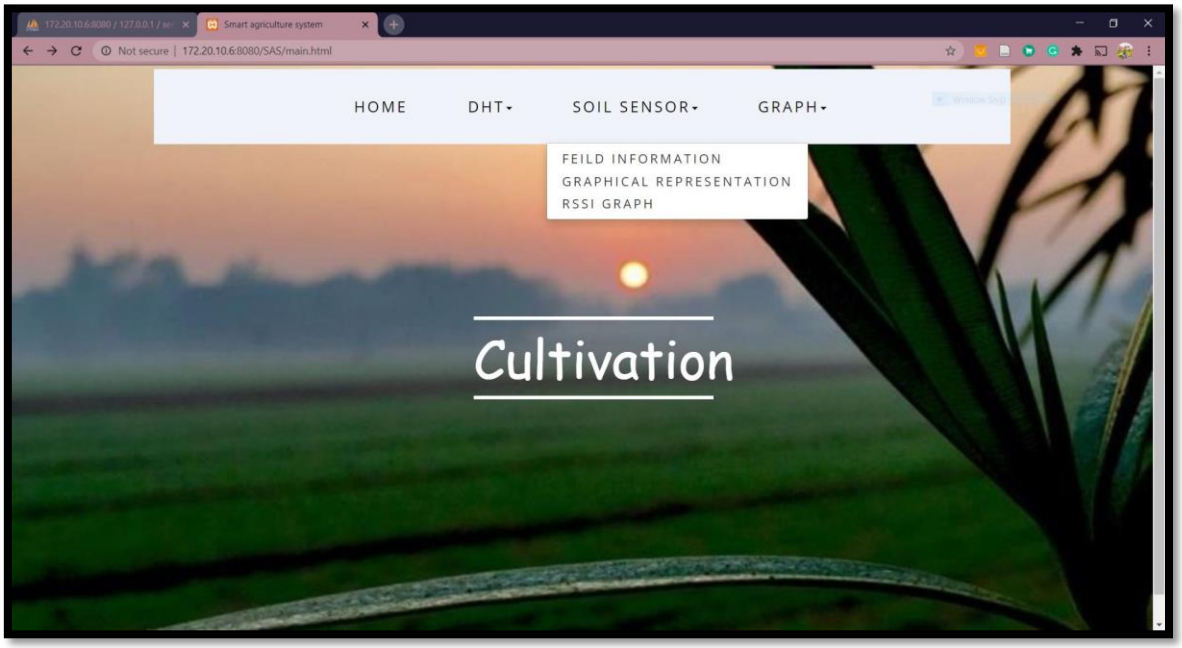
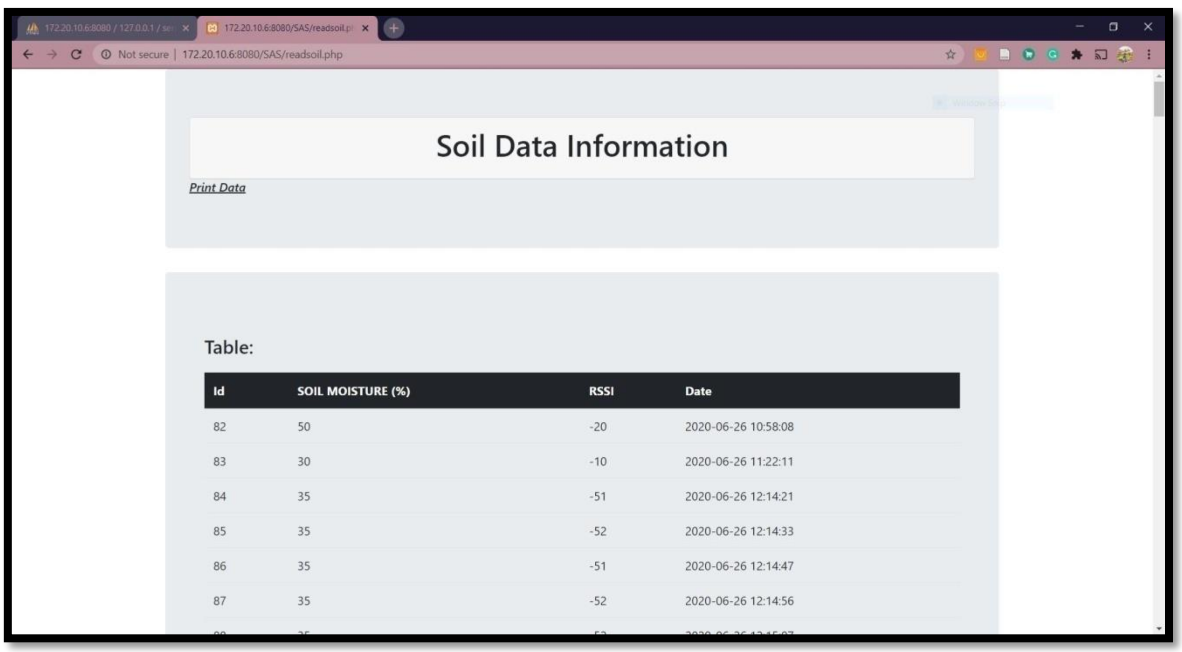


Figure 4.29: Soil Moisture Home Page.

We display the store data in tabular form on the web site.


Soil Data Information

Print Data

Table:

Id	SOIL MOISTURE (%)	RSSI	Date
82	50	-20	2020-06-26 10:58:08
83	30	-10	2020-06-26 11:22:11
84	35	-51	2020-06-26 12:14:21
85	35	-52	2020-06-26 12:14:33
86	35	-51	2020-06-26 12:14:47
87	35	-52	2020-06-26 12:14:56

Figure 4.30: Collection of Live Moisture data in Table form on Web Site.

And base on the store data value, we are plot a graph with a good interface. Using that farmers can easily monitor the major and minor changes in soil moisture.

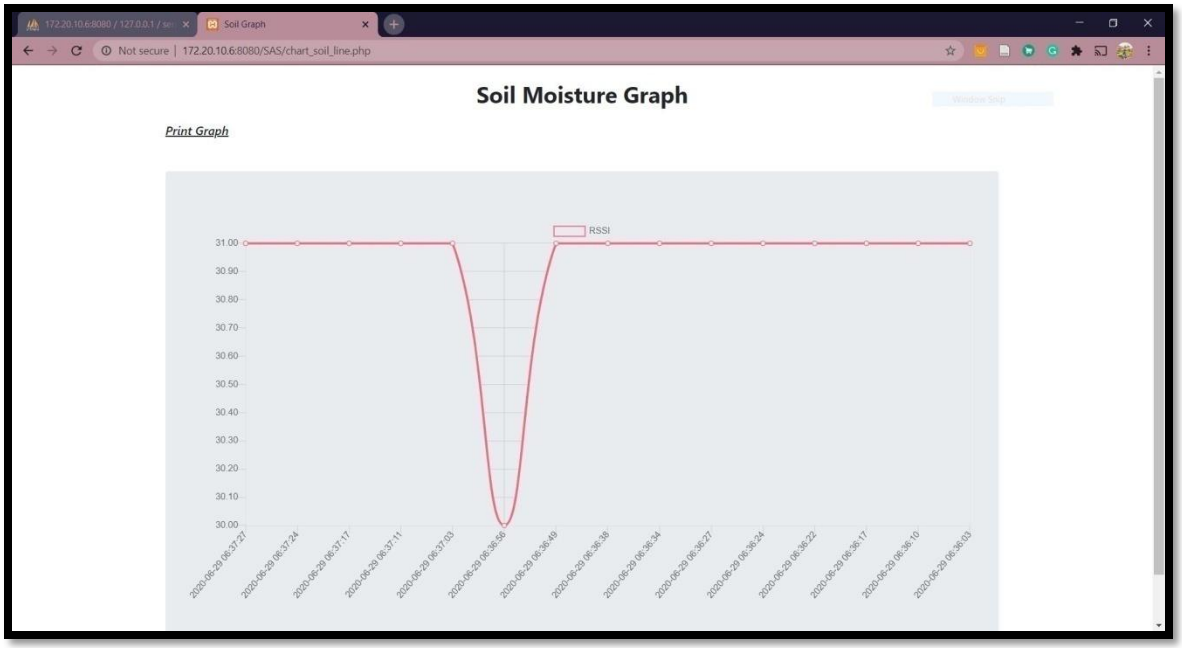


Figure 4.31: Soil Moisture Graph

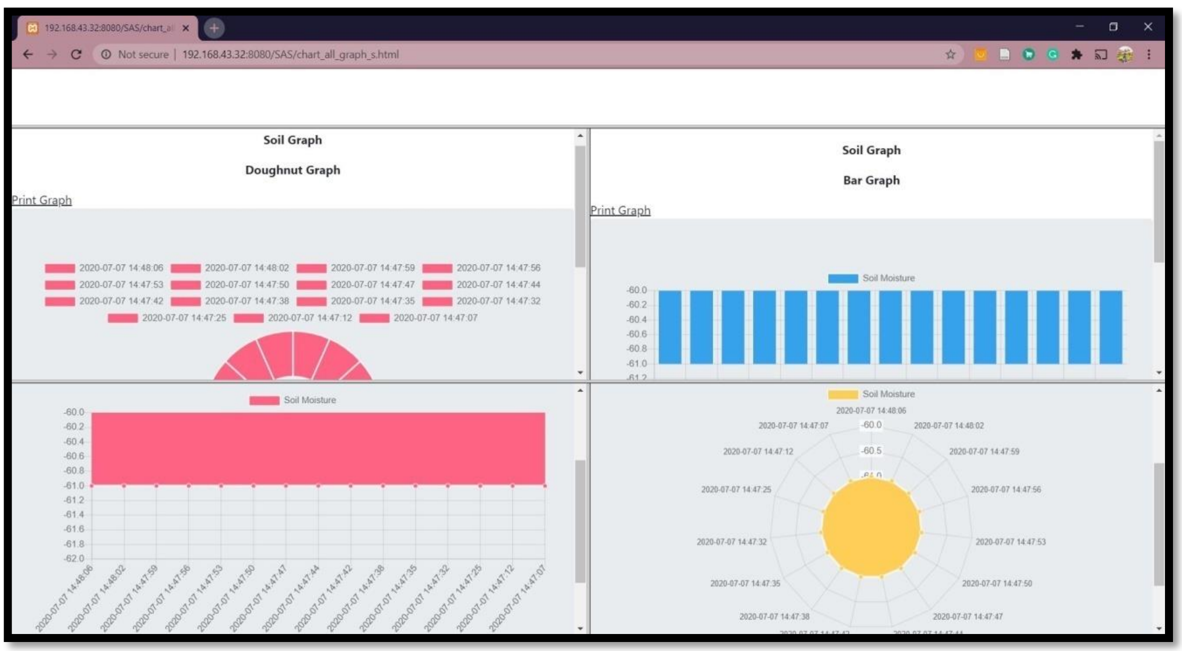


Figure 4.32: Soil Moisture Graph Representation.

Here the soil moisture graph is represented in various kinds of graphs using that, farmers can easily monitor and understand field data.

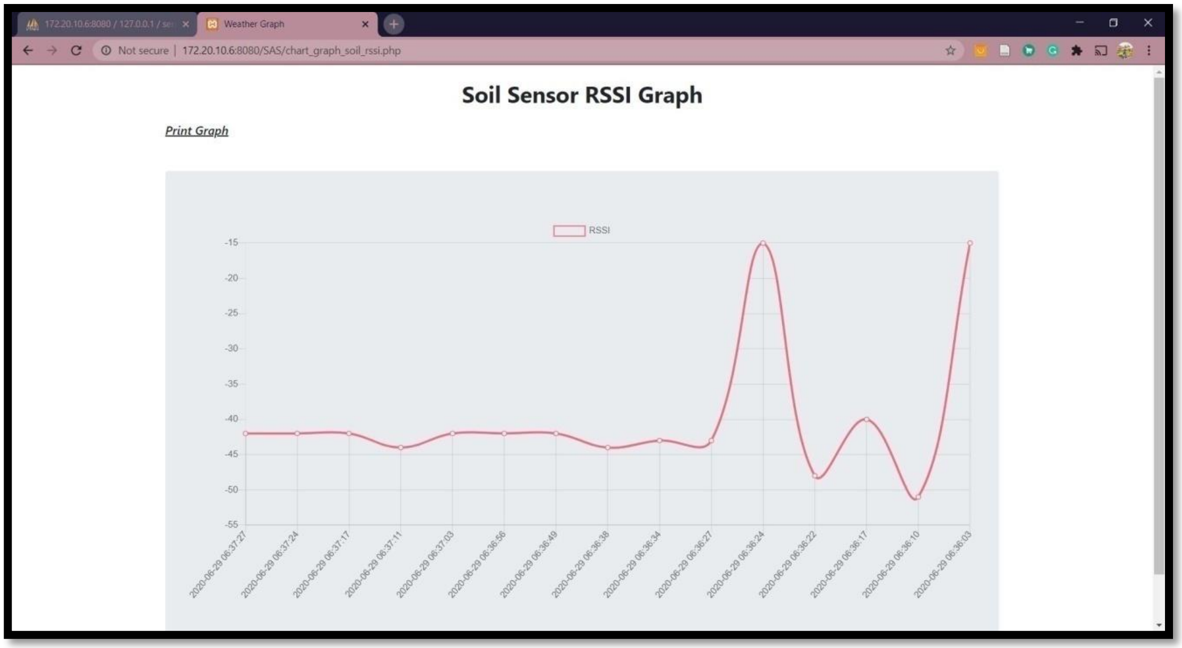


Figure 4.33: Soil Moisture RSSI Graph

Here the RSSI of LoRa signal strength value for soil moisture transmitter is also monitored using a plotted graph.

4.6 Complete node with Motor control:

A. Lavric, et al. [21] design an Internet of Things and LoRa Low-Power Wide-Area Network: A Survey. As discussed in the LoRa communication stack, LoRaWAN defines three classes of devices. Depending on the application needs, A, B, or C class can be chosen. The C class is used by bi-directional (both direction) with maximal receive slots, which has almost continuously open receive windows, which are only closed when transmitting [21]. Means LoRa is used to transmit information in both directions, LoRa module is base on a transceiver.

The main aim of making a smart agriculture system is to reduce manual work and it does after remotely monitoring the field information like temperature, humidity, and soil moisture. But after providing different controllers, the smart agriculture system is much more efficient.

Note: Here for experiment purposes, we are using LED rather than Motor.

A. Transmitting side:

Using a website or android application, the farmers can remotely control the motor (LED). Here system receiver work as a transmitter. Now our transmitter is a collection of NodeMCU, LoRa SX1278 with antenna, 5V power supply, and controlling web page. The block diagram of the transmitter side is as shown below.

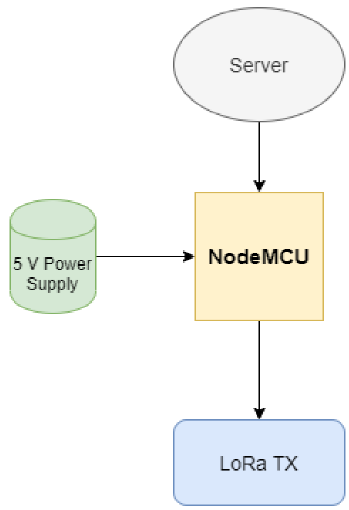


Figure 4.34: Block Diagram Of Transmitter for Motor (LED).

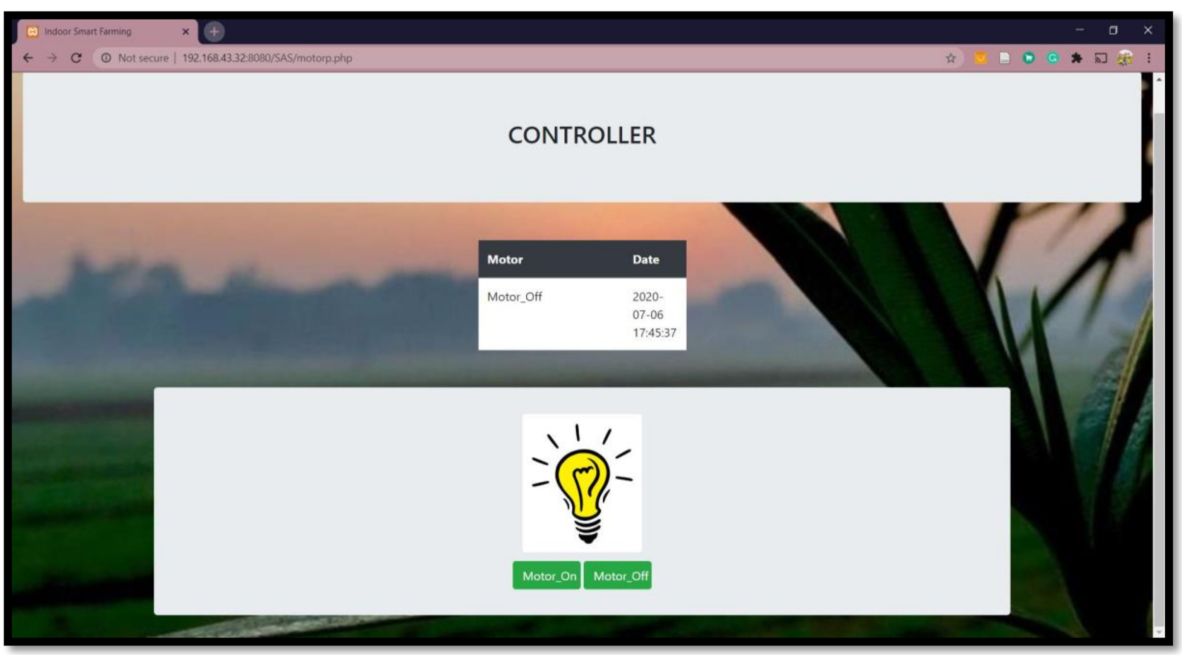


Figure 4.35: LED Controller Web Page.

B. Receiving Side:

The LED has two different pins: A) Negative, B) Positive. Negative pin connects with the GND pin of Arduino UNO and the positive pin of LED connects with any digital pin of Arduino UNO. Here, the positive pin of LED connected with DIO 8 on Arduino UNO.

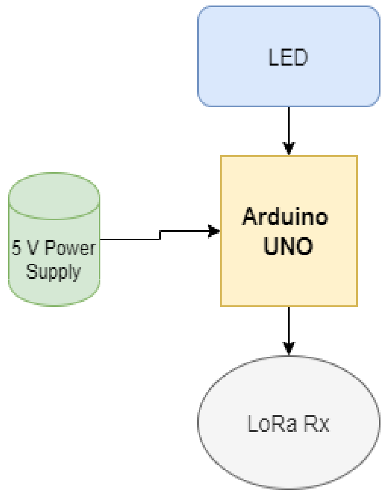


Figure 4.36: Block Diagram Of Transmitter for LED.

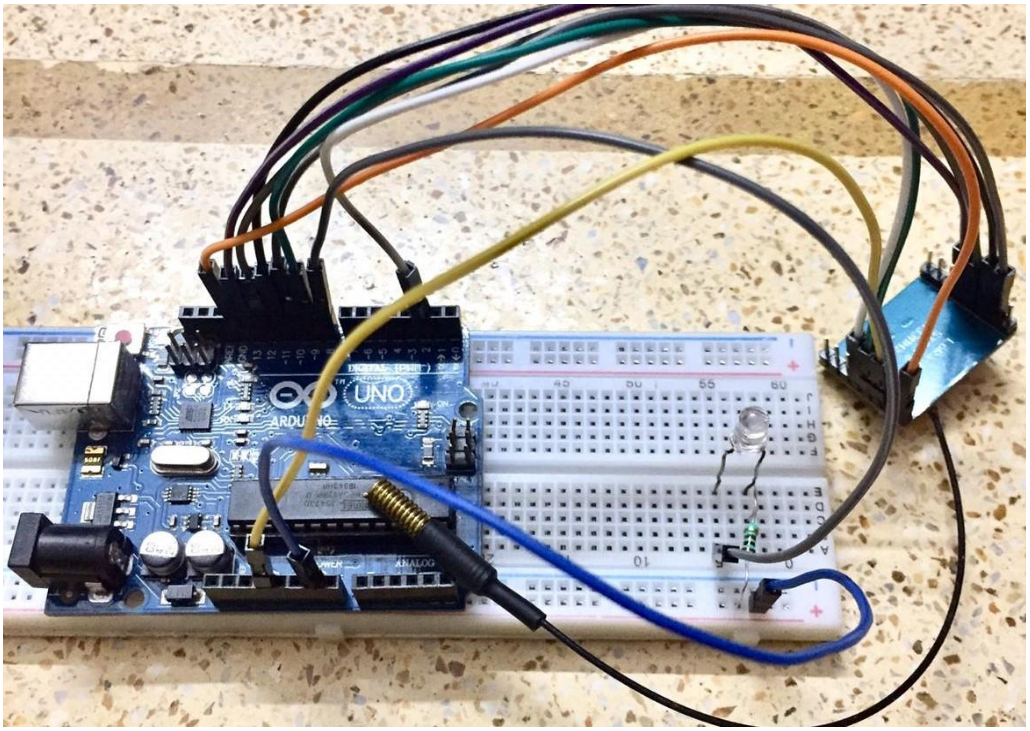


Figure 4.37: Implemented Receiver for LED.

C. Prepare Database and Web Page:

We want to provide remote access to farmers, so we have to create one website. Using that, farmers can easily control the motor (LED) of the field. But before that, we have to create one database. As we see in chapter 3, using XAMPP phpMyAdmin we do that.

In the first step we need to start Apache and MySql from XAMPP:

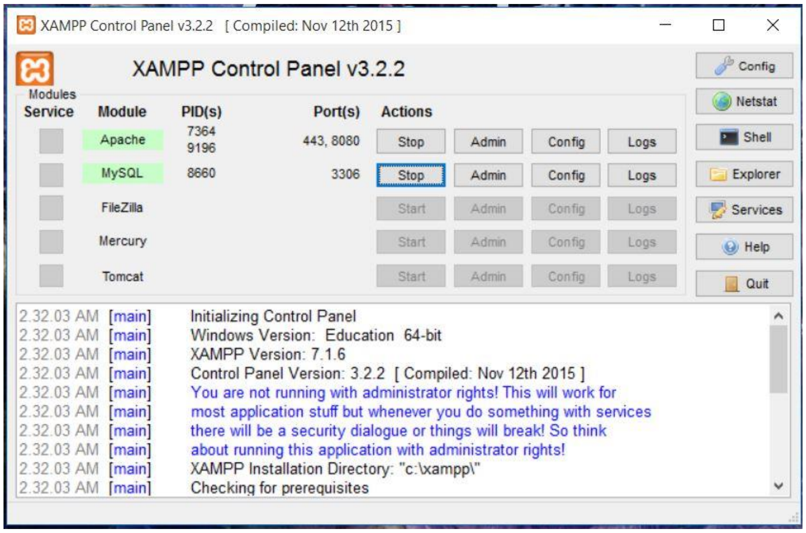


Figure 4.38: XAMPP Control Panel.

Open phpMyAdmin by searching "localhost/phpMyAdmin" on a browser and create one new database, after that create one table in that database and store the sensor value in that.

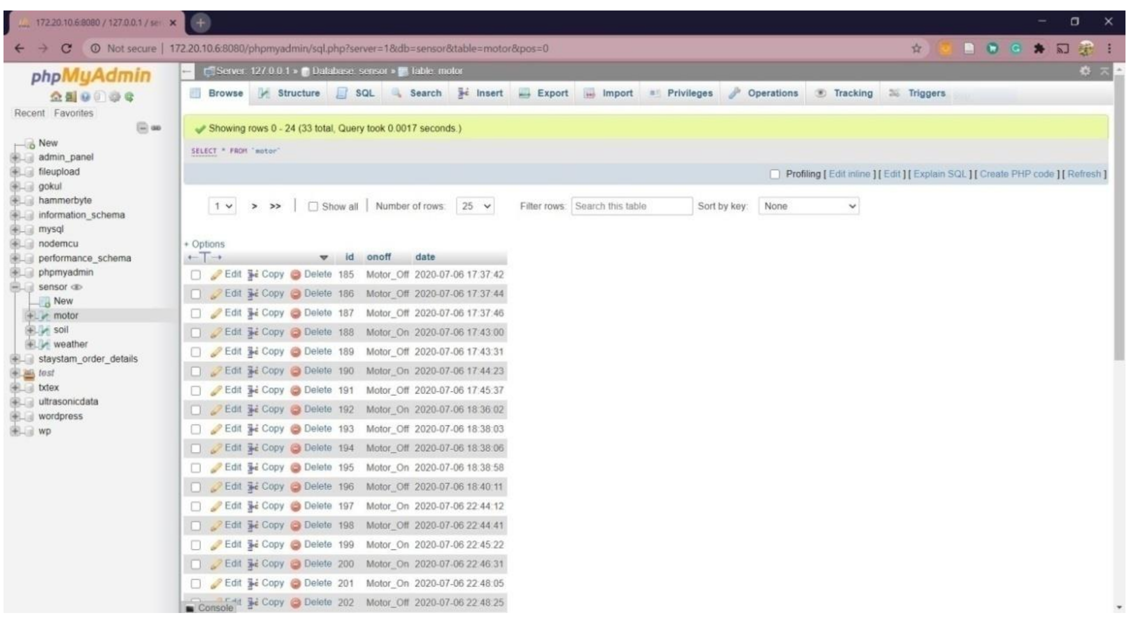


Figure 4.39: Motor Database.

Here the database name is a “sensor” and the table name is the “motor”. In the table we store the id number of data, then onoff status of the motor (LED) with date and time.

D. Implementation:

By clicking the Motor_On button on the web site, the LED is going in on condition. And using the Motor_Off button, the LED is going in off condition. Which can be explained in the following two steps: [Same thing use for motor control]

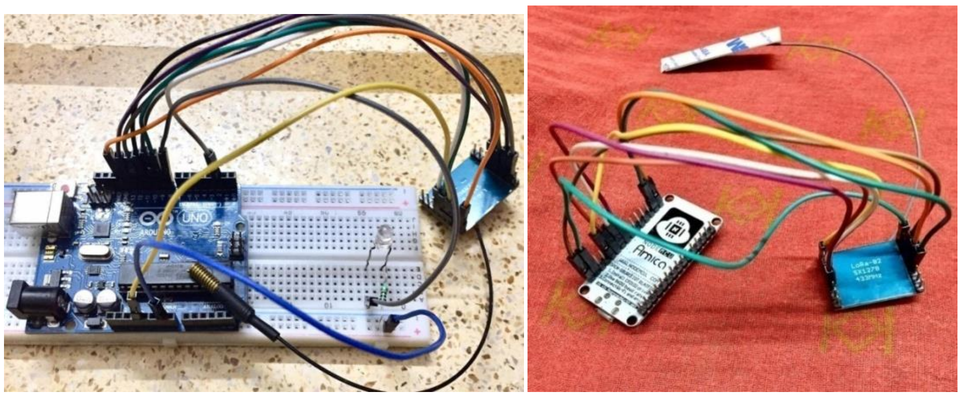


Figure 4.40: Implemented LED Controller Tx Rx.

Step 1: Motor_On

In the beginning stage, the motor (LED) is in the ideal stage, which means that the motor (LED) is in off condition. The web page also displays the last deactivated status of the motor (LED).

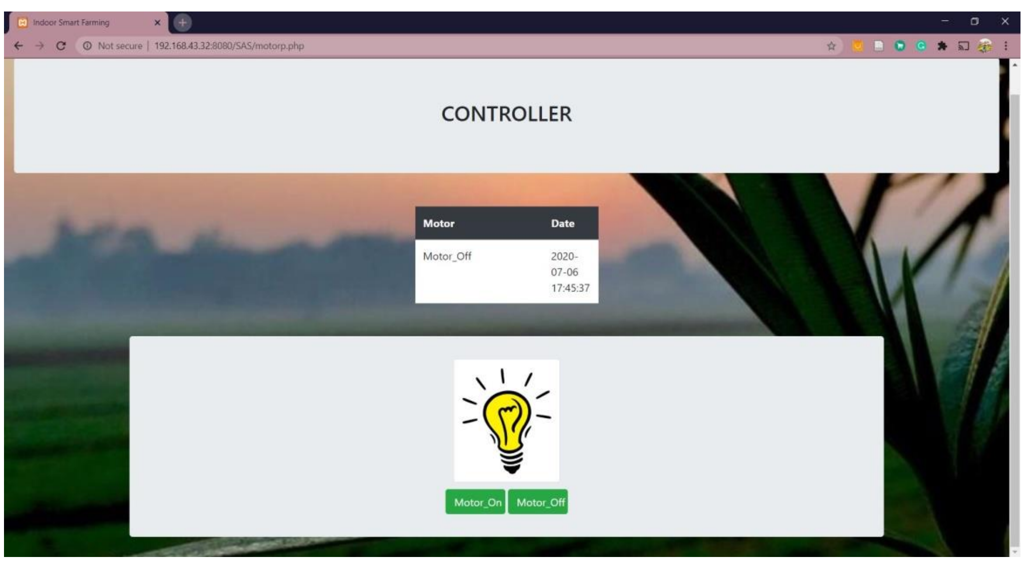


Figure 4.41: Motor (LED) Controller Web page.

Now clicking the Motor_On button, the motor (LED) goes into the active condition and also displays the activation status of the motor (LED) on the web page.

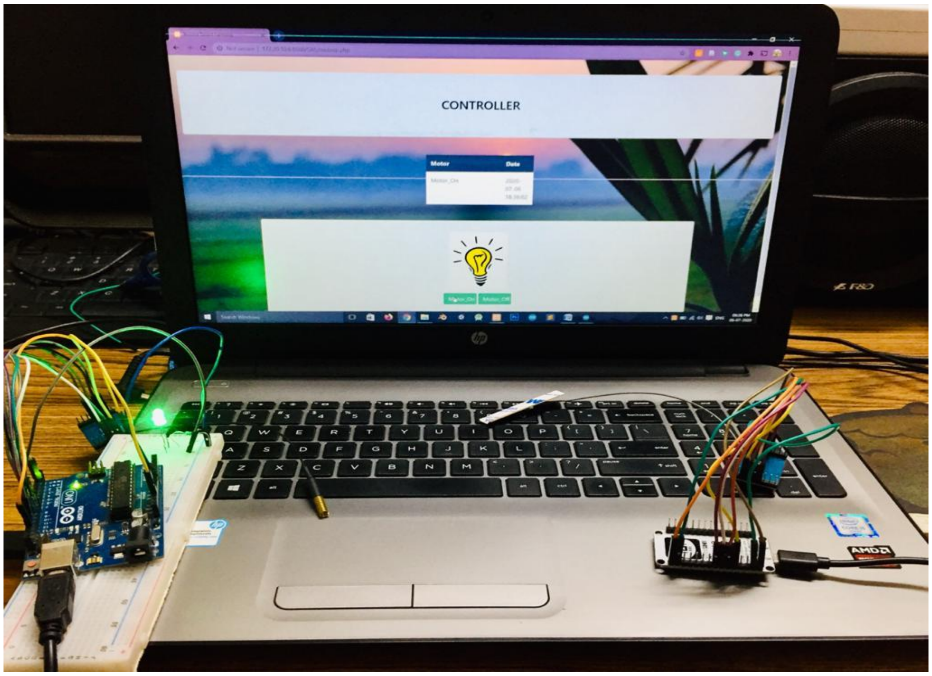


Figure 4.42: Implemented Motor (LED) is in an active condition.

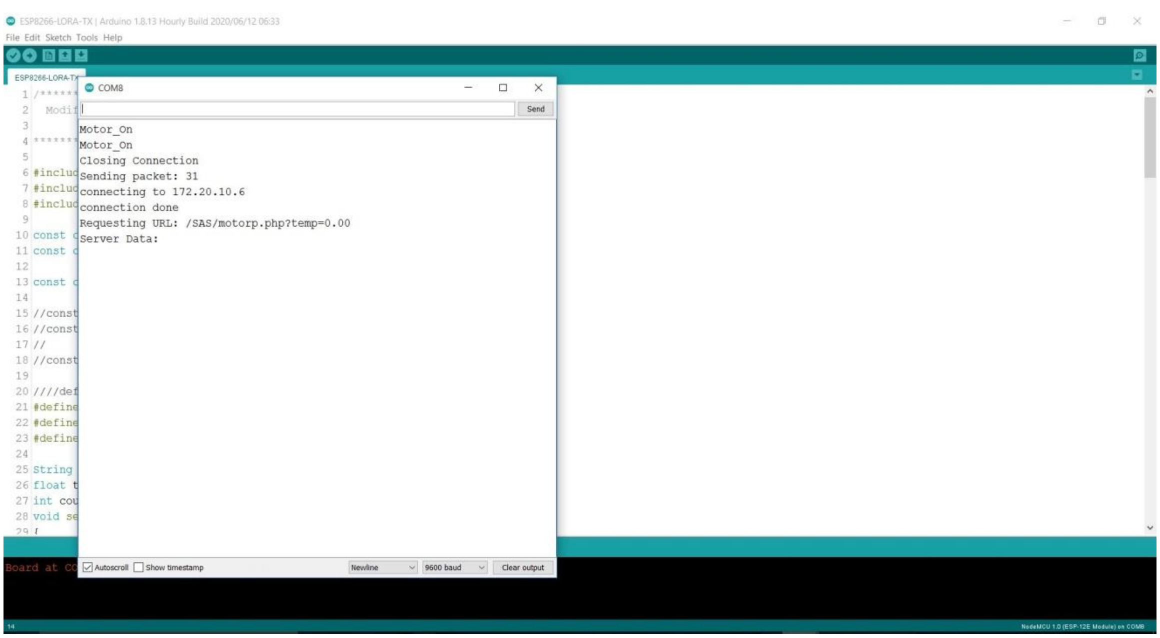


Figure 4.43: Motor (LED) with Serial Monitoring.

Step 2: Motor_Off

In the second stage, when the motor (LED) is in an active state, at that time the web page displays the activation status of the motor (LED).

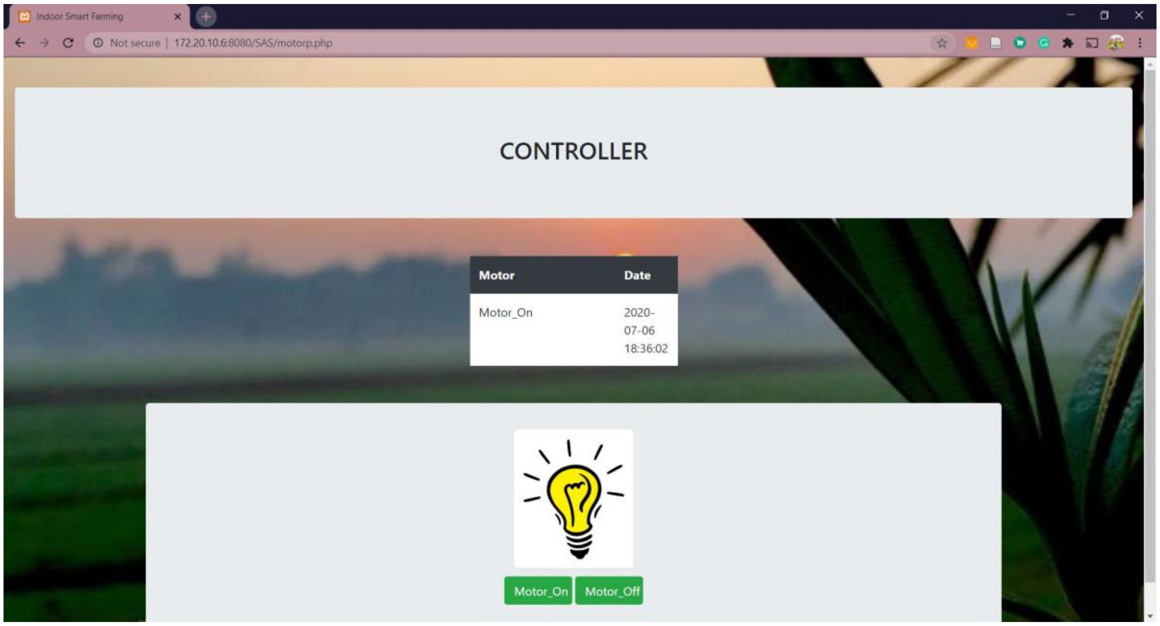


Figure 4.44: LED Controller Web page.

Now clicking the Motor_Off button, the motor (LED) goes into the off condition and also displays the deactivation status of the motor (LED) on the web page.

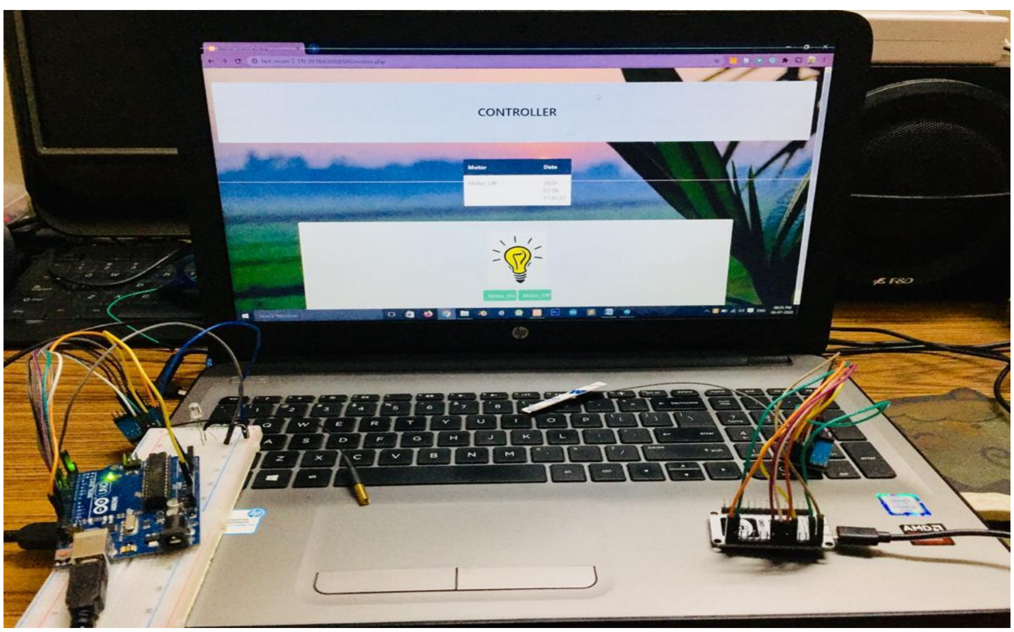


Figure 4.45: Implemented LED in Off condition.

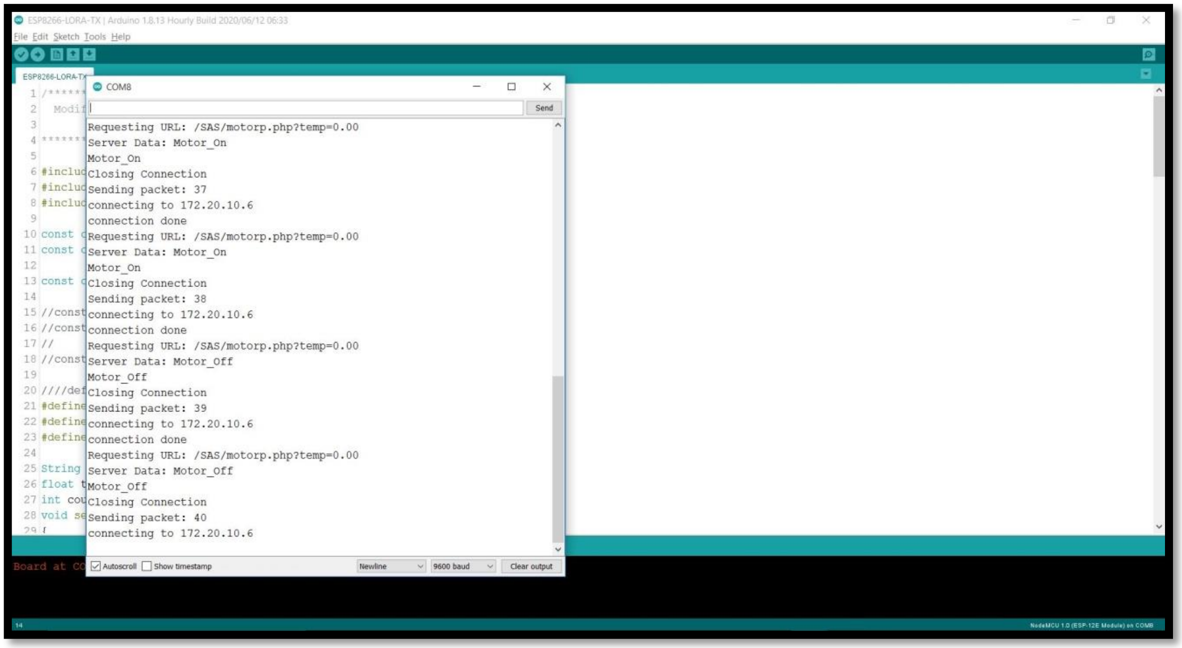


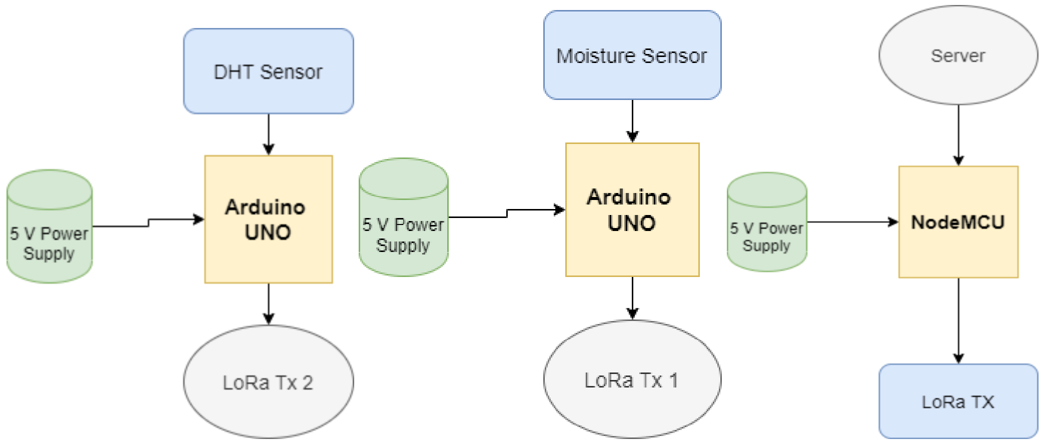
Figure 4.46: LED with Serial Monitoring.

4.7 Wireless Sensor Network:

The farmer requires to build multiple nodes in a single field, for accurate field data monitoring and controlling. For that purpose, one can create a single network, in which multiple nodes are connected, and they monitored and controlled a field simultaneously. In a single network, multiple transmitters transmit the various values which are received by the single receiver.

In our case, we are using two different transmitters. one transmitter uses a DHT sensor to measure the temperature and humidity of the field. And the second transmitter uses a soil moisture sensor to measure the moisture in the soil. The values of both transmitters are received by the receiver and also from the server-side, we give the command for controlling some components. They all are connected wirelessly between each other, as per the proposed block diagram in chapter 3. The connection between them is similar to the above.

A. WSN Transmitting side:



a) DHT Sensor Tx b) Soil Moisture Sensor Tx c) Server as a Tx

Figure 4.47: Tx Block Diagram of WSN Network.

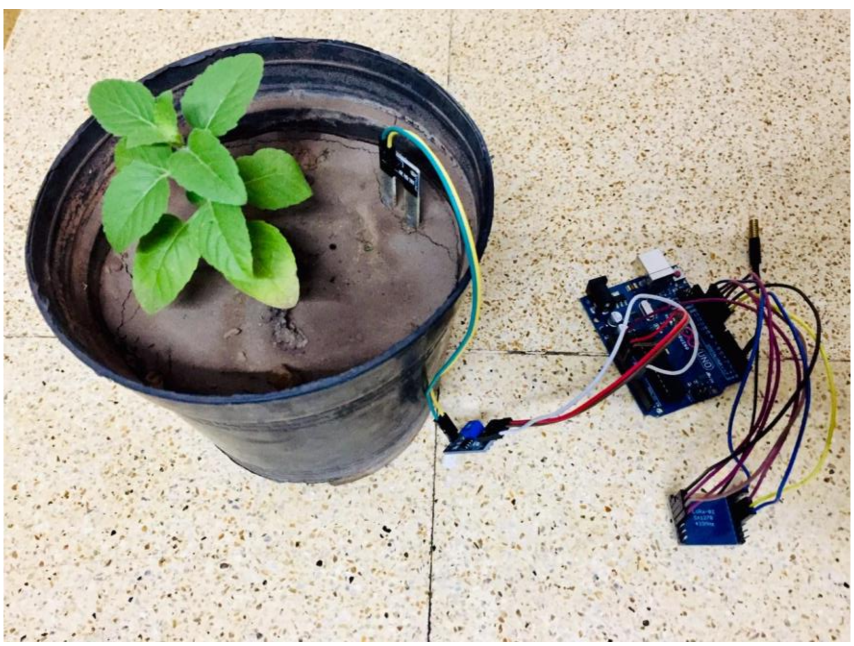


Figure 4.48: Tx 1 for WSN Network.

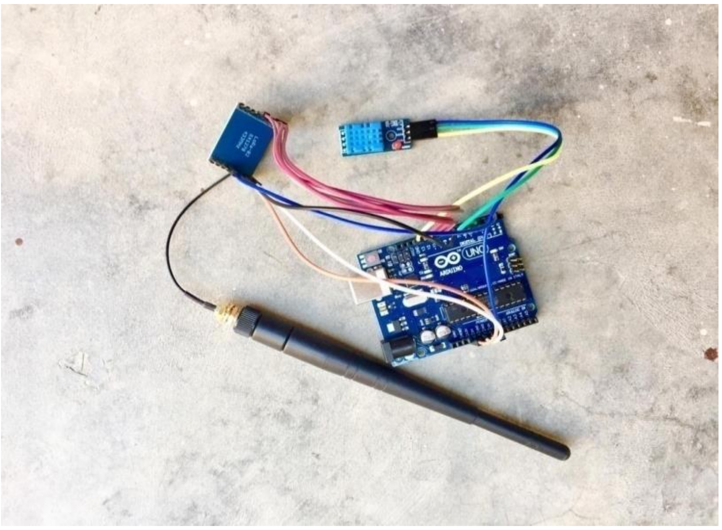
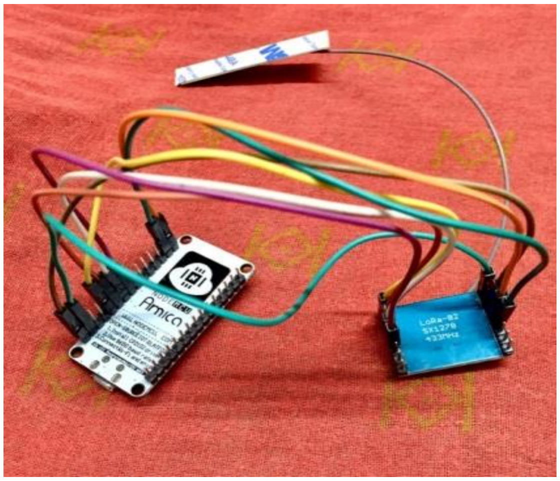
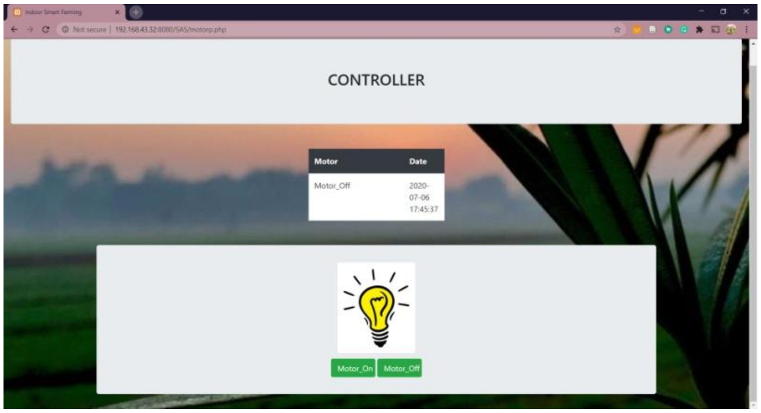


Figure 4.49: Tx 2 for WSN Network.



a) Tx 3

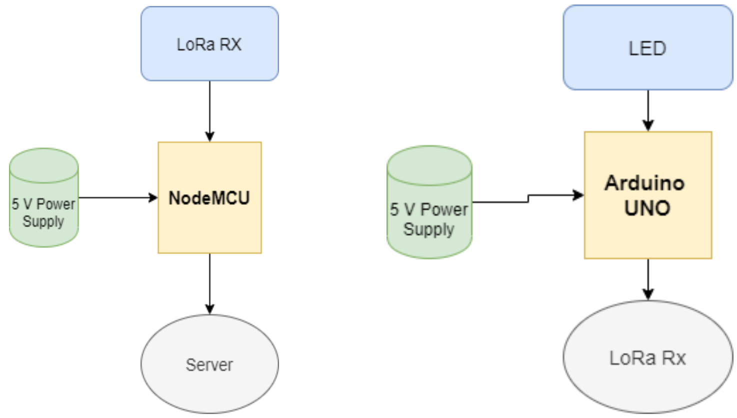


b) Tx 3

Figure 4.50: Tx 3 for WSN Network.

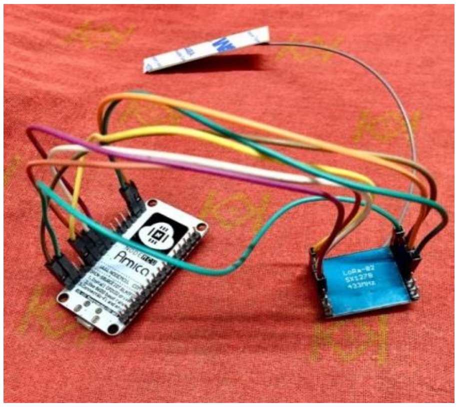
B. Receiving Side:

As we discuss in chapter 4 topic number 4.2, we are using the same thing here. Use the NodeMCU module on the receiving side.

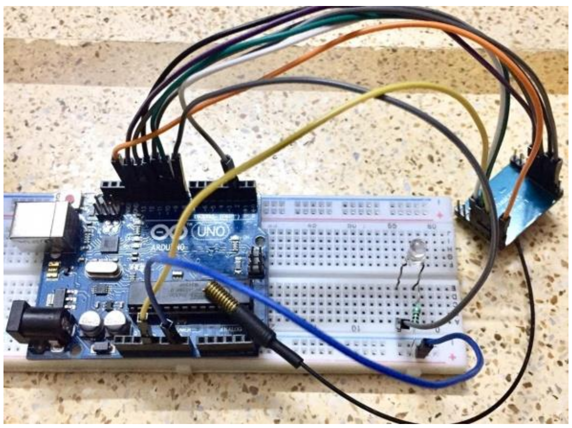


a) Receiver Block diagram b) Receiver for Motor (LED)

Figure 4.51: Rx Block Diagram of WSN Network.



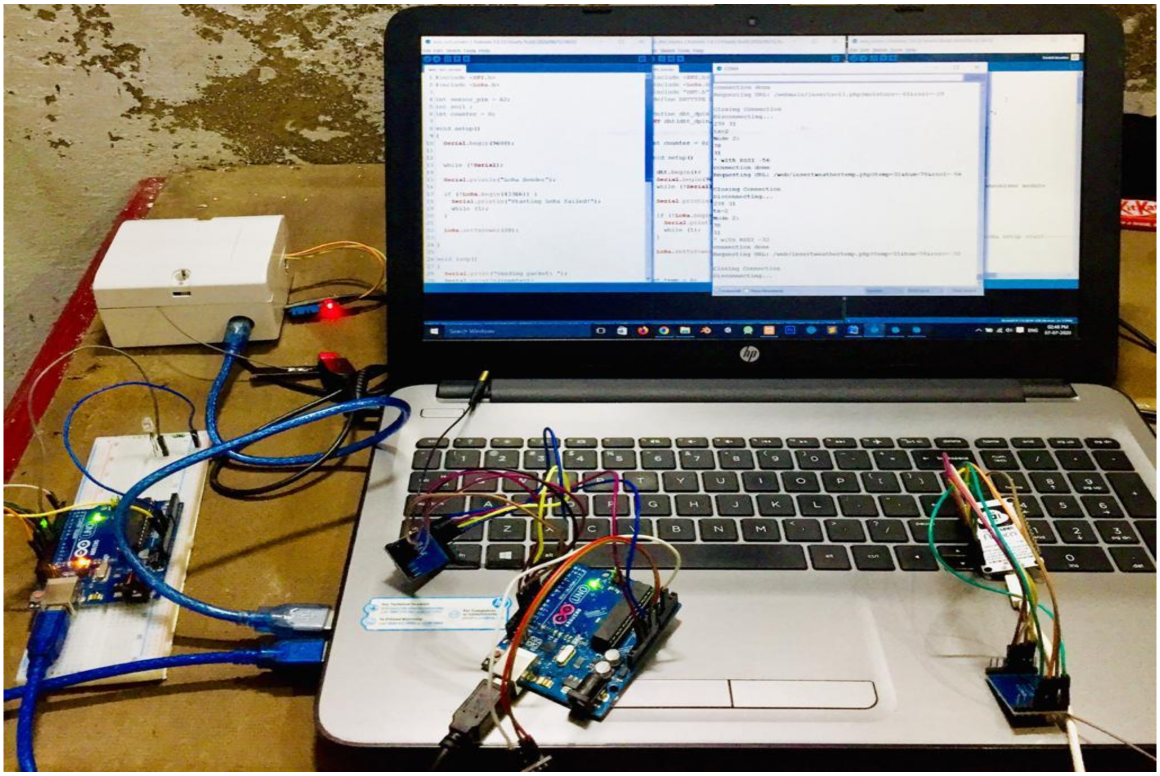
a) Receiver



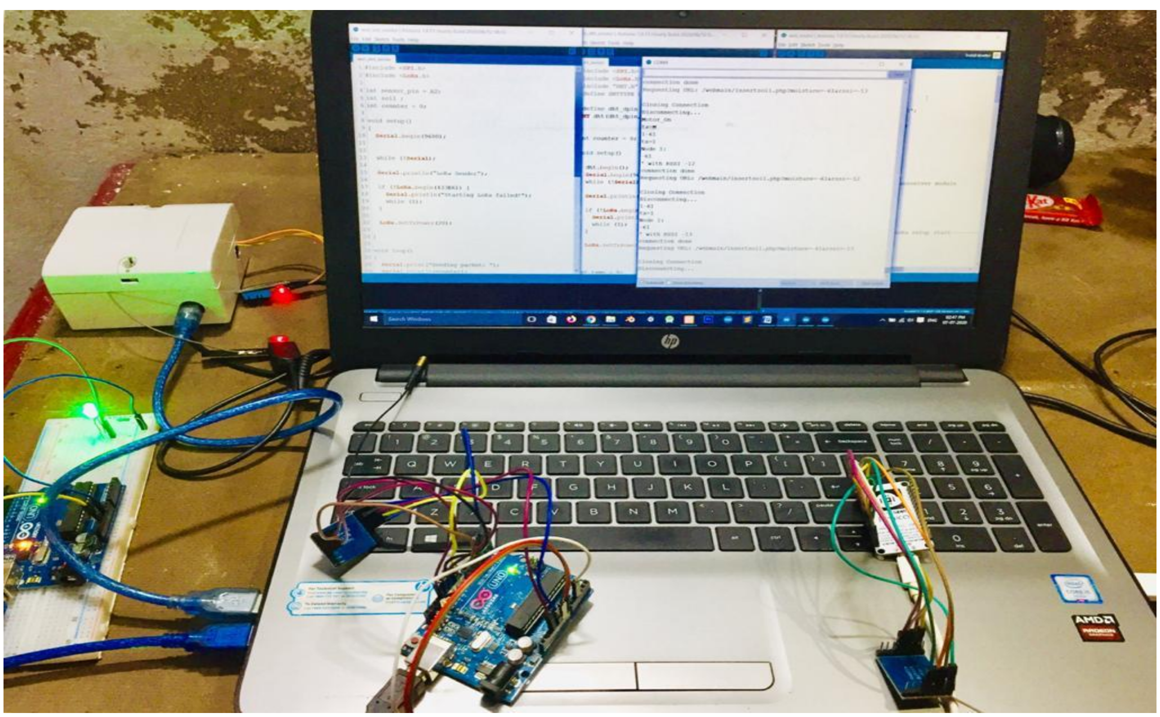
b) Receiver for Motor (LED)

Figure 4.52: Rx of WSN Network.

C. Implementation:



a) Implemented WSN Output 1



b) Implemented WSN Output 2

Figure 4.53: Implemented WSN Output

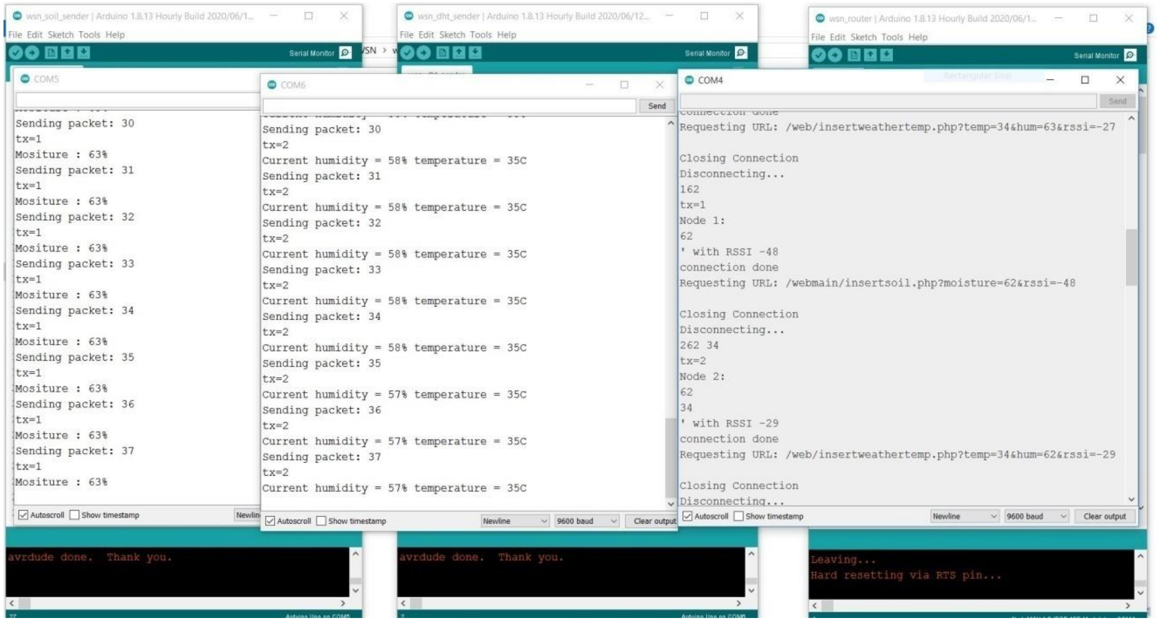
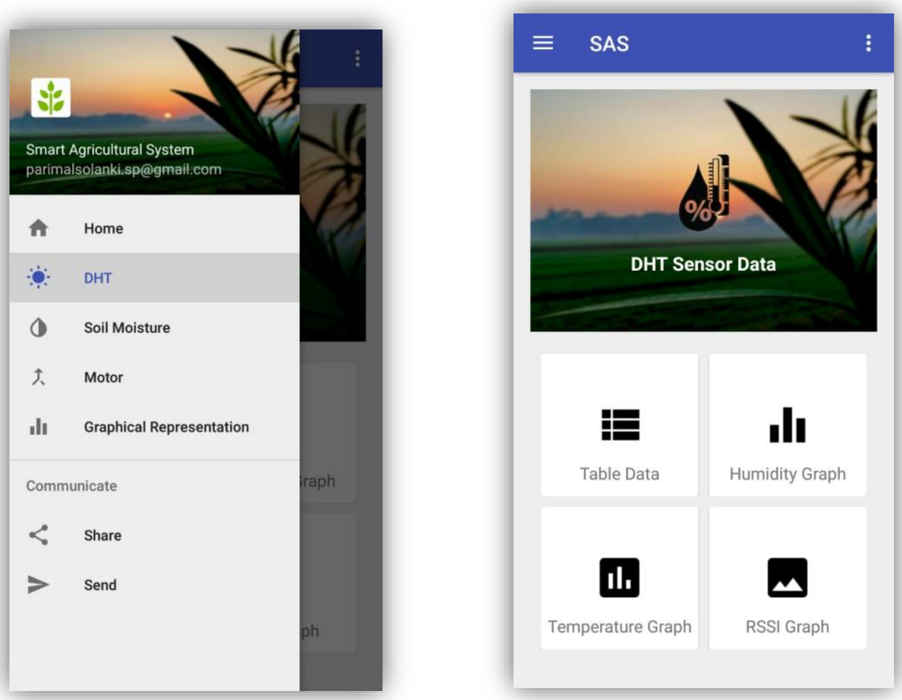
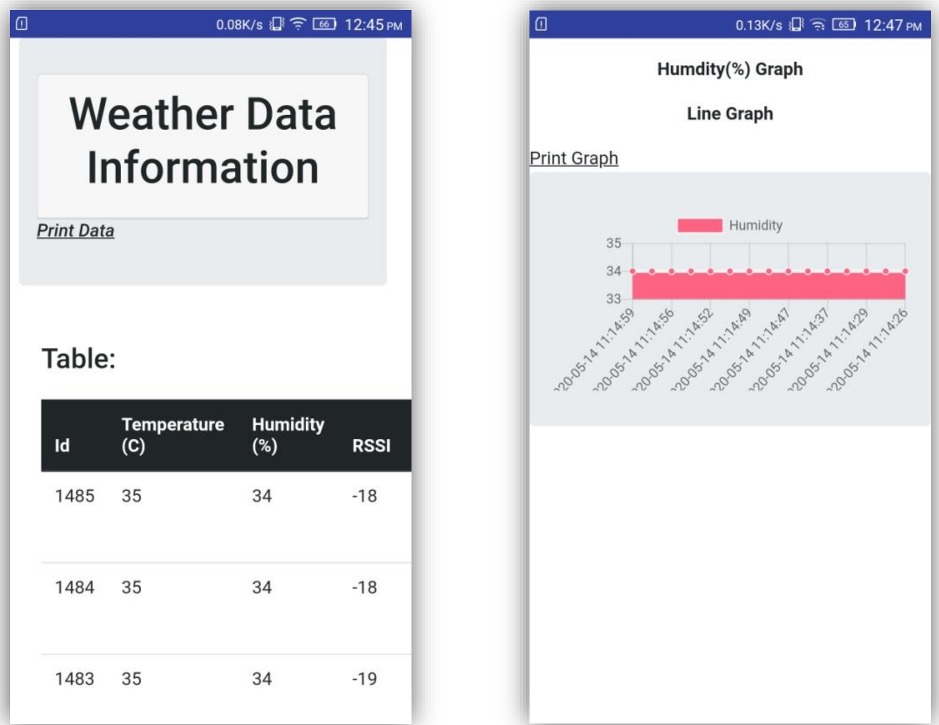


Figure 4.54: WSN Tx Rx With Serial Monitoring.

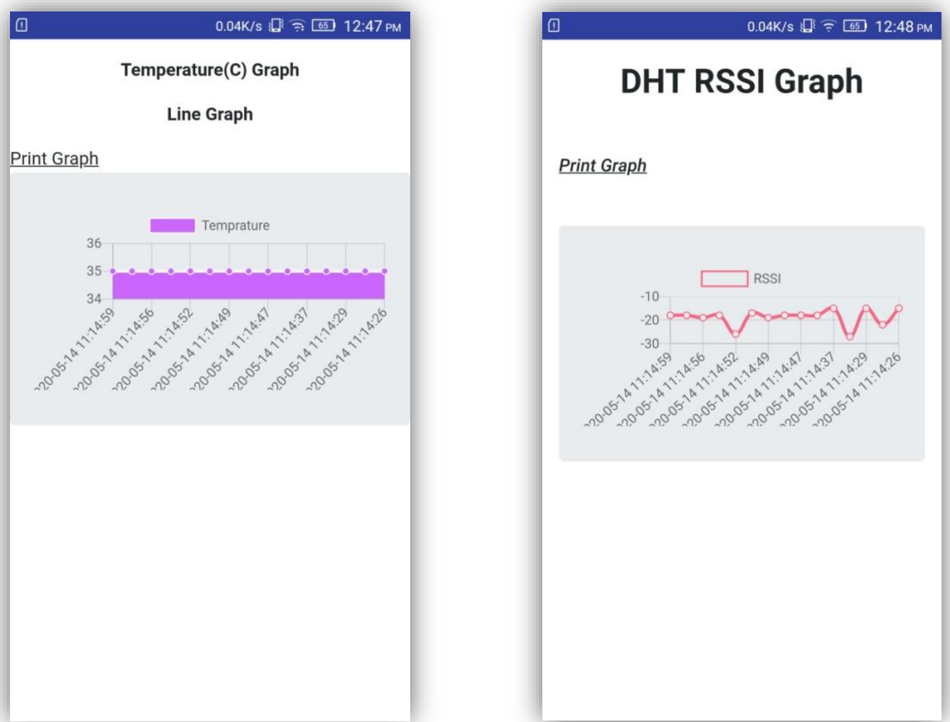
4.8 Android Mobile Application:



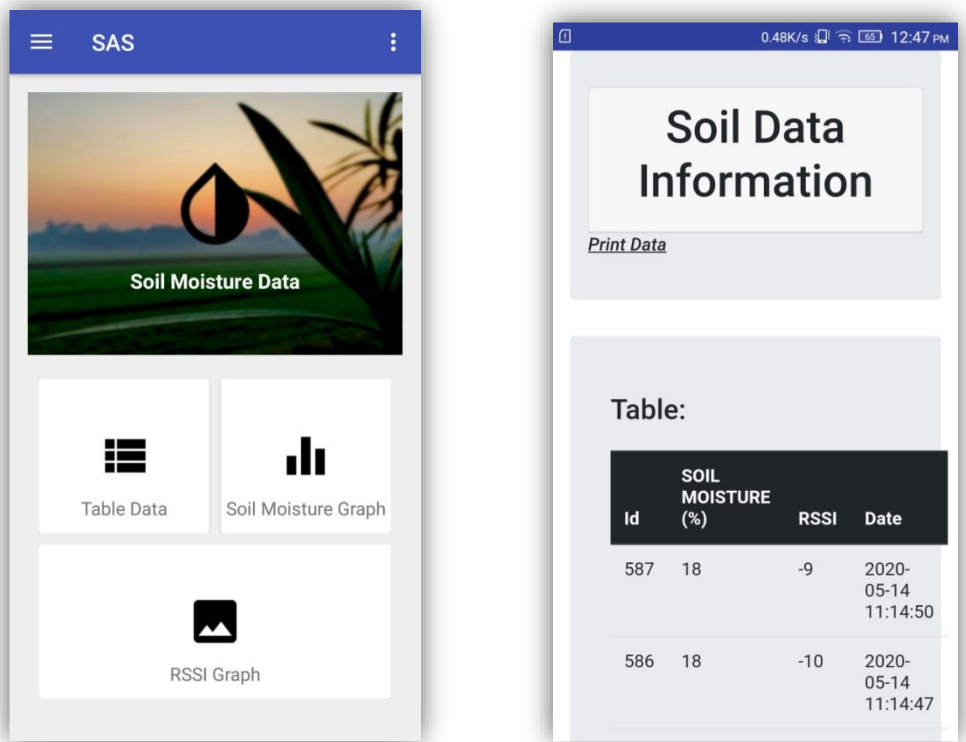
a) Android Mobile Application.



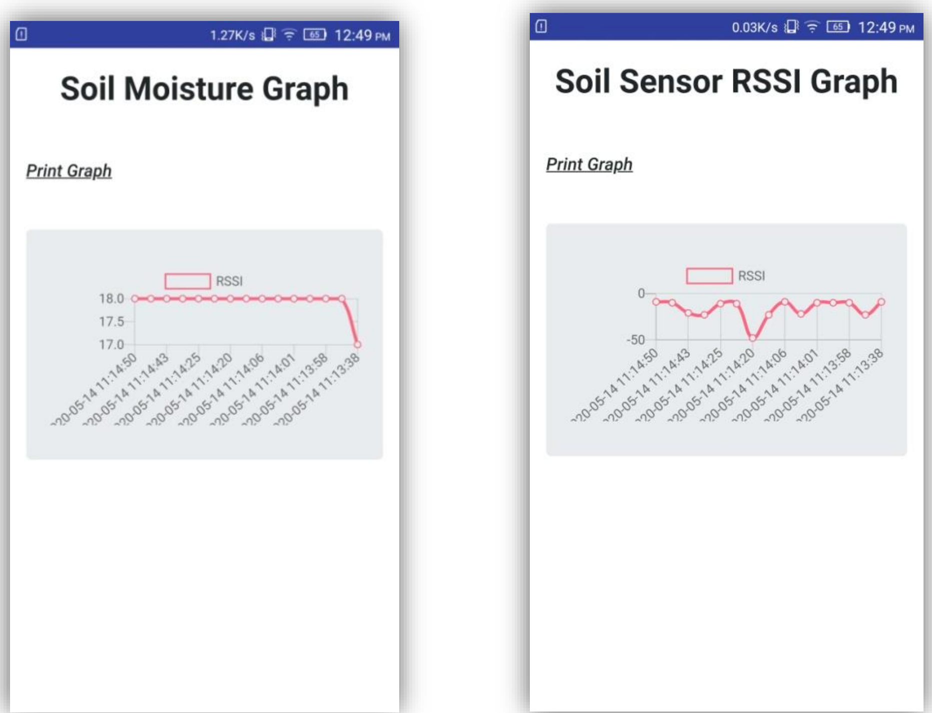
b) Android Mobile Application.



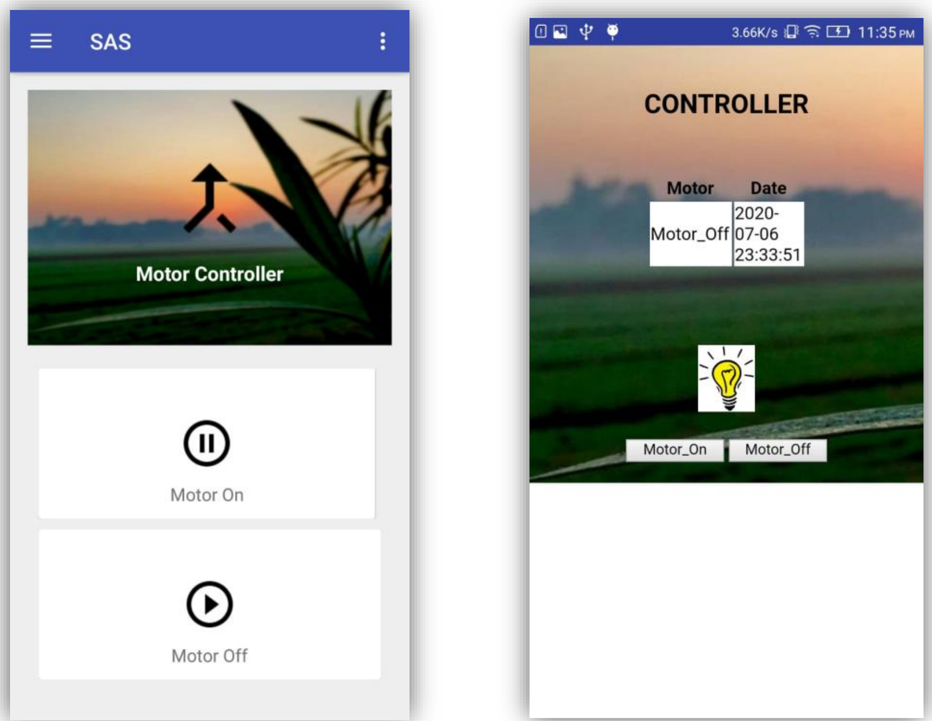
c) Android Mobile Application.



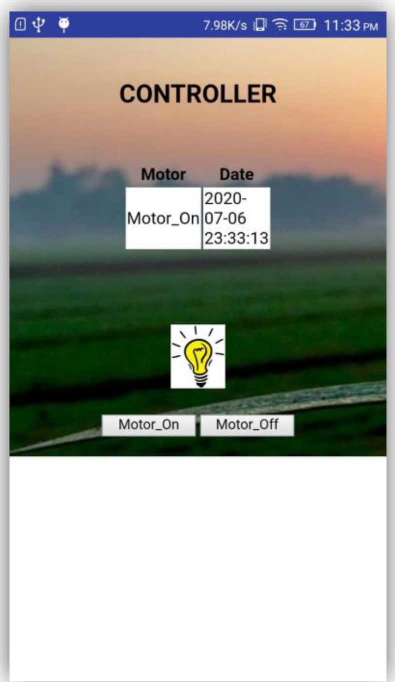
d) Android Mobile Application.



e) Android Mobile Application.



f) Android Mobile Application.



g) Android Mobile Application.

Figure 4.55: Android Mobile Application.

4.8 000Webhost Web Hosting:

000WebHost [33] is a free web hosting company and its power by hostinger. They also provide web hosting at zero charges including 99.9% uptime certified. We use this free web hosting for providing worldwide accessibility for the farmer. For that, we host the website on this web hosting. For that, we need to log in with the email id.

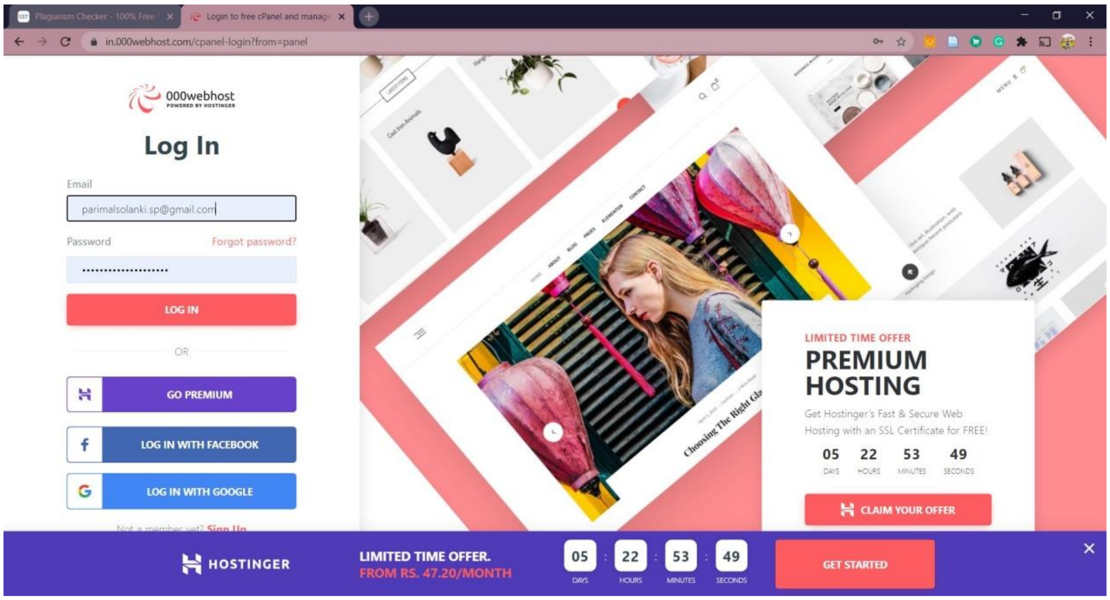


Figure 4.56 Login Page of 000webhost.

After login, create a new site, for that we provide one unique name of the site and it displays a dashboard for controlling a website.

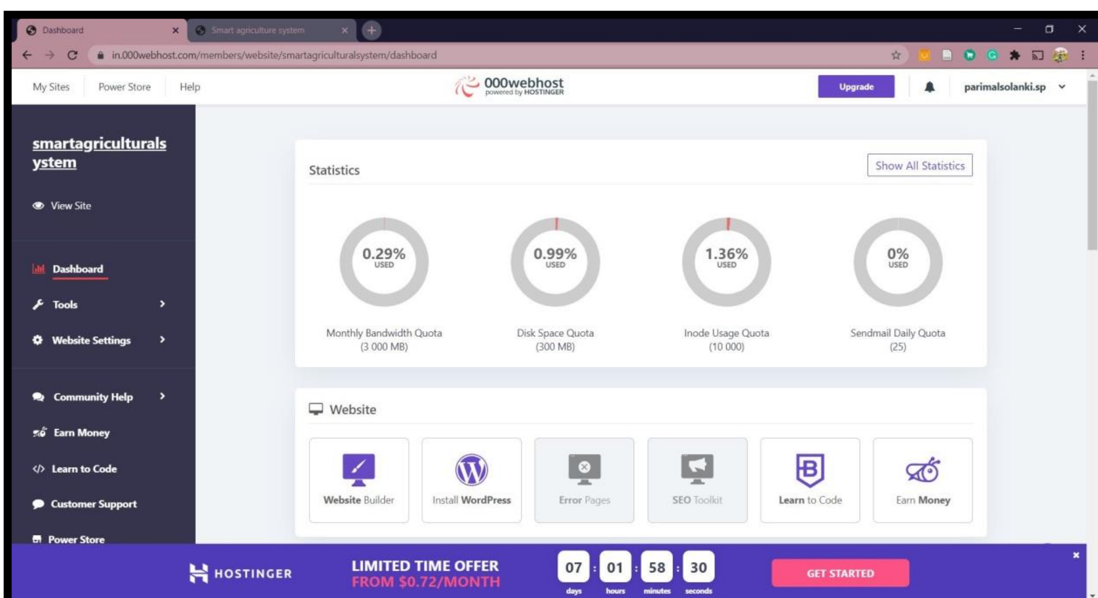


Figure 4.57 Dashboard of 000webhost.

For uploading website design files, select tools → file manager → upload files.

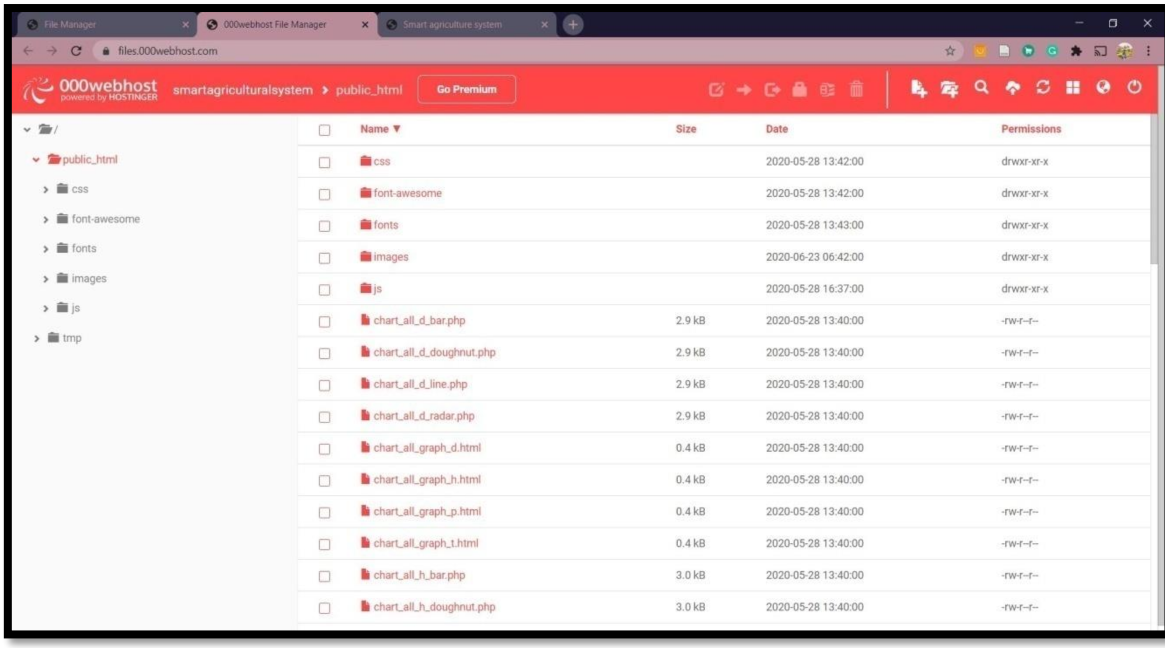


Figure 4.58 File manager of 000webhost.

Create one database for storing the sensor value on that. Go to tools → Database Manager.

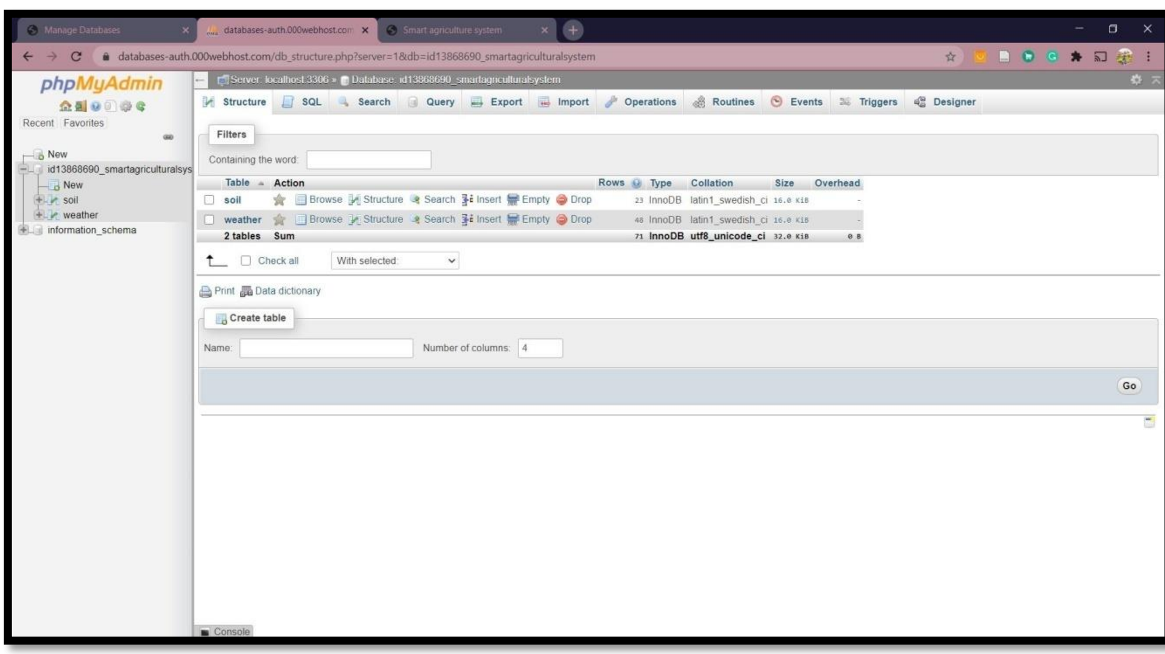


Figure 4.59 Database Manager of 000webhost.

Now our website is ready to use via the internet. Here I am attaching some screenshots of my website.

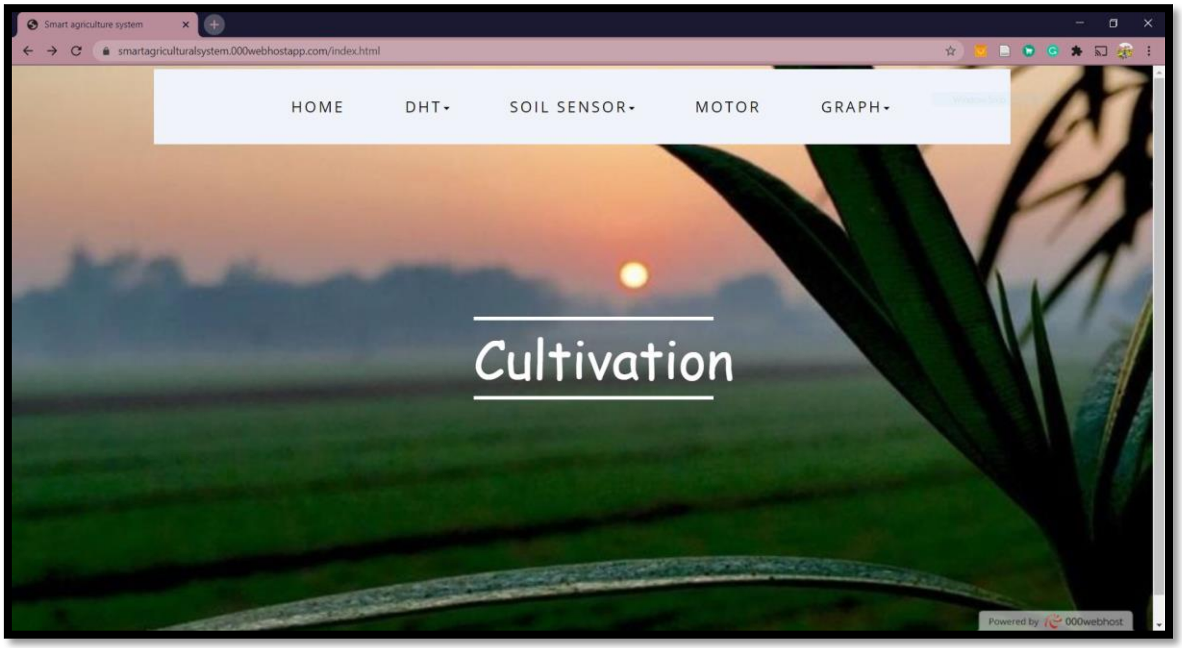
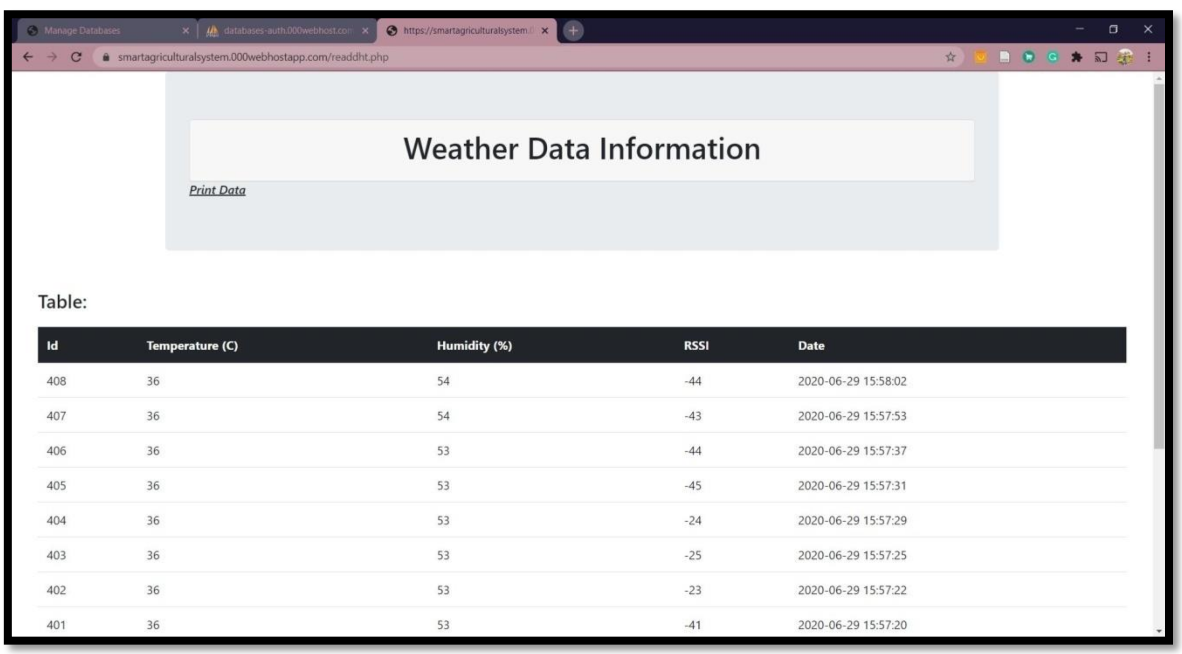


Figure 4.60: Home Page of the website on 000webhost.

The stored weather data are represented in table-form.



Id	Temperature (C)	Humidity (%)	RSSI	Date
408	36	54	-44	2020-06-29 15:58:02
407	36	54	-43	2020-06-29 15:57:53
406	36	53	-44	2020-06-29 15:57:37
405	36	53	-45	2020-06-29 15:57:31
404	36	53	-24	2020-06-29 15:57:29
403	36	53	-25	2020-06-29 15:57:25
402	36	53	-23	2020-06-29 15:57:22
401	36	53	-41	2020-06-29 15:57:20

Figure 4.61: DHT sensor data monitoring on 000webhost.

The stored temperature, humidity, and RSSI data are represented in graphical form.

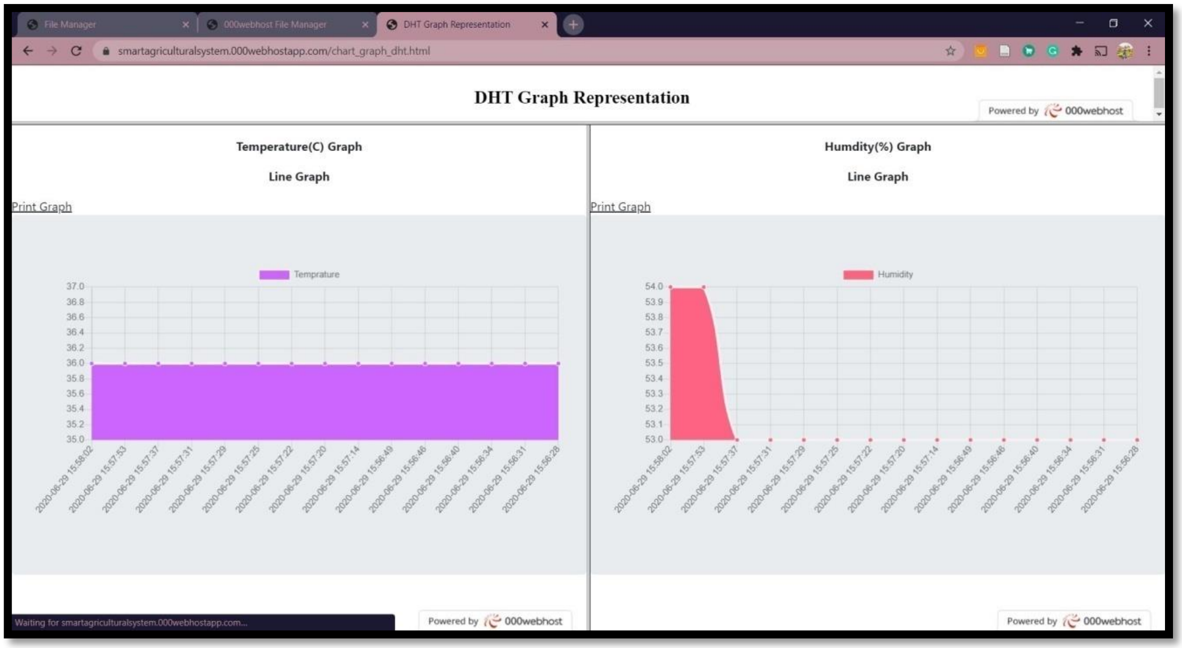


Figure 4.62: DHT Graph Representation on 000webhost

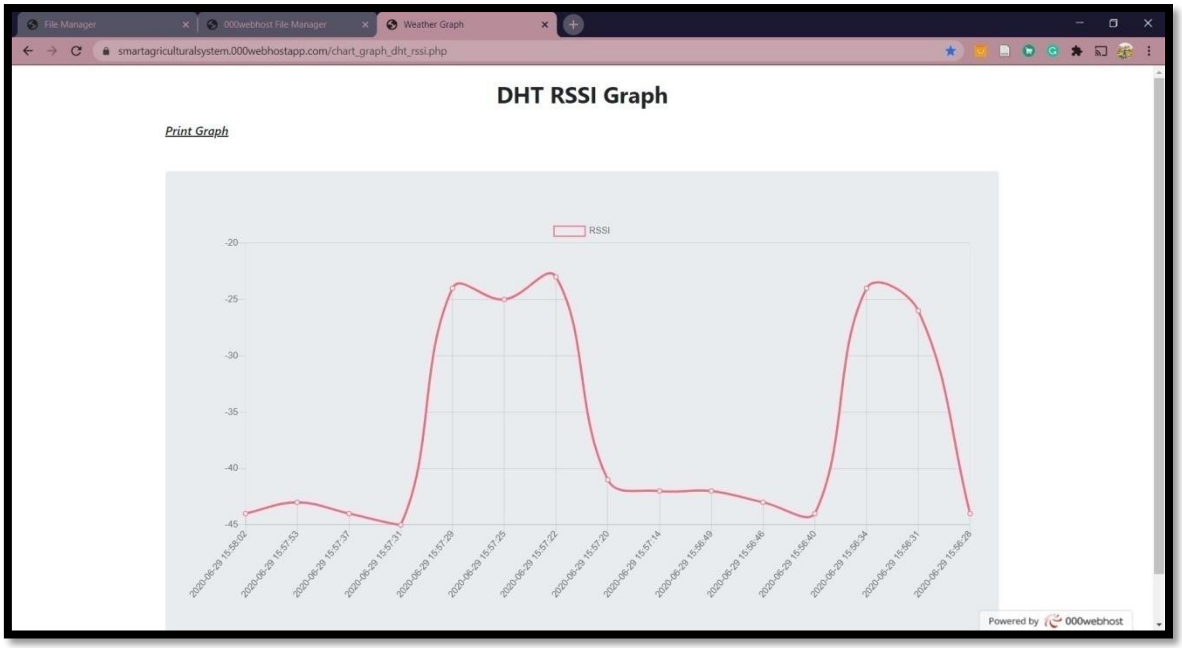


Figure 4.63: DHT RSSI Graph on 000webhost.

Here the "temperature graph" is illustrated in a different graph forms. Using that, farmers can easily monitor and understand field data.

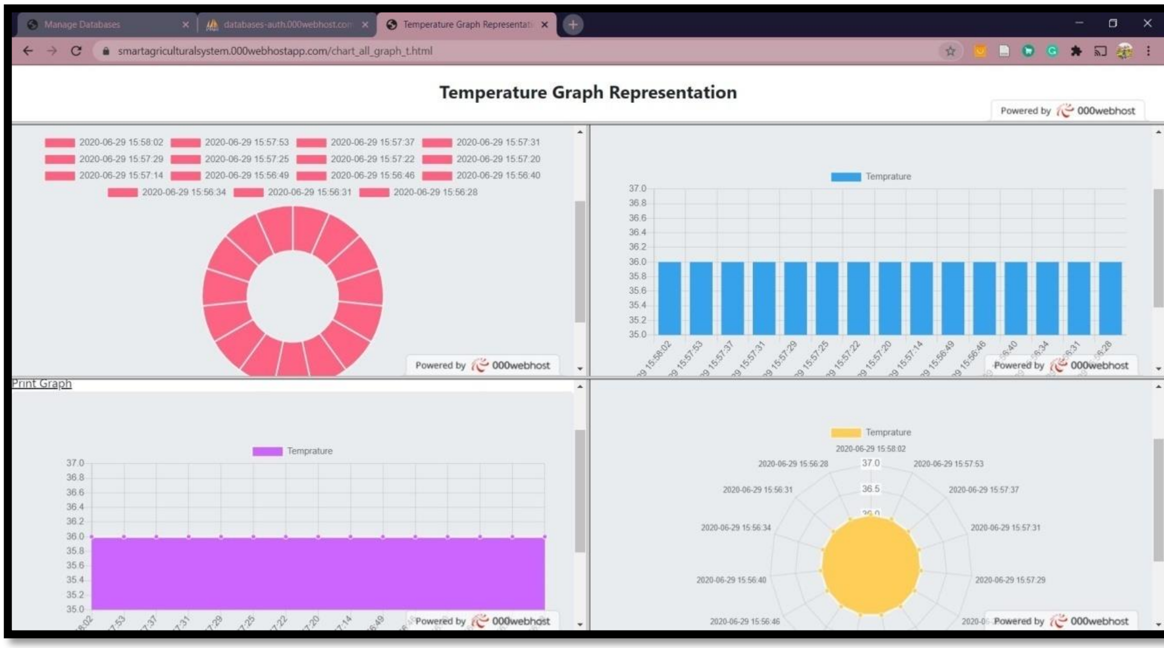


Figure 4.64: Temperature Graph on 000webhost.

Here the "humidity graph" is represented in a different graph form. Using that, farmers can easily monitor and understand field data.

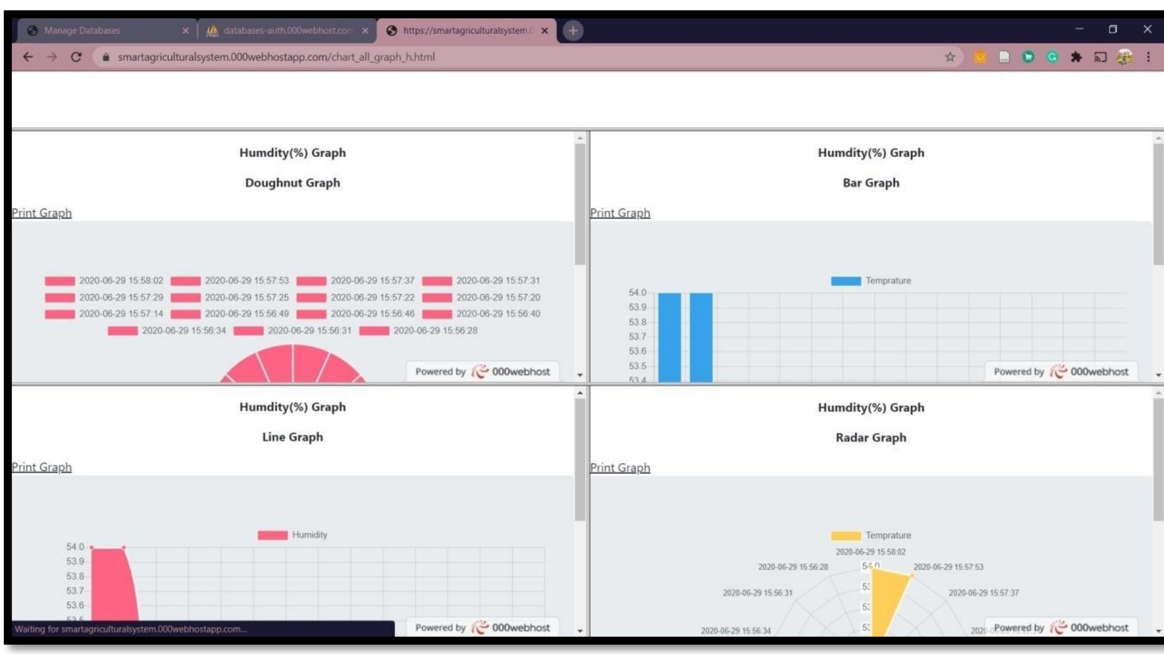


Figure 4.65: Humidity graph on 000webhost.

The stored soil moisture data are represented in table-form.

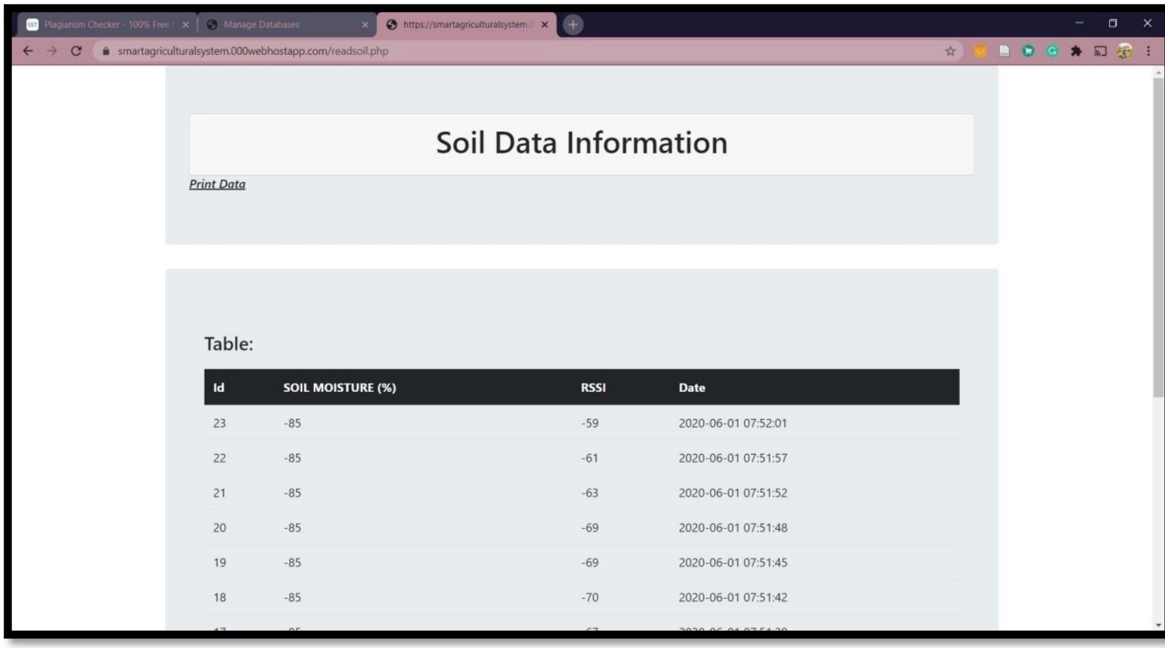


Figure 4.66: Soil data monitoring on 000webhost.

The stored soil moisture and RSSI data are represented in graphical form.

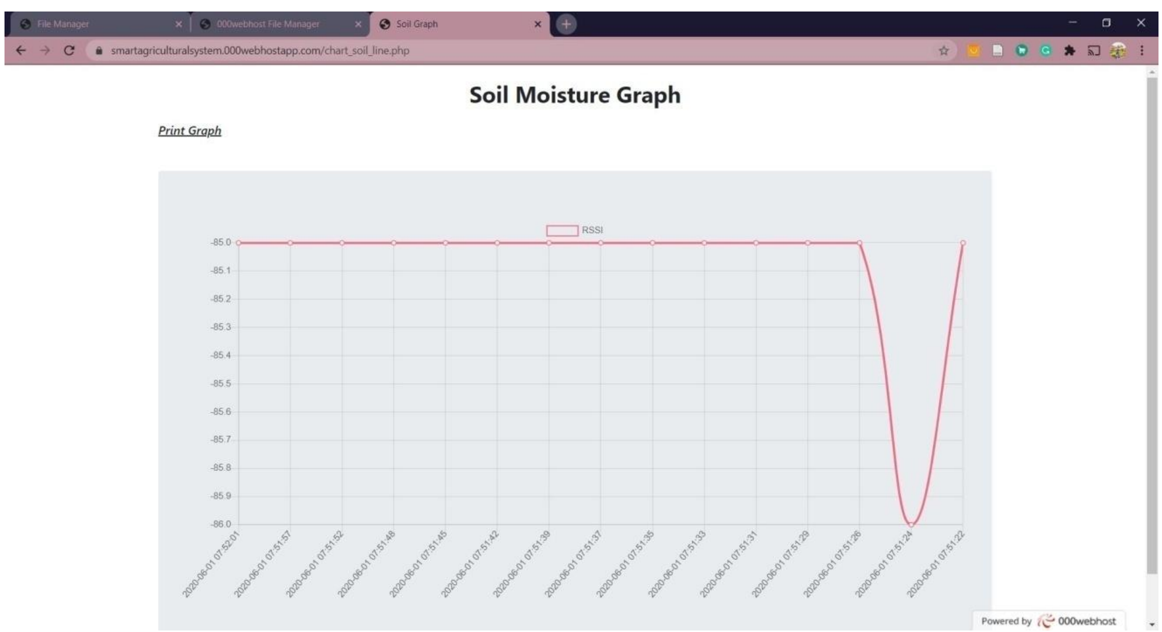


Figure 4.67: Soil Moisture Graph (a) on 000webhost.

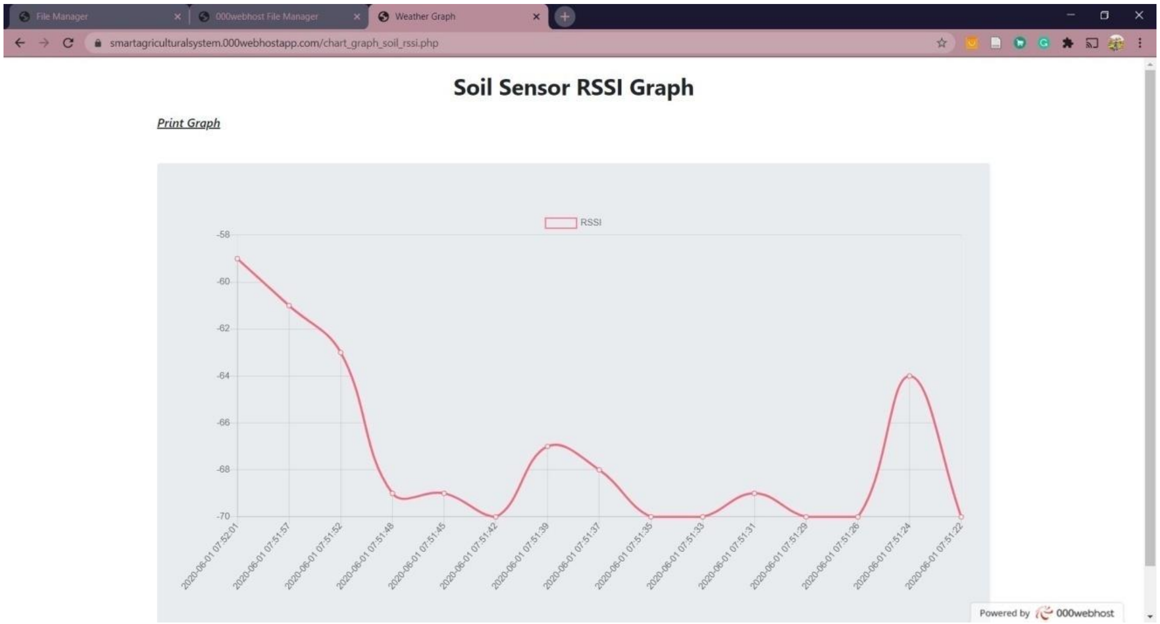


Figure 4.68: Soil RSSI Graph on 000webhost.

Here the soil moisture graph is demonstrated in different graph forms. Using that, farmers can easily monitor and understand field data.

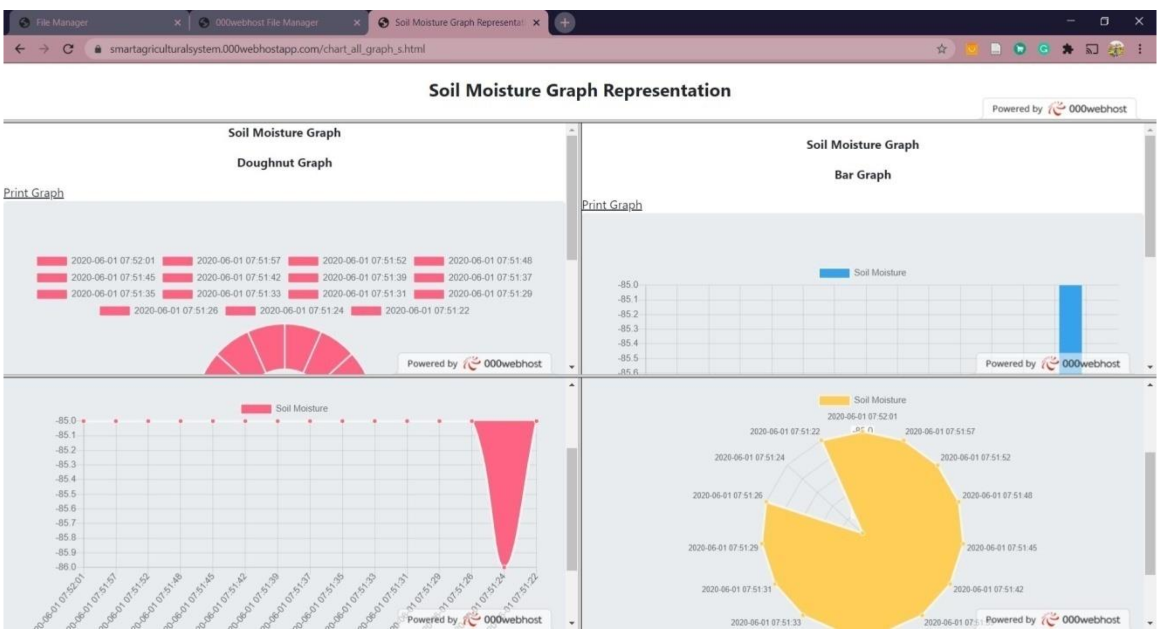


Figure 4.69: Soil Moisture Graph (b) on 000webhost.

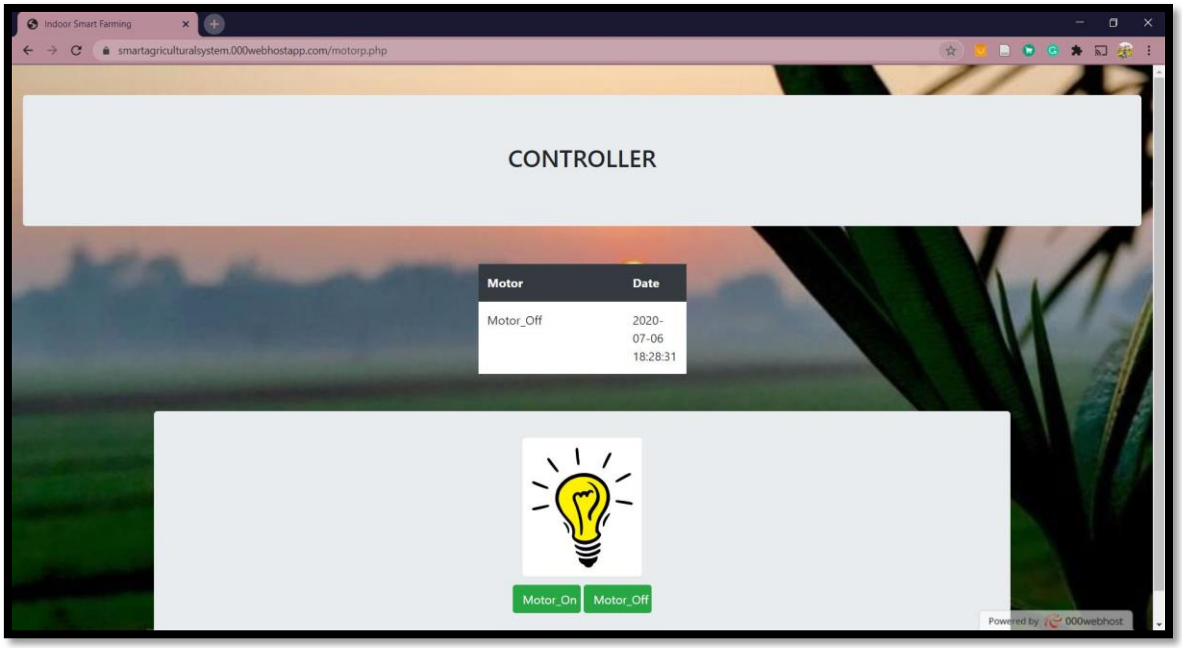


Figure 4.70: Motor Controller on 000webhost.

Chapter-5

Summary

For any farmer, the monitoring of information about soil moisture, temperature, and humidity is very essential for producing superior yield and controlling various components like motor (LED), etc. For that purpose wireless technology is a must. There is much wireless technology available in the market right now, but apart from them, LoRa technology is very suitable in the agriculture sector because it does not require internet connection moreover it operated at a greater distance.

To be used this technology one can place the transmitter at the different places in the field whereas the data generated by them are collected with the help of the receiver.

Now farmers can observe this collected data through the website as well as Android application.

References

[1] "Arduino LoRa Tutorial: Interfacing SX1278 (Ra-02) LoRa Module with Arduino." https://circuitdigest.com/microcontroller-projects/arduino-lora-sx1278-interfacing-tutorial (accessed Nov. 27, 2019).
[2] "Certification | LoRa Alliance®." https://lora-alliance.org/lorawan-certification (accessed Jul. 20, 2020).
[3] "lora comparison - Google Search." https://www.google.com/search?q=lora+comparison&sxsrf=ACYBGNRa9EsJ4w1grb5vRir4gcJdPWDABQ:1574843836978&source=lnms&tbm=isch&sa=X&ved=2ahUKEwi6-Oq7_onmAhXw7HMBHQwFBN8Q_AUoAXoECA4QAw&biw=1536&bih=792#imgrc=tC4H5lVJnlB50M: (accessed Nov. 27, 2019).
[4] Santoshkumar and Udaykumar R.Y, "Development of WSN system for precision agriculture," in *2015 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS)*, Mar. 2015, pp. 1–5, doi: 10.1109/ICIIECS.2015.7192904.
[5] M. Dholu and K. A. Ghodinde, "Internet of Things (IoT) for Precision Agriculture Application," in *2018 2nd International Conference on Trends in Electronics and Informatics (ICOEI)*, May 2018, pp. 339–342, doi: 10.1109/ICOEI.2018.8553720.
[6] D. Davcev, K. Mitreski, S. Trajkovic, V. Nikolovski, and N. Koteli, "IoT agriculture system based on LoRaWAN," in *2018 14th IEEE International Workshop on Factory Communication Systems (WFCS)*, Jun. 2018, pp. 1–4, doi: 10.1109/WFCS.2018.8402368.
[7] Y. Kim, R. G. Evans, and W. M. Iversen, "Remote Sensing and Control of an Irrigation System Using a Distributed Wireless Sensor Network," *IEEE Trans. Instrum. Meas.*, vol. 57, no. 7, pp. 1379–1387, Jul. 2008, doi: 10.1109/TIM.2008.917198.
[8] A. Hanggoro, M. A. Putra, R. Reynaldo, and R. F. Sari, "Green house monitoring and controlling using Android mobile application," in *2013 International Conference on QiR*, Jun. 2013, pp. 79–85, doi: 10.1109/QiR.2013.6632541.
[9] P. Gangurde and M. Bhende, "A Novel Approach for Precision Agriculture Using Wireless Sensor Network," p. 8, 2015.
[10] D. I. Săcăleanu, R. Popescu, I. P. Manciu, and L. A. Perişoară, "Data Compression in Wireless Sensor Nodes with LoRa," in *2018 10th International Conference on Electronics, Computers and Artificial Intelligence (ECAI)*, Jun. 2018, pp. 1–4, doi: 10.1109/ECAI.2018.8679003.
[11] R. N. Rao and B. Sridhar, "IoT based smart crop-field monitoring and automation irrigation system," in *2018 2nd International Conference on Inventive Systems and Control (ICISC)*, Jan. 2018, pp. 478–483, doi: 10.1109/ICISC.2018.8399118.
[12] G. Sushanth and S. Sujatha, "IOT Based Smart Agriculture System," in *2018 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET)*, Mar. 2018, pp. 1–4, doi: 10.1109/WiSPNET.2018.8538702.
[13] M. AshifuddinMondal and Z. Rehena, "IoT Based Intelligent Agriculture Field Monitoring System," in *2018 8th International Conference on Cloud Computing, Data Science Engineering (Confluence)*, Jan. 2018, pp. 625–629, doi: 10.1109/CONFLUENCE.2018.8442535.
[14] "Arduino - Introduction." https://www.arduino.cc/en/guide/introduction (accessed Jun. 27, 2020).
[15] "Arduino Uno," *Wikipedia*. Jun. 04, 2020, Accessed: Jun. 27, 2020. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Arduino_Uno&oldid=960701078.
[16] "arduino image - Google Search." https://www.google.com/search?q=arduino+image&sxsrf=ACYBGNTVJptchmLm4c8MgRrl

-O6CrZYs0A:1574842640177&source=lnms&tbm=isch&sa=X&ved=2ahUKEwju55OB-onmAhXIILcAHWeWBk8Q_AUoAXoECA4QAw&biw=1536&bih=792 (accessed Nov. 27, 2019).
[17] "what is lora ra02 - Google Search." https://www.google.com/search?sxsrf=ACYBGNSng9ehKhSaZv-jXEpYGhX2P48onQ%3A1574842939925&ei=OzLeXcSEOPLZz7sPlYOVkA8&q=what+is+lora+ra02&oq=what+is+lora+ra02&gs_l=psy-ab.3...3384.5128..5754...0.2..0.405.1864.0j5j2j0j1......0....1..gws-wiz.......0i71j35i304i39j0i13j0i13i30.DvoZPi3kvrU&ved=0ahUKEwiEjouQ-4nmAhXy7HMBHZVBBfIQ4dUDCAs&uact=5 (accessed Nov. 27, 2019).
[18] "nodemcu board - Google Search." https://www.google.com/search?q=nodemcu+board&sxsrf=ALeKk03_w5ZTkFaXIzlpgZQB3CDI7z5wIA:1593215478375&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiNk46V1qDqAhXFlOYKHV9OBC4Q_AUoAXoECBkQAw&biw=1536&bih=754#imgrc=Jm9WX4lV4msaDM (accessed Jun. 27, 2020).
[19] "dht sensor - Google Search." https://www.google.com/search?q=dht+sensor&oq=dht&aqs=chrome.1.69i57j69i59l2j69i60l3.2048j0j7&sourceid=chrome&ie=UTF-8 (accessed Nov. 27, 2019).
[20] "moisture sensor image - Google Search." https://www.google.com/search?biw=1536&bih=792&tbm=isch&sxsrf=ACYBGNQ07RlkIa5hdhunjVpBuGnygxSl_Q%3A1574843238923&sa=1&ei=ZjPeXc3wN-bYz7sP1cqIyAc&q=moisture+sensor+image&oq=moisture+sensor+image&gs_l=img.3..0j0i5i30.11209.15152..15334...2.0..0.308.3277.0j6j8j1......0....1..gws-wiz-img.......35i39j0i7i30j0i24j0i8i30.WL6rmVjvJds&ved=0ahUKEwjNu9Se_InmAhVm7HMBHVUlAnkQ4dUDCAc&uact=5#imgrc=pqWVRFyp5lCIGM: (accessed Nov. 27, 2019).
[21] "LoRa — A survey of recent research trends - IEEE Conference Publication." https://ieeexplore.ieee.org/document/8400161 (accessed Jan. 09, 2020).
[22] "What is LoRa? | Semtech LoRa Technology | Semtech." https://www.semtech.com/lora/what-is-lora (accessed Jan. 09, 2020).
[23] "PHP Introduction." https://www.w3schools.com/php/php_intro.asp (accessed Jun. 28, 2020).
[24] "XAMPP," *Wikipedia*. Jun. 26, 2020, Accessed: Jun. 28, 2020. [Online]. Available: https://en.wikipedia.org/w/index.php?title=XAMPP&oldid=964658334.
[25] "XAMPP Installers and Downloads for Apache Friends." https://www.apachefriends.org/index.html (accessed Feb. 19, 2020).
[26] "Arduino - Environment." https://www.arduino.cc/en/guide/environment (accessed Jun. 28, 2020).
[27] S. Mistry, *sandeepmistry/arduino-LoRa*. 2020.
[28] "Installing ESP8266 in Arduino IDE (Windows, Mac OS X, Linux)," *Random Nerd Tutorials*, Jul. 05, 2019. https://randomnerdtutorials.com/how-to-install-esp8266-board-arduino-ide/ (accessed Jun. 28, 2020).
[29] "LoRa SX1278 & ESP8266 Transmitter Receiver with DHT11 Sensor," *How To Electronics*, Feb. 15, 2020. https://how2electronics.com/lora-sx1278-esp8266-transmitter-receiver/ (accessed Jun. 28, 2020).
[30] "bluetooth range - Google Search." https://www.google.com/search?q=bluetooth+range&oq=bluet&aqs=chrome.0.69i59j69i57.1537j0j7&sourceid=chrome&ie=UTF-8 (accessed Jun. 29, 2020).
[31] "wifi range - Google Search." https://www.google.com/search?sxsrf=ALeKk01klBnzqAvOJkNW-XUl5DnNn1bllw%3A1593385191134&ei=5yD5XuXhB9jE4-EPm7yWyAk&q=wifi+range&oq=wifi+range&gs_lcp=CgZwc3ktYWIQAzIFCAAQkQIyC

ggAELEDEBQQhwIyAggAMgIIADICCAAyAggAMgIIADICCAAyAggAMgIIADoECAAQRzoECAAQDVDFLljVUmDJW2gAcAN4AIAB2guIAbgPkgEJMC4xLjEuNy0xmAEAoAEBqgEHZ3dzLXdpeg&sclient=psy-ab&ved=0ahUKEwil8bqyzqXqAhVY4jgGHRueBZkQ4dUDCAw&uact=5 (accessed Jun. 29, 2020).

[32] "zigbee range - Google Search." https://www.google.com/search?q=zigbee+range&oq=zigbee+range&aqs=chrome..69i57.4280j0j7&sourceid=chrome&ie=UTF-8 (accessed Jun. 29, 2020).

[33] "Free Web Hosting with PHP, MySQL and cPanel, No Ads." https://in.000webhost.com/ (accessed Nov. 27, 2019).

APPENDIX A

Abbreviation Notation

Table 3 Abbreviation Notation

WSN	Wireless sensor network
LoRa	Long Range
BLE	Bluetooth Low Energy
IOT	Internet Of Things
RF	Radio Frequency
Tx	Transmitter
Rx	Receiver

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W	URL: https://en.wikipedia.org/w/index.php?title=XAMPP&oldid=964658334. Fetched: 7/21/2020 6:56:00 AM	2
W	URL: https://www.arduino.cc/en/guide/environment Fetched: 7/21/2020 6:56:00 AM	3
W	URL: https://iotdesignpro.com/projects/lora-communication-between-two-arduino-using-LoR ... Fetched: 11/1/2019 12:50:33 PM	1
W	URL: https://www.hackster.io/334313/lora-ra-02-receiver-using-nodemcu-display-on-app-c0a1fc Fetched: 7/21/2020 6:56:00 AM	1
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