Smart Irrigation Control System For Bangladesh Rice Research Institute

By

Md. Imdadul Huq, ID: 011 141 112
Nabil Ahmed Haque, ID: 011 151 228
Md. Ashraful Alam, ID: 011 151 196
A.S.M Asif Ul Hasan, ID: 011 151 205
Sadia Afrin Nova, ID: 011 151 248
Ruhina Akter, ID: 011 152 073

Submitted in partial fulfilment of the requirements
of the degree of Bachelor of Science in Computer Science and Engineering

Thursday 10th October, 2019

Department of Computer Science and Engineering
United International University

Abstract

Bangladesh is an agriculture-dependent country. The total area of the country is 14.86 million hectares, whereas the cultivable land area is 8.52 million ha. 19.6% of the countries GDP comes from agriculture. In Bangladesh more than 156 million people consume rice. Irrigation is a big concern while producing rice. This project is a task given by the Water Management and Irrigation Division of Bangladesh Rice Research Institute. In this project, we are using Alternate Wetting and Drying (AWD) technology to irrigate the rice field. We are automating the conventional AWD technology that will be used during irrigation for boro rice. Boro usually grows in the winter season. Every rice has three-part in its life cycle. Irrigation for boro rice is very crucial, especially during its vegetative part of life. We are making an Arduino based water measurement device. This device will help the farmer to monitor the current water level of the rice field. Based on water level irrigation will be provided. We are also using NodeMCU to process the field data and store it on both local and cloud servers. We also made a web application for visualizing the data and a mobile application that can help the farmer keep informed about the field remotely. We are using a sonar sensor for measuring the water level and RF module for communication between the field monitoring device and the base station.

Acknowledgements

This work would have not been possible without the input and support of many people over the last two trimesters. We would like to express my gratitude to everyone who contributed to it in some way or other.

First, we would like to thank my academic advisors, Mohammad Mamun Elahi, Assistant Professor, Department of CSE.

Our sincere gratitude goes to our co-supervisor Dr. Md. Towfiqul Islam, Chief Scientist Officer and Head of Irrigation and Water Management Division, Bangladesh Rice Research Institute.

We are also thankful to Abu Shafin Mohammad Mahdee Jameel, Assistant Professor, Department of CSE. Dr. Debjit Roy, Senior Scientist, Irrigation and Water Management Division, Bangladesh Rice Research Institute. Azim Uddin Chowdhury, Instructor, Cisco Networking Academy.

Last but not the least, We owe to our family including our parents for their unconditional love and immense emotional support.

Publication List

[Optional] The main contributions of this research are either published or accepted or in preparation in journals and conferences as mentioned in the following list:

Journal Articles

1.

Conference Papers

1.

Additional Publications

Following is the list of relevant publications published in the course of the research that is not included in the thesis:

1.

Table of Contents

List of Figures

List of Tables

Chapter 1

Introduction

This chapter will focus on the detailed explanation of the AWD technology. The motivation behind our project and the objectives and outcome we want to achieve from our project.

1.1 Project Overview

Irrigation is a significant factor for rice cultivation. In the Asian region, rice needs up to 1500mm water for each cropping season based on soil condition [2]. AWD reduces the extreme use of ground water in irrigation up to 80% [3],[2]. Growing 1 Kg of rice cost about 2500-3000 litres of water [4],[5]. There are several different ways to irrigate rice (i) Continuous Standing, (ii) AWD, (iii) Soil amelioration, (iv) reducing turn-around time and direct seeding, (v) saturated soil culture, (vi) use of aerobic rice [5]

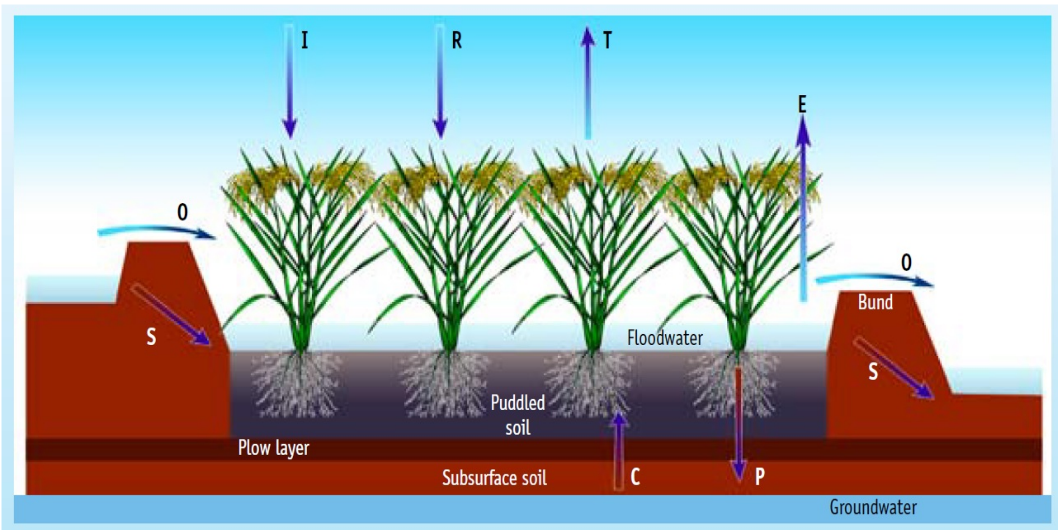


Figure 1.1: WATER Balance of a puddled rice field: C = capillary rise; E= evaporation; I = irrigation; O = over-bund flow; p = percolation; R = rainfall; S = seepage, T = transpiration [1]

Cost Items	Kustia		Rangpur		Feni	
	AWD	Conven.	AWD	Conven.	AWD	Conven
Seed and Seedbed	3336	3455	3102	2770	3115	3084
Land Preparation	4930	5125	5052	4378	7945	7832
Pre-Harvest labour cost	11670	10950	10746	10019	17731	16621
Fertilizer	9758	7800	6025	5073	8423	6330
Manure	12225	1280	525	765	512	686
Irrigation	12338	14059	6572	7792	6774	6774
Herbicide	343	543	415	245	-	-
Insecticide	615	889	844	270	950	1086
Post har. labour cost	10416	10208	7171	7200	12325	12325
Total Var. cost	55769	55440	41295	39924	58979	55881
Rental val. of land	18302	18302	20916	20916	18216	18216
Total cost of production	74071	73742	62211	60840	77195	74097
Yield (t/ha)	5.63	5.25	5.65	5.36	5.57	5.48
Gross Return	112028	100723	105162	104917	104912	98992
Paddy	102748	91875	101789	101402	101652	95900
Straw	9280	8848	3373	3515	3260	3092
Unit cost of production	13.16	14.05	11.01	11.35	13.86	13.52

Table 1.1: Comparative cost and return (Tk/ha) for BORO production under AWD and conventional irrigation method [2]

Rice is a water-intensive crop. Rice plant uses water in 3 ways (i) transpiration, (ii) evaporation, (iii) seepage and percolation [1]. Rice has three stages in its life cycle. They are Vegetative, Reproductive and Ripening respectively. Irrigation is mainly necessary during the vegetative period of life.

Bangladesh in an agriculture-dependent country. More than 54% of our population is actively or passively working in the agricultural sector, which measures 89% of the cultivable lands [6]. Continuous standing water is the conventional irrigation system for rice. Such irrigation system uses more water than needed. Alternate Wetting and Drying (AWD) is a technique which prevents excessive use of water and fuel cost of irrigation [3].

The research is conduct by a researcher in central parts of our country using AWD technology to find out the outcome of this technology. The research was conduct on BORO rice. BORO is dry season rice. During the winter season, the lack of rain affects the cultivation of BORO. Irrigation is a must in this situation. BORO grows in 4.6 million hectares of land, also shares 56% of total rice production [3]. Though the result shows no significant yielding; however, it shows 28% water saving through AWD technology.

Items	Kustia		Rangpur		Feni	
	AWD	Conven.	AWD	Conven.	AWD	Conven
No. of Irrigation	10(33)	15	9	12(33)	7(30)	10
Diesel req(Lit/ha)	99	148	89	119	-	-
Diesel Cost(Tk/ha)	4158(33)	6216	3582(25)	4790	-	-
Machine rent(Tk/ha)	8180	7843	2990	3002	-	-
Total Cost(Tk/ha)	1338	14059	6572	7792	6774	6774

Table 1.2: Difference in Irrigation between AWD and Conventional method [2]

1.2 Motivation

The data from the researcher of the Bangladesh Rice Research Institute, indicates that not all the rice need an enormous amount of water to grow. After doing long time research, they found out that 15cm available water in the soil is good enough for rice cultivation. Conventional irrigation system uses so much water for irrigation that leads to wastage of water or potentially harms the plant by giving more water than needed. There is no system to monitor the overuse of water at all. This type of irrigation system also uses a tremendous amount of electricity and fuel which leads to environmental degradation in the long run.

Our motivation is to introduce a irrigation method that will change the conventional irrigation process. There will be less human interaction needed for the irrigation purpose. The system will monitor the whole irrigation process by itself and act according to the condition of the rice field.

1.3 Objectives

The primary objective of our project is to automate the conventional AWD technology. Researchers are currently using the manual version of this technology. Our objective is to make it efficient by using proper technologies. We are hoping this project will increase the interest of using AWD among farmers in our country. The following table shows the difference between the conventional irrigation and the proposed smart irrigation system.

Functionality	Conventional Irrigation	Smart Irrigation (AWD)
Implementation Method	Manual	Smart device
Farmers Involvement	Manual	Digital
Monitor Water Level	Measure by hand	Digital reading system
Irrigation Method	Manual	Automatic
Field Coverage	1 Field	Multiple Fields (up to 1000)
Crop yield outcome	similar	Similar
Water Usage	1500 mm	35% less than conventional
Electricity Usage	As usual rate	20% less than conventional
Fuel Usage	As usual rate	25% less than conventional
Web Application	No	Yes
Mobile Application	No	Yes
Remote Monitoring	No	Yes
Data Monitoring	No	Yes

Table 1.3: Comparison between Conventional Irrigation and Smart Irrigation System

1.4 Methodology

The first step to solve any problem is to find out the possible path that leads to our goal. After successful meeting with the Head and assistant scientists of Irrigation and Water Management Division of Bangladesh Rice Research Institute we learned a lot about the AWD technology. They gave us first hand experience about the AWD technology. How they are using it now and many more. The first hand experience helps us formulate our plan to approach the problem. Based on the explanation and detailed information gathered from Bangladesh Rice Research Institute, as well as extensive study on paper based on AWD technology we formulate our idea to approach the problem.

To reduce the workload our whole team is divided into three small teams namely (i) Measurement Team, (ii) Communication Team, (iii) Simulation Team. Each of these three team serves a different purpose of the project.

1.4.1 Measurement Team

The main target of this team is to make a device prototype that will measure the distance of water from the sensor. This team ensures the accuracy of the distance measurement. Though according to researchers a few centimeter here and there will not impact the outcome at all, still we are trying to avoid that situation from the beginning.

1.4.2 Communication Team

Communication team is working on sending the measurement data to the base station using the RF module. At the very beginning, they create a pair of a prototype of the communication device. The measurement team shares its part with the communication team then they finally implement the program and check whether the information is transferring to the base station properly.

1.4.3 Simulation Team

Simulation team is working on making a virtual prototype of the project. They are testing both measurement and communication part using simulation software “Proteus.”

1.5 Project Outcome

The main purpose of this project is to

- Automate the manual AWD technology.
- Make a smart irrigation system.
- Introduce new farming technology.
- Save valuable resources such as water, fuel, electricity.
- Improve farmers lifestyle.
- Reduce cost of rice cultivation and maximize profit margin.

1.6 Organization of the Report

The Project is divided into 6 chapter that shows all the aspects of the project.

- **Chapter 1:** This chapter explains broadly the technology we are using,our motivation, method we used and outcome we want to achieve.
- **Chapter 2:** This chapter focus on the previous work done by others using the same technology.
- **Chapter 3:** This chapter is all about the system requirements. Functional, non functional requirements, design diagram and hardware specification.
- **Chapter 4:** This chapter focus on the implementation of different version of our prototype and the results we achieved from it.
- **Chapter 5:** Standards and design constrains of our project.
- **Chapter 6:** Chapter includes summary of our project as well as limitation and future works.

1.7 Summary

We learn about the alternate wetting and drying technology and it motivates us to find the objectives we want to achieve.

Chapter 2

Background

The following chapter will focus on the previous work done by others that were similar to our project. How their research helps us understand our project better and leads us to find a better solution then the existing one.

2.1 Preliminaries

Water, one of the critical element of environment human, depends on a large scale. Water is a crucial element of rice irrigation in our country. A significant amount of groundwater is used every year for irrigating rice. Few technologies are introduced that can mitigate the excessive use of water. AWD is one such technology that will reduce the overuse of groundwater for irrigation from 20% to 40% [3],[2],[5],[7]. Why is water saving so substantial? This question can be answered using the one-word "Sustainability." Sustainability is a complex relationship between human and environmental elements. Since water is an environmental element, we have to make sure when we are using it for humankind; we are not using it at an excessive level that it can harm the ecosystem [8].

2.2 Literature Review

A field study has been conducted in the Philippines to ensure the significance of AWD technology introduced by the International Rice Research Institute. In a paper, the rice researchers express that despite the unchanged yielding result, AWD does save up to 40% in irrigation [5] [3]. Researchers do a few field study to find out the outcome of AWD by implementing this technology in different regions such as Kustia, Rangpur, and Feni in our country [3]. Though the result does not show significant yielding of rice production, there is a significant result in saving water. According to the test result, they claimed this technology could save groundwater up to 35% [3],[7]. Researchers also predict that by the time 2025, more than 15-20 million hectares of irrigated rice field in Asia will suffer water scarcity [7][4].

Research also shows that up to 4500 BDT is achievable by using AWD technology [3].

The main focus of AWD is not increasing the yield of rice. Instead, the proper use of water is ensured. This also leads to other environmental factors such as the greenhouse gas effect and use of fossil fuel for irrigation.Burning fuel can emit deadly greenhouse gas that can increase the temperature.

We also studied Arduino based papers for a better understanding of the hardware. In this project, They divided the whole system into two parts. First the transmitter, second the receiver. The information about the soil condition was collected using soil moisture, temperature, humidity sensor. Then using the micro-controller the analog data that was provided by the sensor was converted into digital data using an algorithm. They are monitoring the data via MATLAB in PC that was transmitted using the RF module [9].

According to this project, They develop the system in 2 parts system hardware and system software. They used pH, Humidity and Temperature sensor for their project. They provided a predefined data set for the system. At the time of reading the data from the sensor if the data received through the sensor does not match the system data, it takes action. This system is using an Arduino UNO as its core processing power. Arduino received all the data and process it. Base on the process data the decision are taken accordingly. The system also introduced a mobile application. All the related data was sent directly to the smartphone. This application helps the user get real-time feedback of the field immediately [10].

In this project, The team uses Arduino UNO as its core processing hardware. As for the sensor, they used temperature, soil moisture, and humidity sensor. They are using the wireless sensor for monitoring the real-time information of the irrigation system. They are checking whether the soil moisture level is reaching a threshold or not. If the sensor indicates a threshold value, then the system automatically turns ON the motor. There is an android application which also provides a real-time condition of the field on the smartphone along with the current motor status [11].

2.3 Summary

This chapter basically explained the research that were conduct previously by researchers around the world. We study their research and gain knowledge that will help us focus on the solution we want to achieve.

Chapter 3

Project Design

The following chapter will focus on explaining the requirements that we have to fulfill for our project. The road map of our projects such as selecting the right hardware and software application that fits our requirements.

3.1 Requirement Analysis

3.1.1 System Requirement Specification (SRS)

The introduction part provides a overall explanation of the whole project.

3.1.2 Purpose

The primary purpose of this project is to modernize the conventional irrigation system. We are developing Alternate Wetting and Drying (AWD) irrigation system for boro rice. Boro usually grows during the winter season. Irrigation is a crucial part of boro's life-cycle. The main focus of our project will be to irrigate boro throughout its vegetative period.

3.1.3 Scope

Scope of initial release: Our initial release will provide a hardware device that will monitor the field water level. Depending on the water level the device will turn on/off the motor for irrigation purpose. The main obstacle for us is to stabilize the device under harsh weather.

Scope of subsequent release: In the future release, we would like to make a smart-phone application to execute all the functionality of the device via the application. If possible, we will also include more modern high technology to enrich our project.

3.1.4 System Overview

The system can be divided into two section.
System Side: This part will monitor all the fields condition and relay the information to the main base station.

User Side: A base station is available for the user to monitor the condition of the fields from one place. If the user do not participate in any action then the base station will automatically take action. Otherwise, the user can take action manually.

3.2 Use Cases

3.2.1 Use case diagram

This is the use case diagram of our project. Use case Diagram

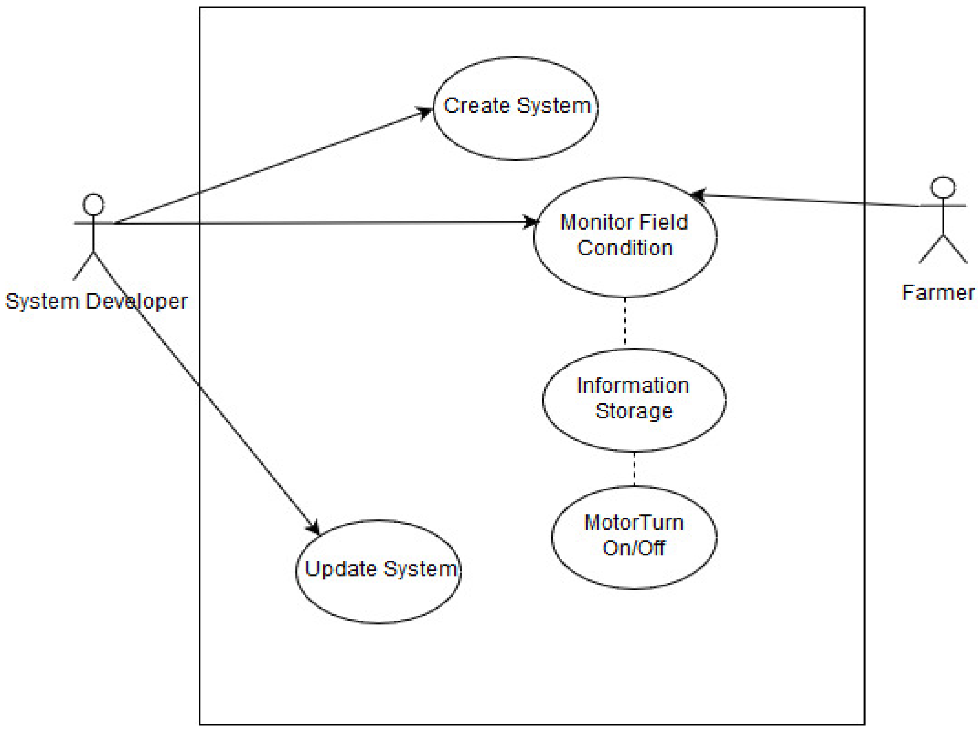


Figure 3.1: Project use case diagram.

3.2.2 Use case diagram description (UC-01)

Name	UC - 01: Create System.
Summery	This is the very initial part of the project. Objective is to create the initial system.
Rationale	The system is a combination of both hardware and software. Here the developer will make a hardware device that will execute the software for the project.
Users	System Developer
Pre-Conditions	The developer have all the proper tools to build the whole Project.
Basic course of events	1. The developer will design the layout of the whole system first. 2. According to the system layout developer will assemble the hardware. 3. The software code will be implemented into the hardware at the very end to complete the project.
Alternative Paths	1. In step 2, some of the hardware might not work properly. We have to make sure that we are working with good hardware. 2. In step 3, the code might not work. We have to tweak here and there with some slight adjustments to make it work properly
Post-Conditions	All the requirements are fulfilled and the project initial hardware device is working properly.

Table 3.1: Use case description table UC-01

3.2.3 Use case diagram description (UC-02)

Name	UC - 02: Monitor Field Condition
Summery	The information collected through the devices will be transfer to the base station and will be monitored there.
Rationale	Collecting the field condition information is the main key point of our project. Using the information collected from the field, the farmer will make decisions and apply them in the fields.
Users	System Developer, Farmer.
Pre-Conditions	All the devices are up and running.
Basic course of events	1. The devices are collecting information from different rice fields. 2. All the information will be shown in the monitor of the base station. 3. If water level in less than 15cm then the motor will automatically turn on until it is back to normal range.
Alternative Paths	1. In step 2, the information might be wrong due to hardware malfunction or environmental condition. 2. In step 3, the sensor might not detect the accurate water level due to environmental condition or physical damage.
Post-Conditions	System is working accordingly and responding against a given condition.

Table 3.2: Use case description table UC-02

3.2.4 Use case diagram description (UC-03)

Name	UC - 03: Update System
Summery	System update will improve the efficiency of the system.
Rationale	In update system we will include all the new features. We will include more functionality to the system according to the BRRI researchers.
Users	System Developer
Pre-Conditions	All the existing program are available. Use a copy of the source code to work on update process.
Basic course of events	1. Configure the hardware device according to update. 2. Complete the new program and implement it into the hardware device. 3. Do some test run to ensure the device is working according to update and working properly.
Alternative Paths	1. In step 2, the program might not work if there is a problem in the code itself. 2. In step 3, the complete device might show false information due to improper implementation.
Post-Conditions	The system is up-to-date and working accordingly.

Table 3.3: Use case description table UC-03

3.2.5 Functional requirement (FR - 01)

Name	FR - 01: Water level reading
Summery	The system will observe and report the water level of various fields.
Rationale	The user will seek current water level of the field and use that data to take action based on the data.
Requirements	1. When the user uses the system, the system must do the following. • It will take the measurement of water level using the sonar sensor • The collected data must be sent over to the base station using the nrf24l01 module. • If the data indicates the need for irrigation, the system will turn on the motor until the requirement is fulfilled.
References	UC – 01: Create system, UC – 02: Monitor field condition

Table 3.4: Functional Requirement table FR - 01

3.2.6 Non - functional requirement (NF - 01)

Name	NF - 01: Performance constraints for measurement reading and data sending.
Summery	The system should give an accurate data reading every time.
Rationale	If the system is not providing an accurate result then it might create a worse situation.
Requirements	While reading and sending information over the wireless module the device must provide an accurate result. The time interval data in also important. Both of this requirements cannot be compromised.
References	UC – 01: Create system, UC – 02: Monitor field condition

Table 3.5: Non Functional Requirement table NF - 01

3.3 Methodology and Design

We already explained the methodology part before. Here we are showing the approach that we will take to solve the problem with visual representation.

3.3.1 Diagrams

The following diagram explains our project. In this diagram, we are taking a conventional approach to tackle the problem at hand. In this case, in the first diagram, we are showing an overall implementation of our device in the rice field. Second Diagram provides an even more clear image of our project.

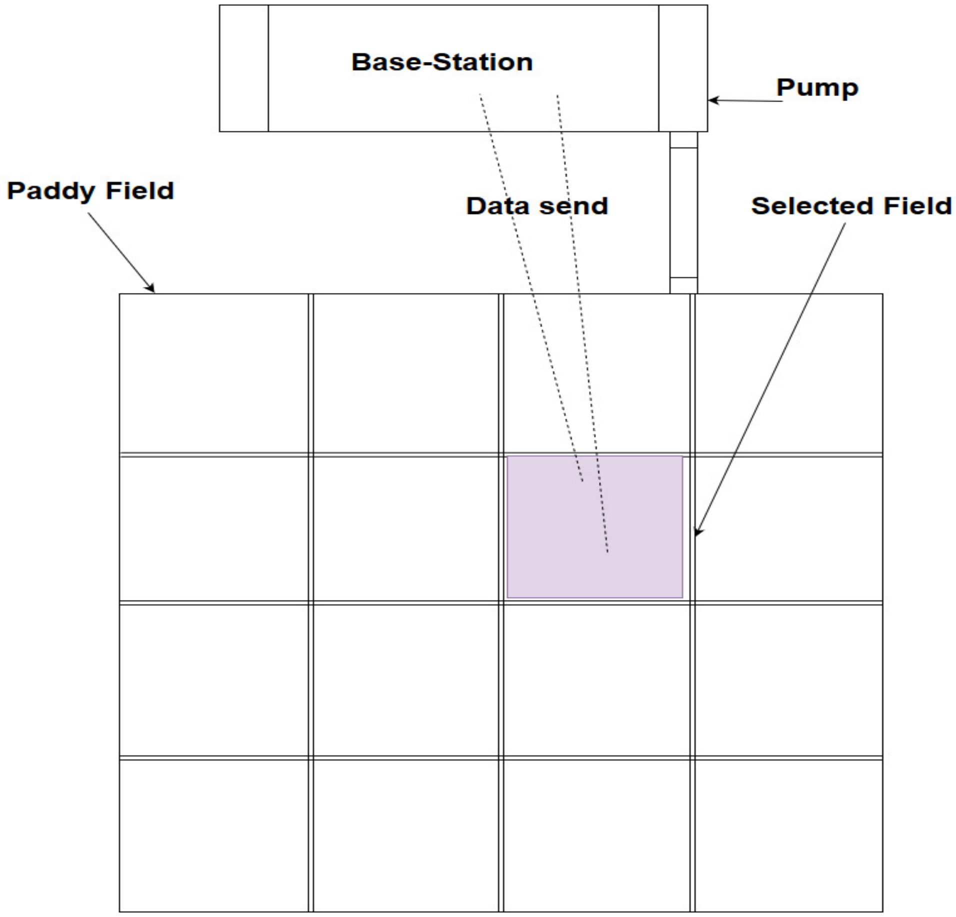


Figure 3.2: Initial Project Layout

In the following diagram, we are showing the irrigation process more precisely. Each field is monitoring the current water level using the device then the information is sent to the base station which has connection establish with the motor. If the condition is triggered, then it will turn on the motor for irrigation. A specific switch gate will open for providing water for a specific field.

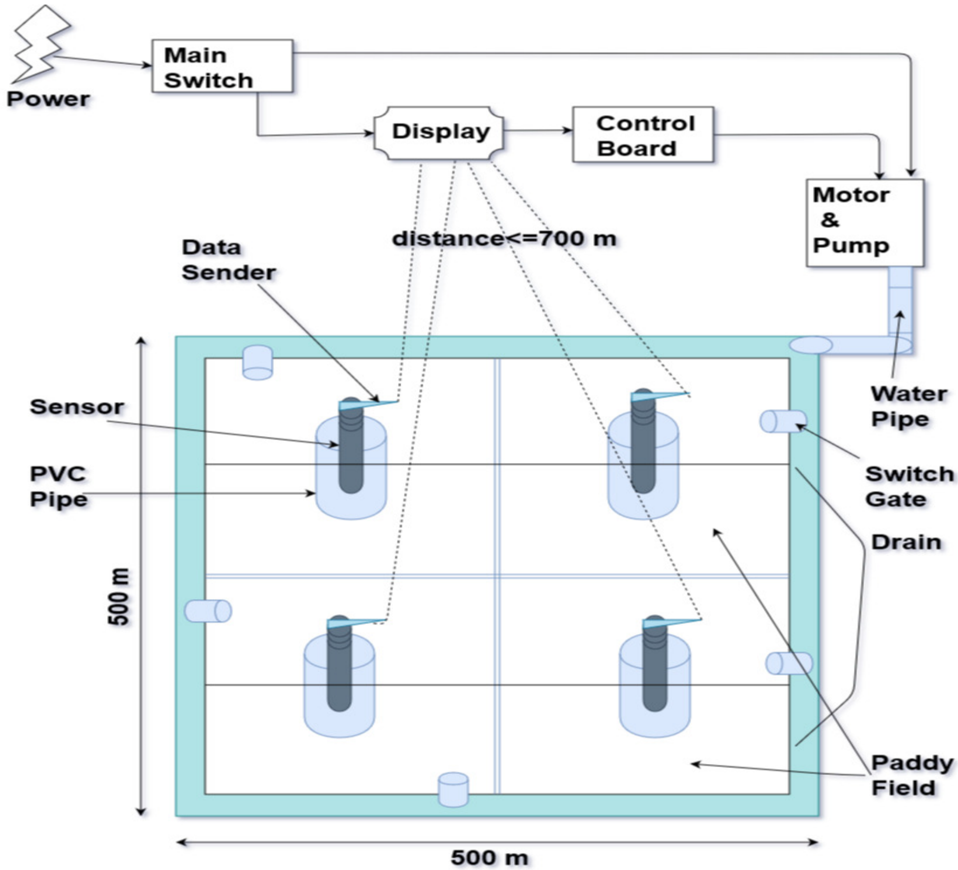


Figure 3.3: Project device working process

The following image is a design model of our project device. The device is a 10cm in diameter and 30 cm long perforated PVC pipe. The device includes an antenna which in our case is the RF module that will transmit the information from the field. A receiver will receive the information at the base station. The water level will be monitor using the ultrasonic sonar sensor HC – SR04. The compact device will be mount at the top of the PVC pipe. The distance threshold between the water and the device itself will be 10cm.

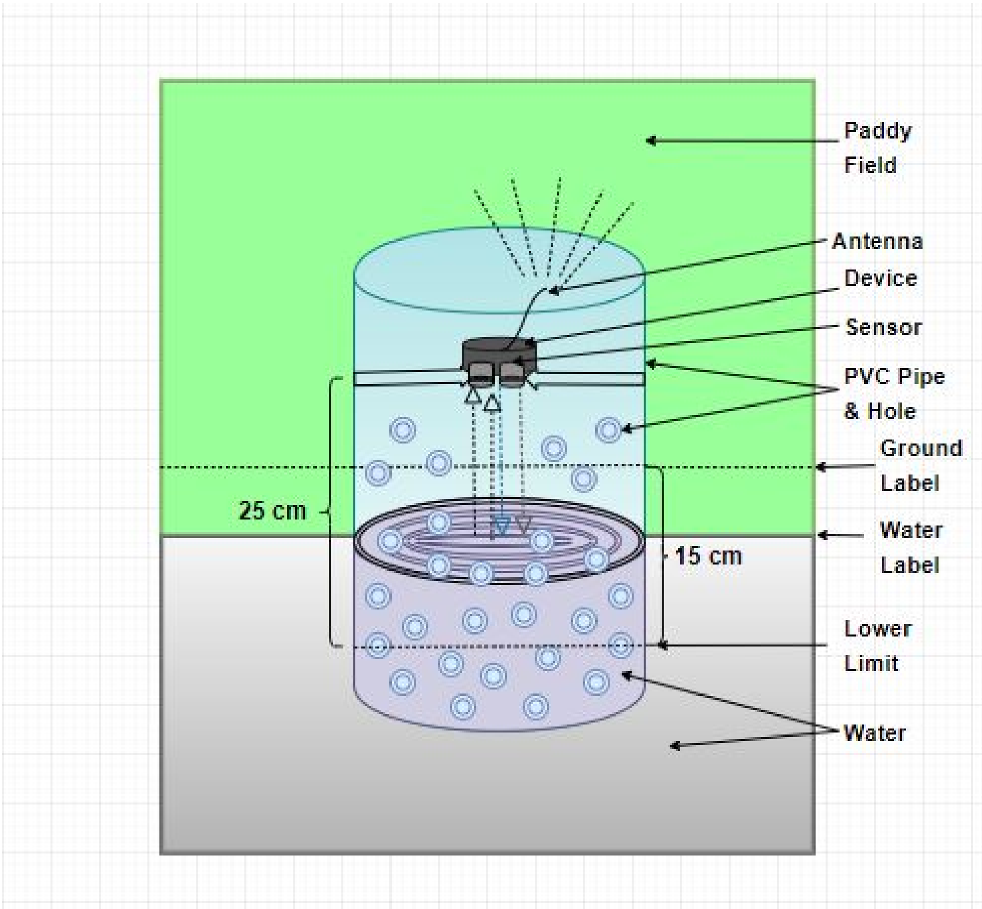


Figure 3.4: Project field monitoring device prototype.

3.3.2 Hardware Specification

Processing Module:

Functionality	Arduino UNO	Raspberry Pi	ATMega30	NodeMCU	Adafruit Metro Mini 328	Arduino Pro Mini
Cheap, Small	Yes, No	No, No	Yes, Yes	Yes, Yes	Yes, Yes	Yes, Yes
Rich Library	Yes	Yes	No	Yes	No	Yes
Programming Capability	Easy	Easy	Not Easy	Easy	Easy	Easy
Power & memory architecture	Low, Low	High, High	Low, Low	Low, Low	Low, Low	Low, Low
Computational Speed	Low	High	Low	Low	Low	Low
Additional parts & Internet access	No, Yes	Yes, Yes	No, No	No, Wireless Module included	No,No	No, FTDI for burning program
Availability	Yes	Yes	No	Yes	Yes	Yes
Price (BDT)	1922	2512	360	500	830	800

Table 3.6: Pros and cons of different processor.

Final Verdict: We are trying to make an affordable and easy to use device for farmers. The program we will run does not require too much computational speed. So, Arduino Pro Mini is a perfect fit for our project since the cost of the whole system is a big concern.

Unfortunately we have to change the processing unit to nodeMCU for our receiver side. Arduino Pro Mini is not capable of handling all the computation and frequently hanging. nodeMCU will be able to handle the load and it will also provide more opportunity. Since we made an web application it will be easy to transfer the data from nodeMCU to localhost for storage purpose easily.

Communication Module:

Functionality	Bluetooth: Ubertooth One	RF Module (nrf24lo1)	WiFi
Data transfer rate	High	Low	High
Communication range (Meters)	100	100	92
Power Consumption	High	Low	High
Data security	Yes, Encryption available	No	Yes, Encryption available
Availability	Yes	Yes	Yes
Price (BDT)	10046	210	920

Table 3.7: Pros and cons of different communication module.

Final Verdict: Most of the communication module are quite expensive. Only RF Module (nrf24l01) fits within our budget. The Distance RF module can cover long enough to fits in our requirements. We choose RF Module as our communication hardware device.

Measurement Module:

Functionality	Bluetooth: Ultrasonic sensor HC-SR04 pro	Liquid Level Sensor	IR Proximity Sensor	Laser VL53L1X
Cheap, small	Yes, Yes	No, Yes	No, Yes	No, Yes
Accuracy	upto 3mm	High accuracy in both liquid & solid level	Better than sonar	Most accurate
Programming capability	Easy	Easy	Easy	Easy
Measurement range	Relatively Lon	Not long	Short	Long
Availability	Yes	Yes	Yes	Yes
Price (BDT)	250	3350	1080	1840

Table 3.8: Pros and cons of different Measurement module.

Final Verdict: We are looking for a device that will be able to measure the distance up to 40cm. Sonar Sensor HC – SR04 is a perfect device for us. Other devices are too much expensive, so using them will no be a viable solution for our project.

3.4 Software Specification

Simulation Software:

Functionality	Proteus	Tinkercad
Application Interface	User Friendly	User Friendly
Experiment Devices	All available	Limited
Online Accessibility	No	Yes
User Experience	Good	Good
Availability	Yes, subscription	Yes, free

Table 3.9: Pros and cons of different simulation software.

Final Verdict: We decided to use Proteus as our simulation software. Proteus is a rich software application that has almost all electrical hardware available. We want to use Tinkercad. Unfortunately, all the necessary hardware for our project are not available in it. So we decided to use Proteus. Since we are using it in some of our previous university course; we are quite familiar with the application.

Programming Software:

Functionality	Arduino IDE	CodeBlocks
Appilacion Interface	User friendly	User friendly
Library	Rich library	Rich library
Programming capability	Easy	Easy
Connection with hardware parts	Yes	No
Availability	Yes	Yes

Table 3.10: Pros and cons of different Programming Software.

Final Verdict: Codeblocks is a great application for C/C++ programming. However, codeblocks does not have any functionality to implement the program directly to a hardware device. In this case, Arduino IDE is a great programming tool for both programming and implementing the program in a hardware device easily. It is easy to create a library file if we want to for any specific hardware tool. So for our project, Arduino IDE is the first choice.

3.5 Project Time-line

Week - 2 Submit project proposal.
Week - 3 Collect related paper/ journal.
Week - 4 Collect hardware from Cisco Networking Academy.
Week - 5 Design a model.
Week - 6 Visiting Bangladesh Rice Research Institute.
Week - 7 Implement hardware and program it.
Week - 8 Test run bugs fixing.
Week - 9 Observer the result for a time period.
Week - 10 Troubleshoot and Simulate the project again.
Week - 11 Test data transmission rate and distance coverage.
Week - 12 Finish prototype.

3.6 Work Distribution

Responsibility	Imdadul	Nabil	Ashraful	Asif	Nova	Ruhina
Report Writing (Latex)	✓					
Report information collection	✓	✓	✓	✓	✓	✓
Collect paper,report,journal	✓	✓	✓	✓	✓	✓
Prepare Presentation Slide.	✓	✓	✓	✓	✓	✓
Prototype Design and testing	✓	✓	✓			
Diagram Design	✓		✓			
PCB Design	✓					
Video Editing and uploading	✓			✓		
Record Project Video.	✓	✓	✓	✓	✓	✓
Cloud & Web Application	✓	✓				
Troubleshooting & Simulation	✓	✓	✓			

Table 3.11: Work distribution table

3.7 Summary

We decide to select the best hardware and software tools for our project. Making decision on how to use them and divide the workload on our team mates equally.

Chapter 4

Implementation and Results

The following chapter holds the information about our implementation strategy and problem that we faced during our testing. The detailed explanation of how we manage to solve each problem is available as well.

4.1 Environment Setup

4.1.1 Transmitter Side Circuit Diagram V1.0

This is the transmitter side V1.0. It will send information to the receiver.

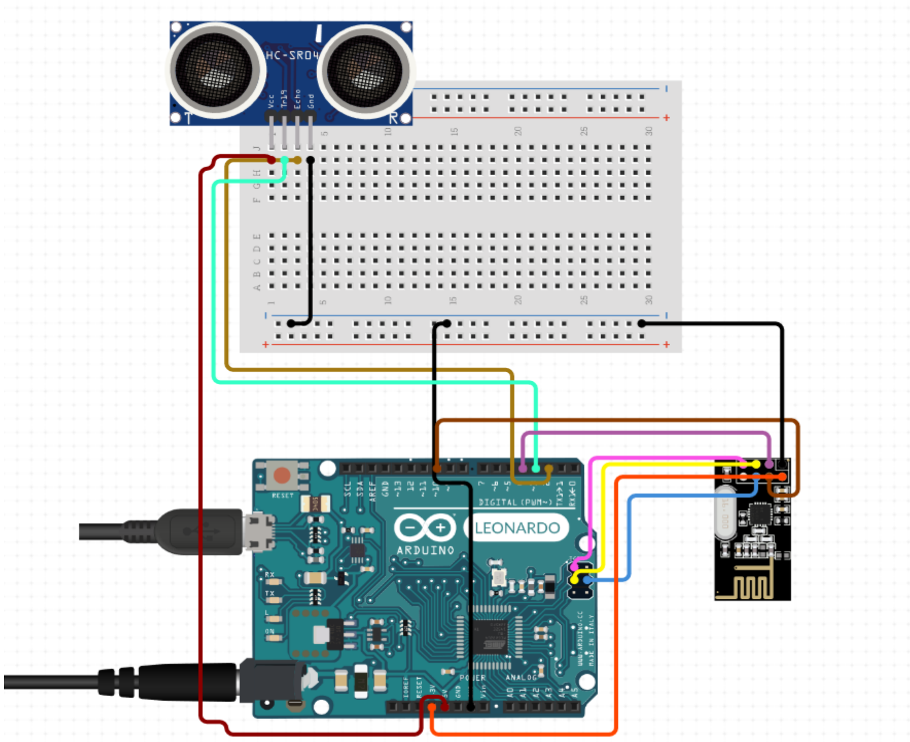


Figure 4.1: Transmitter Device V1.0.

4.1.2 Receiver Side Circuit Diagram V1.0

This is the receiver side of our project. This device will be implement on the base station to receive the information of individual field condition and will be shown in a display.

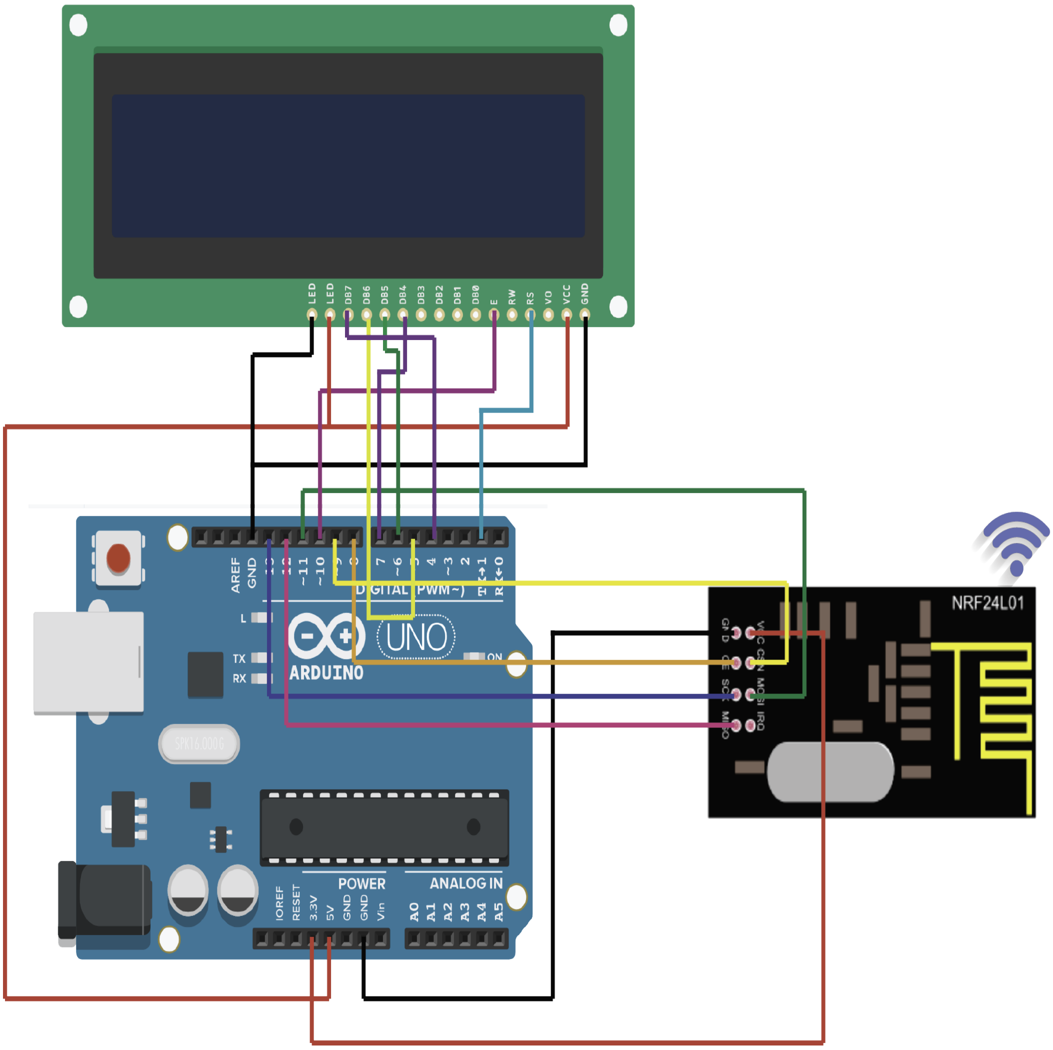


Figure 4.2: Receiver Device V1.0.

4.1.3 Prototype V1.0 implementation of our project

This is the prototype version 1.0 of our project. This is what we did so far last semester.

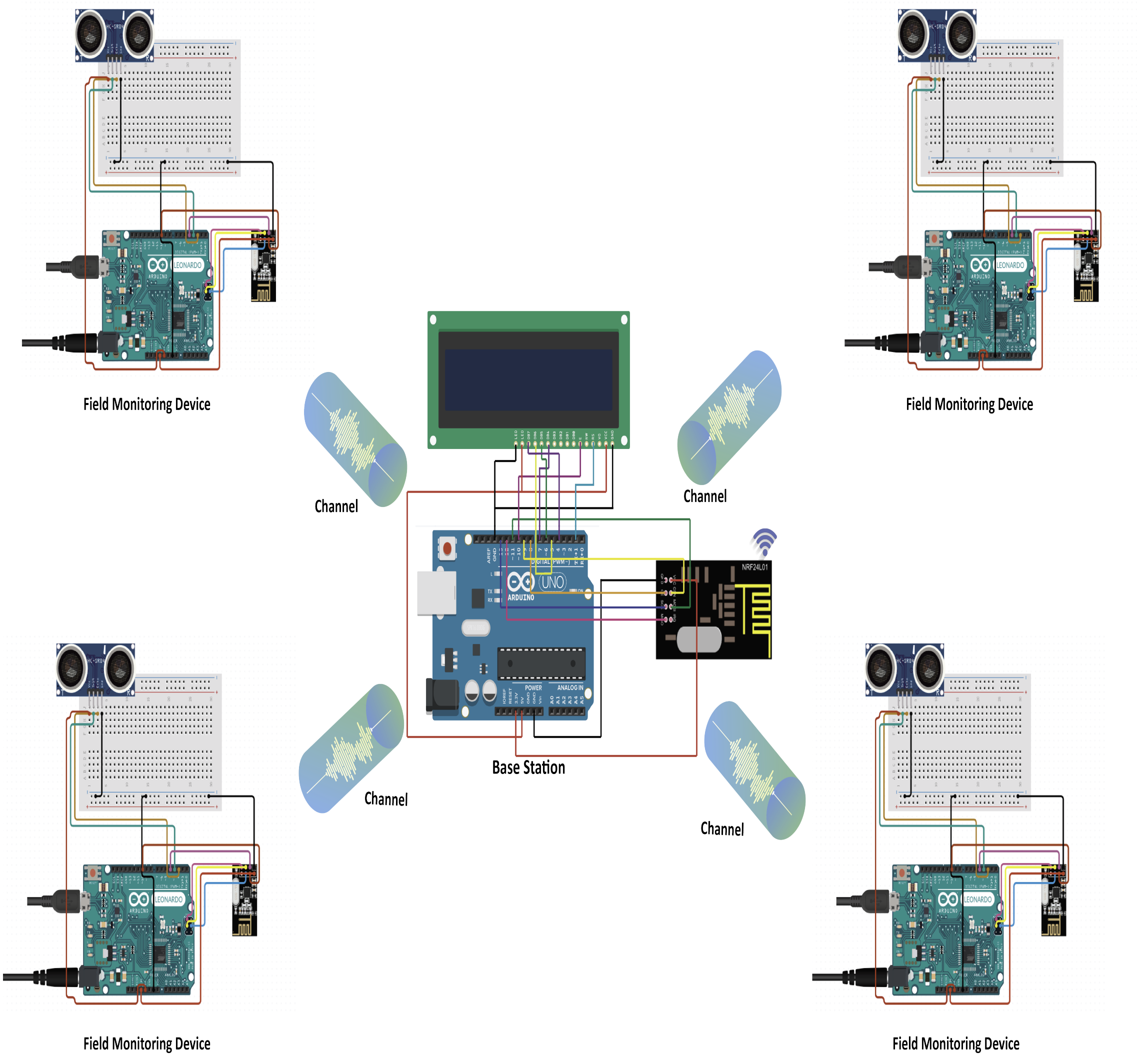


Figure 4.3: Our project prototype V1.0.

4.1.4 Transmitter Side Circuit Diagram V2.0

Transmitter Side V2.0 using Arduino Pro Mini.

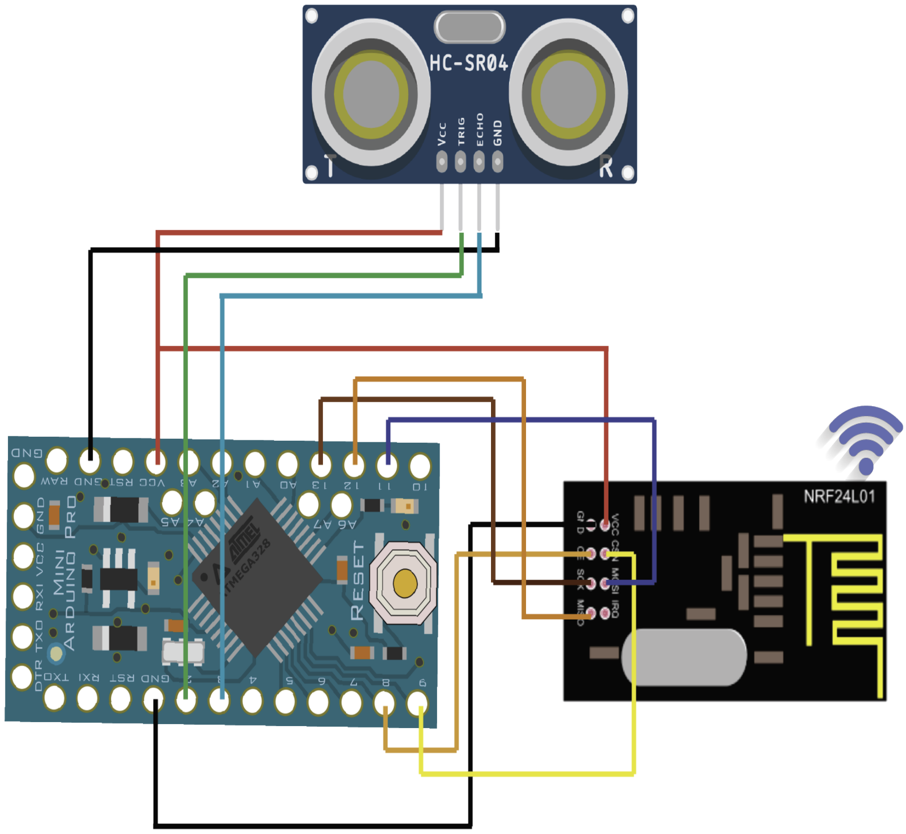


Figure 4.4: Transmitter Device V2.0

4.1.5 Receiver Side Circuit Diagram V2.0

This is the receiver side V2.0 of our project.

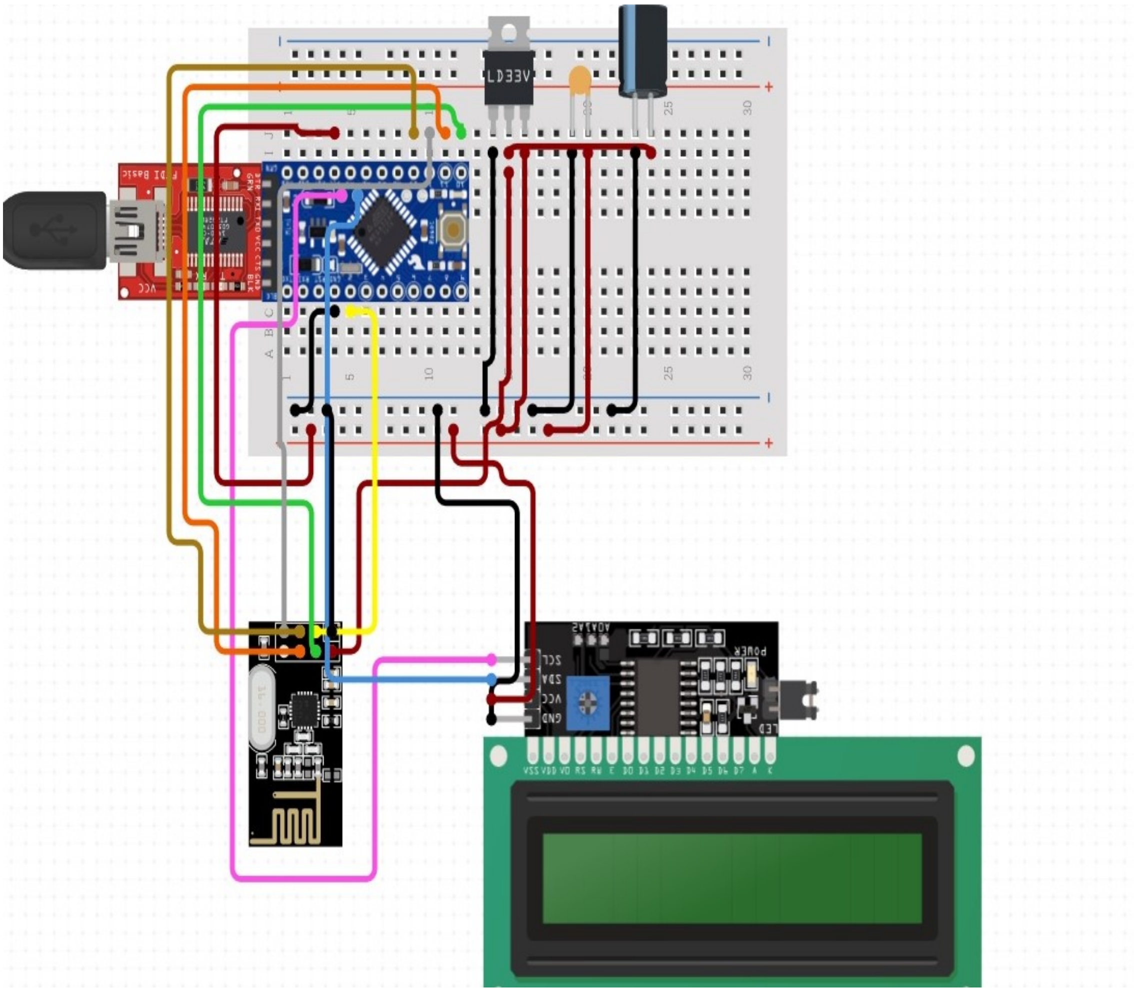


Figure 4.5: Receiver Device V2.0

4.1.6 Prototype V2.0 implementation of our project

This is the prototype version 2.0 of our project.

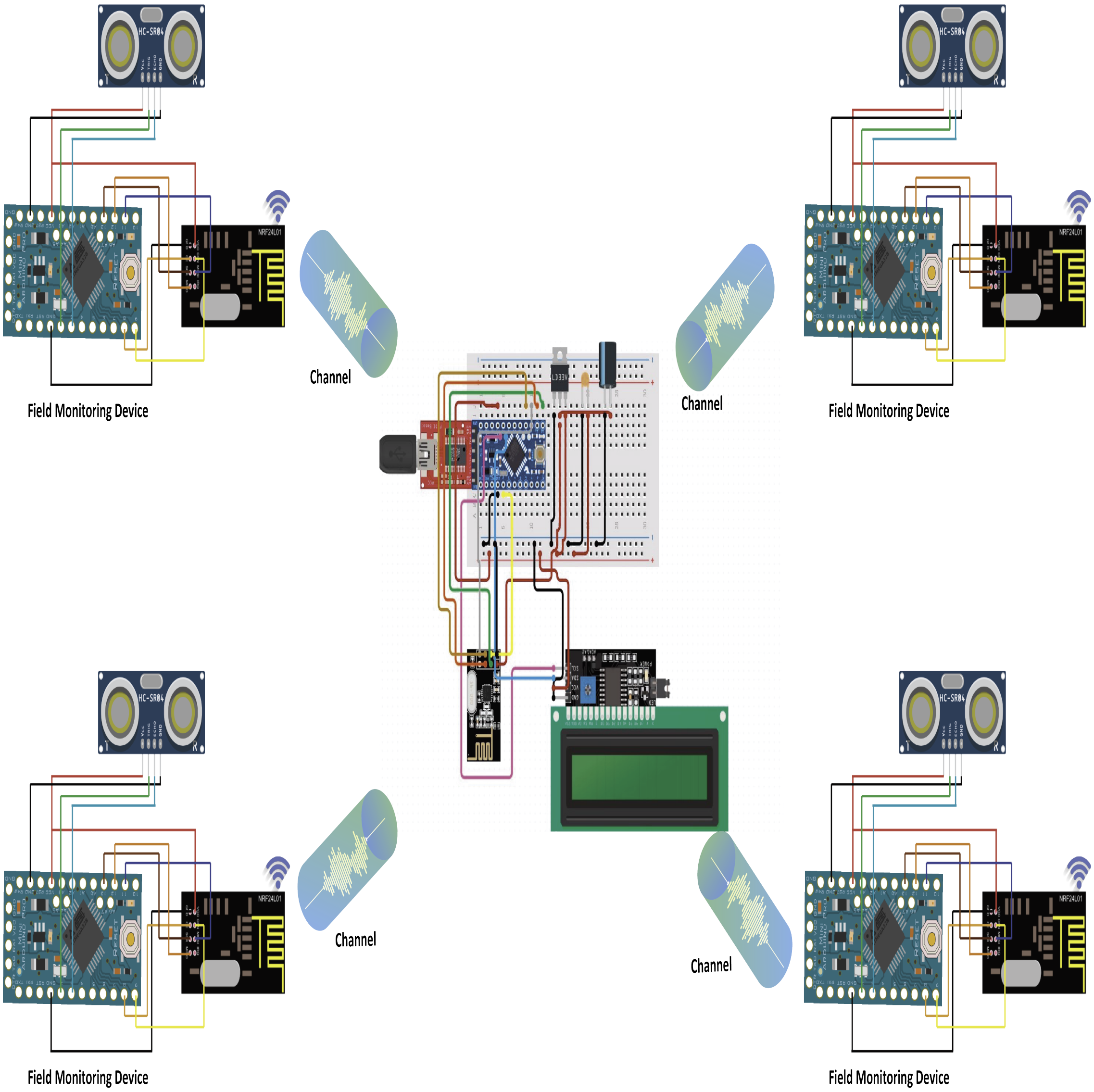


Figure 4.6: Our project prototype V2.0

4.1.7 Transmitter Side Circuit Diagram V3.0

This is the transmitter side V3.0. The final version of transmitter side device.

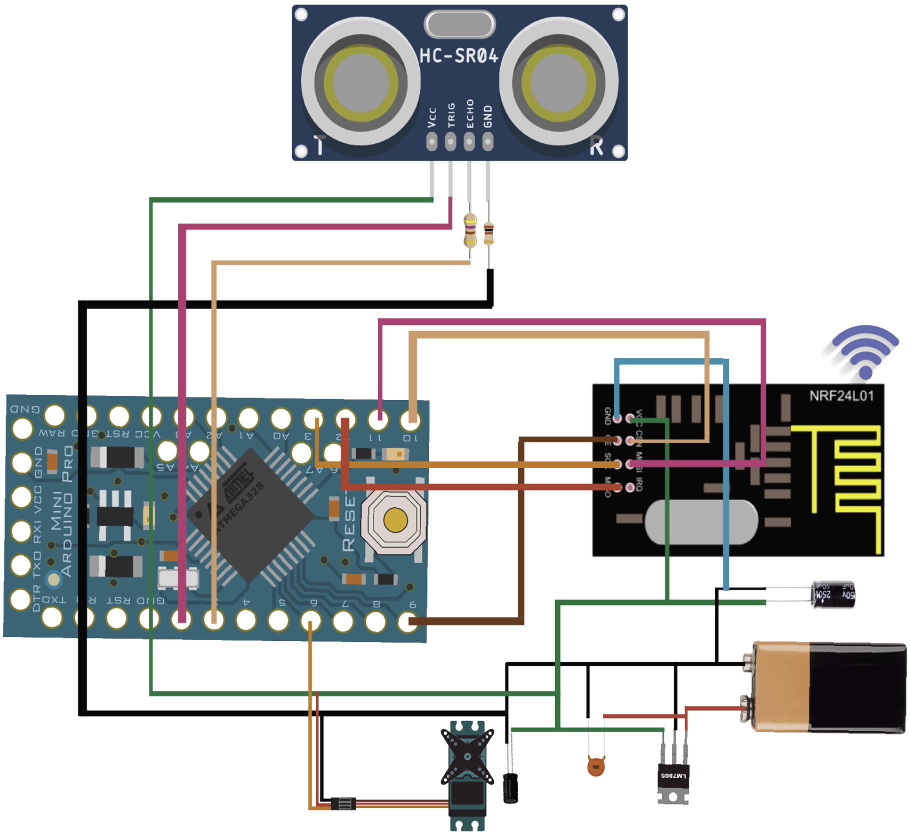


Figure 4.7: Transmitter Device V3.0.

4.1.8 Receiver Side Circuit Diagram V3.0

This is the receiver side V3.0 of our project. This device is the last and final version of our prototype.

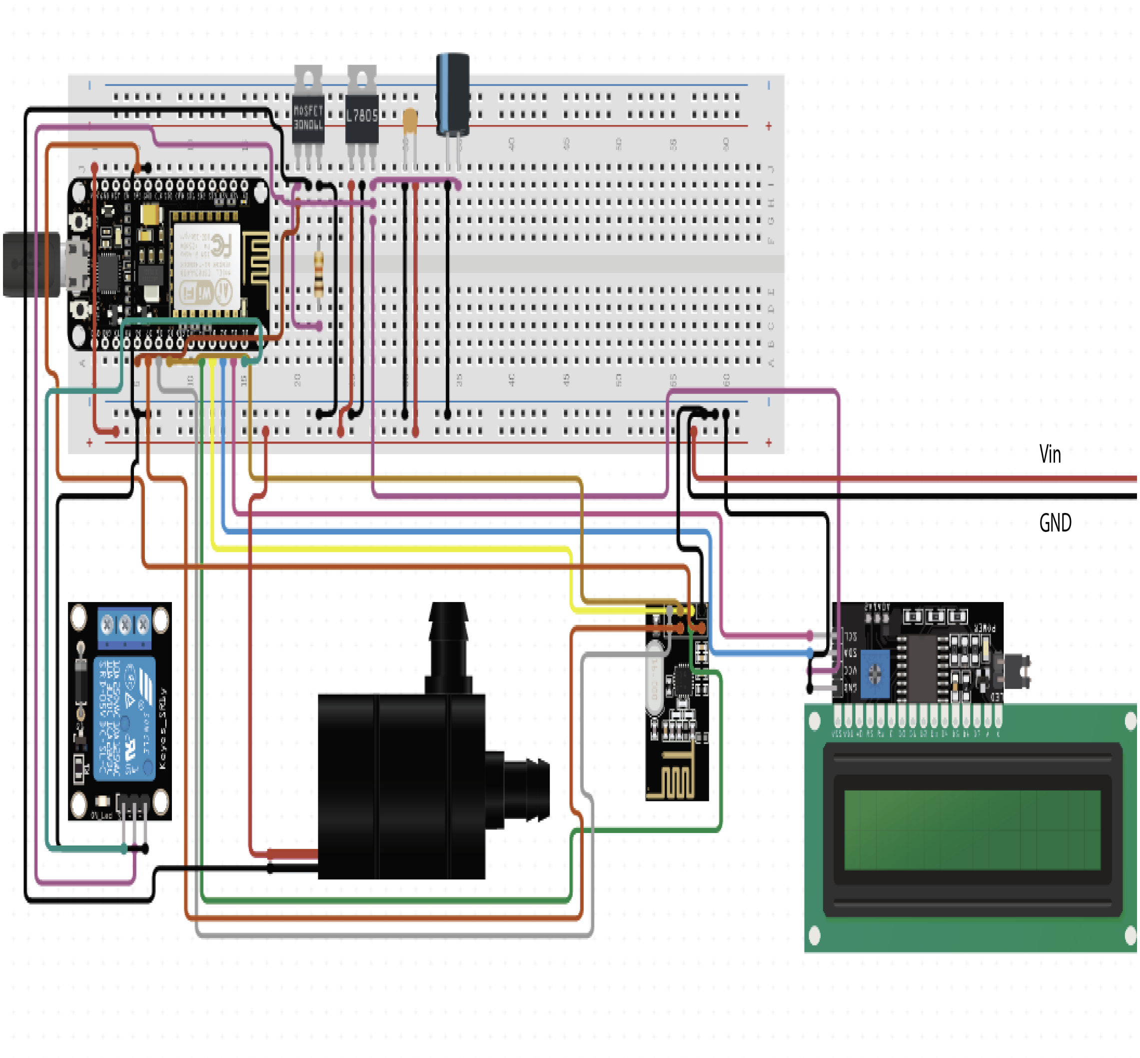


Figure 4.8: Receiver Device V3.0

4.1.9 Prototype V3.0 implementation of our project

This is the prototype version 3.0 of our project.

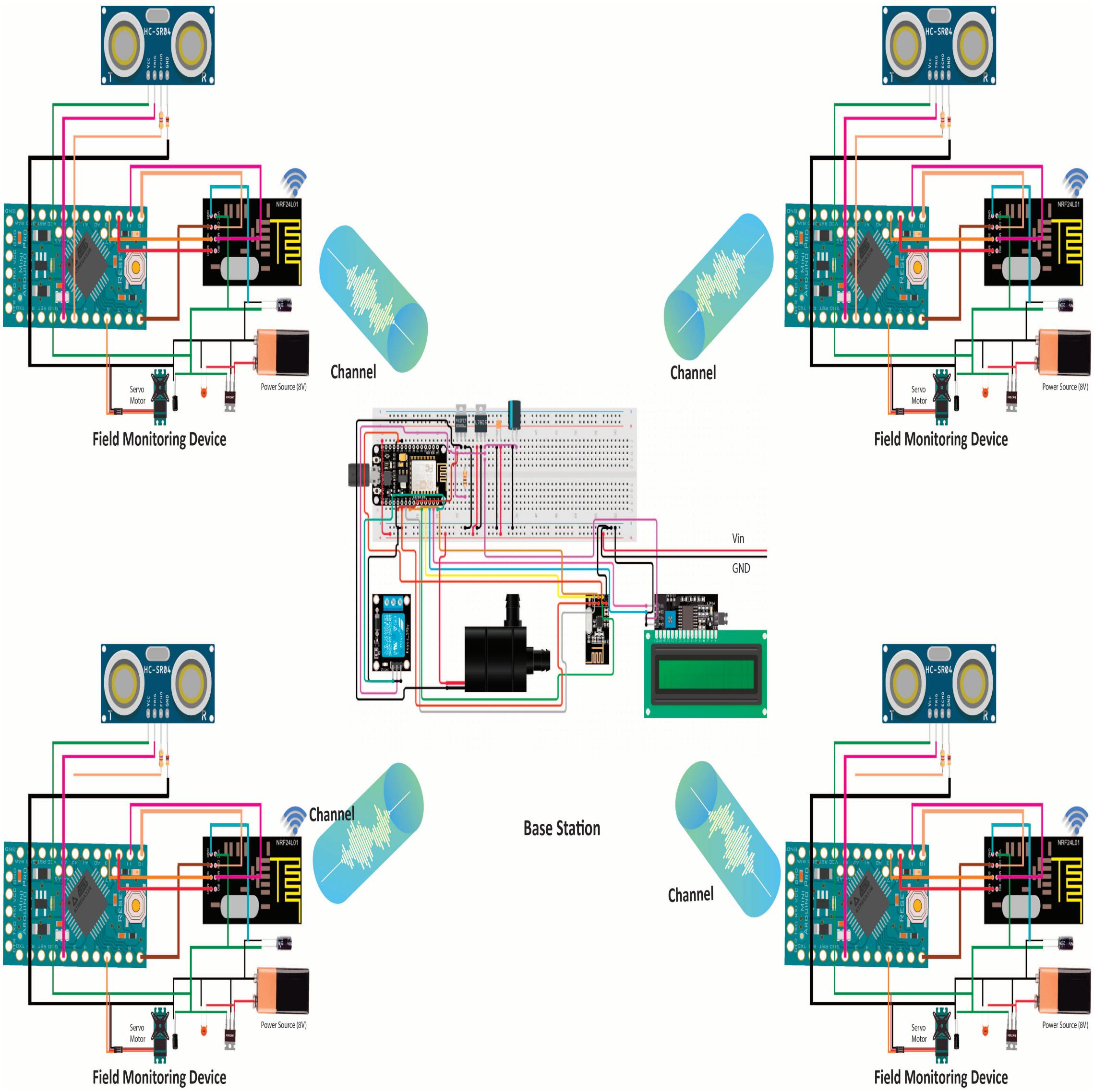


Figure 4.9: Our project prototype V3.0

4.1.10 PCB Design for Transmitter Side V3.0:

Implementing the hardware in a simple breadboard brings many problems. Due to long wiring, there was always voltage and current fluctuation. Arduino Pro Mini hanged frequently or the sonar sensor is not working.

To tackle this problem we decided to make a PCB Design for easier implementation of our project.

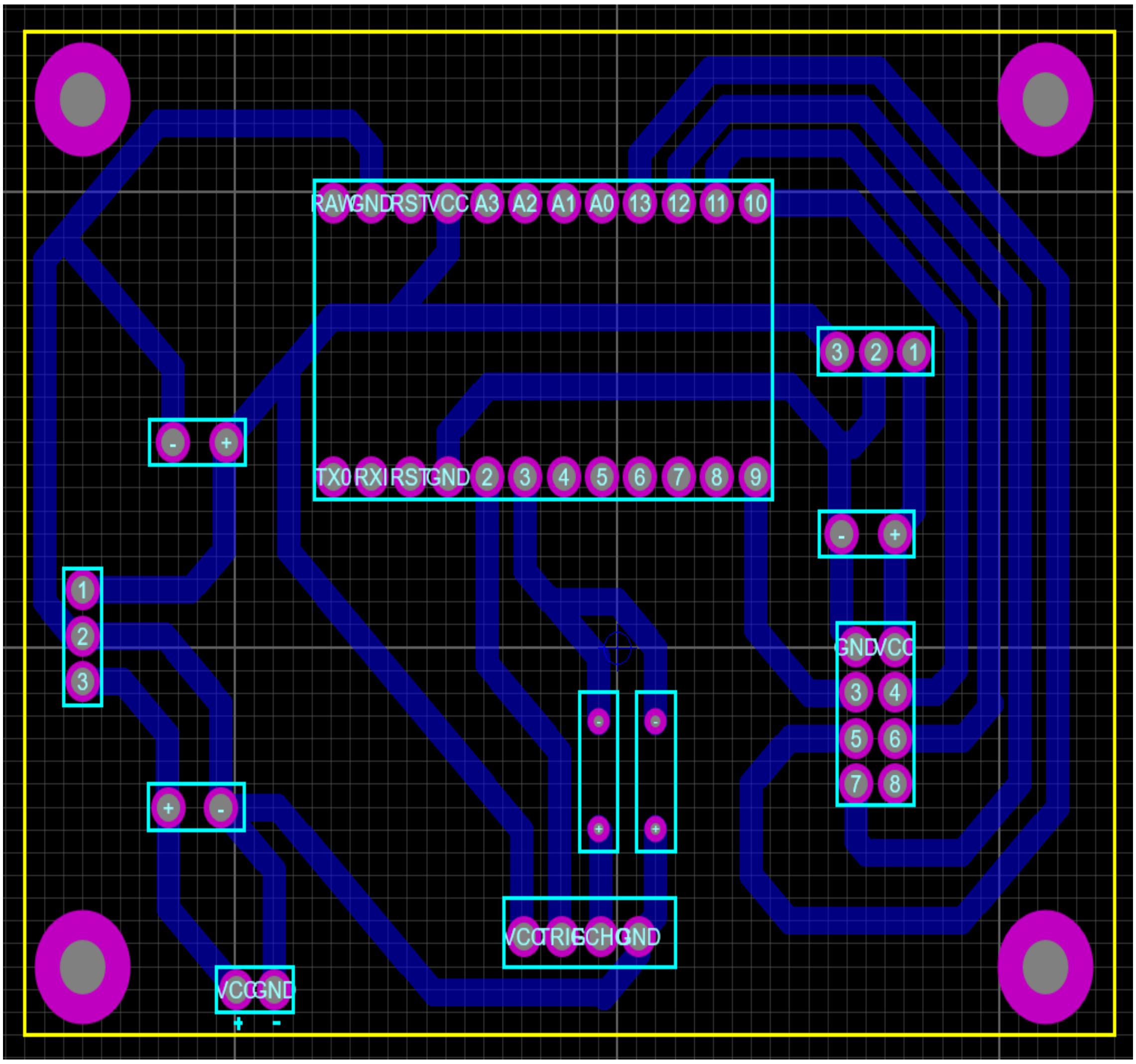


Figure 4.10: PCB Design for Transmitter Side V3.0

4.1.11 Hardware Pin Layout

4.1.12 Transmitter Side

The Following table represents the pins connection between the components, different module and arduino pro mini.

Components	Arduino Pro Mini	Sonar	RF Module	Description
Power, 7805 Vol Reg, 100nf, 1uF	VCC,GND	VCC,GND	VCC,GND	controling the 7V power source with voltage regulator (7805) and capacitor to get a constant 5V output is attached with all the component. For RF module the power source went through another 10uF capacitor to reduce the voltage even more since rf module is sensitive to voltage and current.
	D2	Trig		Trig pin of sonar is connected with D2 of pro mini. This enable the sonar to transmit a high frequency Sound.
470 ohm	D3	Echo		Echo pin of sonar is connected to D3 pin of pro mini. Echo receives the high frequency sound which was sent via trig. When a object reflect the sound back echo capture the frequency.
	D11, D12, D13		MOSI, MISO, SCK	MOSI (Master Out Slave In), MISO (Master In Slave Out) and the clock (SCK) are by default connected to the given digital pins of arduino. it will not work othersiwe. They are embedded inside arduino architecture.
	D9, D10		CE, CSN	Digital pin 9 and 10 is used to connect CE and CSN. CE pin is used for stand by mode and CSN is used for SPI communication.

Table 4.1: Transmitter Side Hardware Pin Layout

4.1.13 Receiver Side

The Following table represents the pins connection between NodeMCU and Rf module of receiver side.

nodeMCU	RF Module	Description
D5, D6, D7	MOSI, MISO, SCK	MOSI (Master Out Slave In), MISO (Master In Slave Out) and the clock (SCK) are by default connected to the given digital pins of arduino. it will not work othersiwe. They are embedded inside arduino architecture.
D3, D4	CE, CSN	Digital pin 3 and 4 is used to connect CE and CSN. CE pin is used for stand by mode and CSN is used for SPI communication.

Table 4.2: Receiver Side Hardware Pin Layout

4.2 Evaluation

4.2.1 Hardware Evaluation for V1.0:

After completing the first part of our capstone project, we mainly focused more on our hardware implementation of the project. 2-3 different types of hardware implementation were proposed and worked on during the whole project time to find out the best possible outcome from the designs.

The following implementation is the transmitter side of our project. We have two versions of the same implementation. The following images are the Ver 1.0 of our transmitter side.

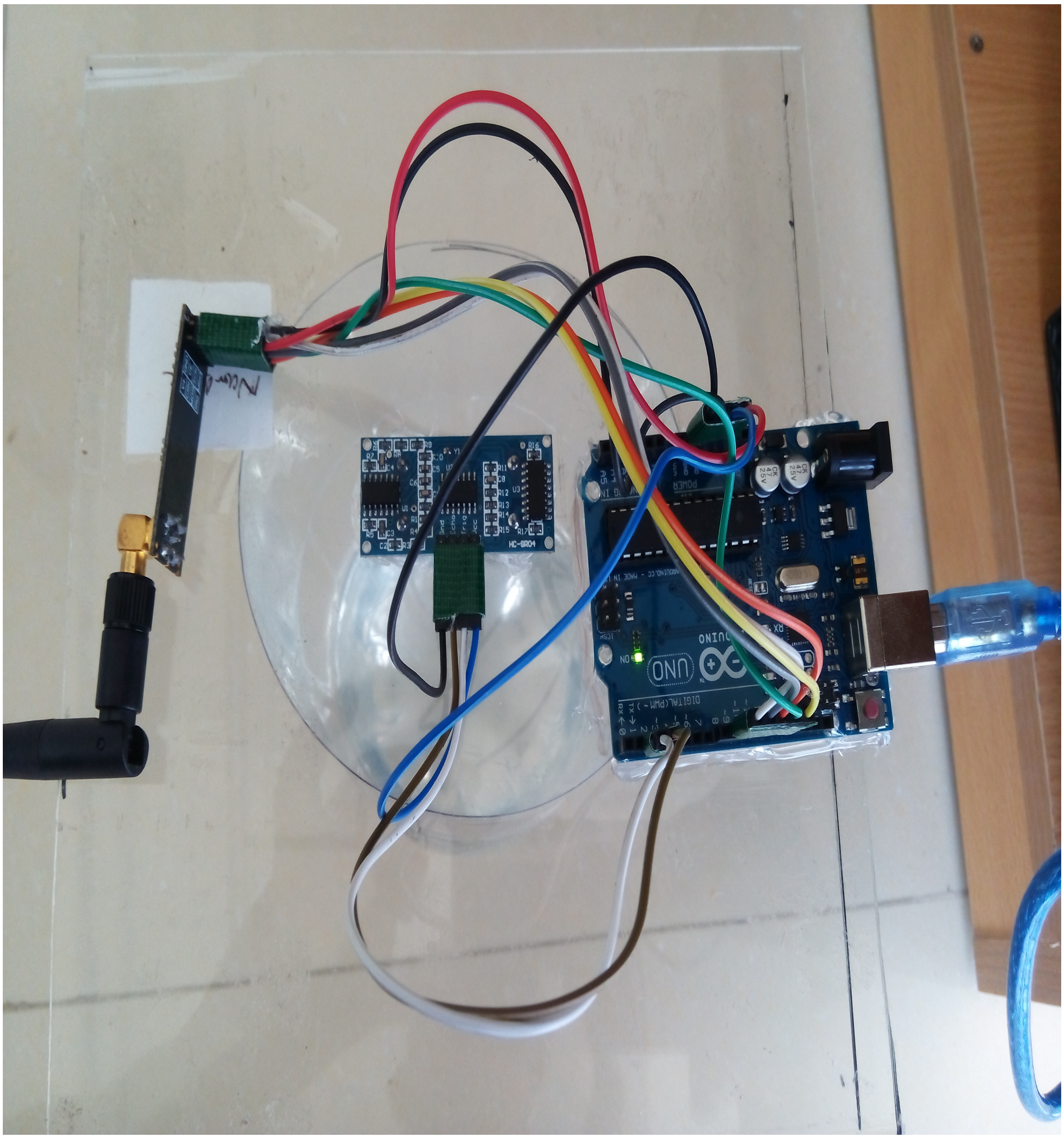


Figure 4.11: Transmitter Side Using Arduino UNO Ver. 1.0

As part of the progress of the ongoing project "Smart Irrigation Control System For Bangladesh Rice Research Institute," we implement and test the project using a microcontroller such as Arduino UNO. Reducing the device size is a must for us. we are currently working on it.

The following device is the receiver side of our project. This is the version 1.0 of our receiver side. Version 2.0 is in working progress.

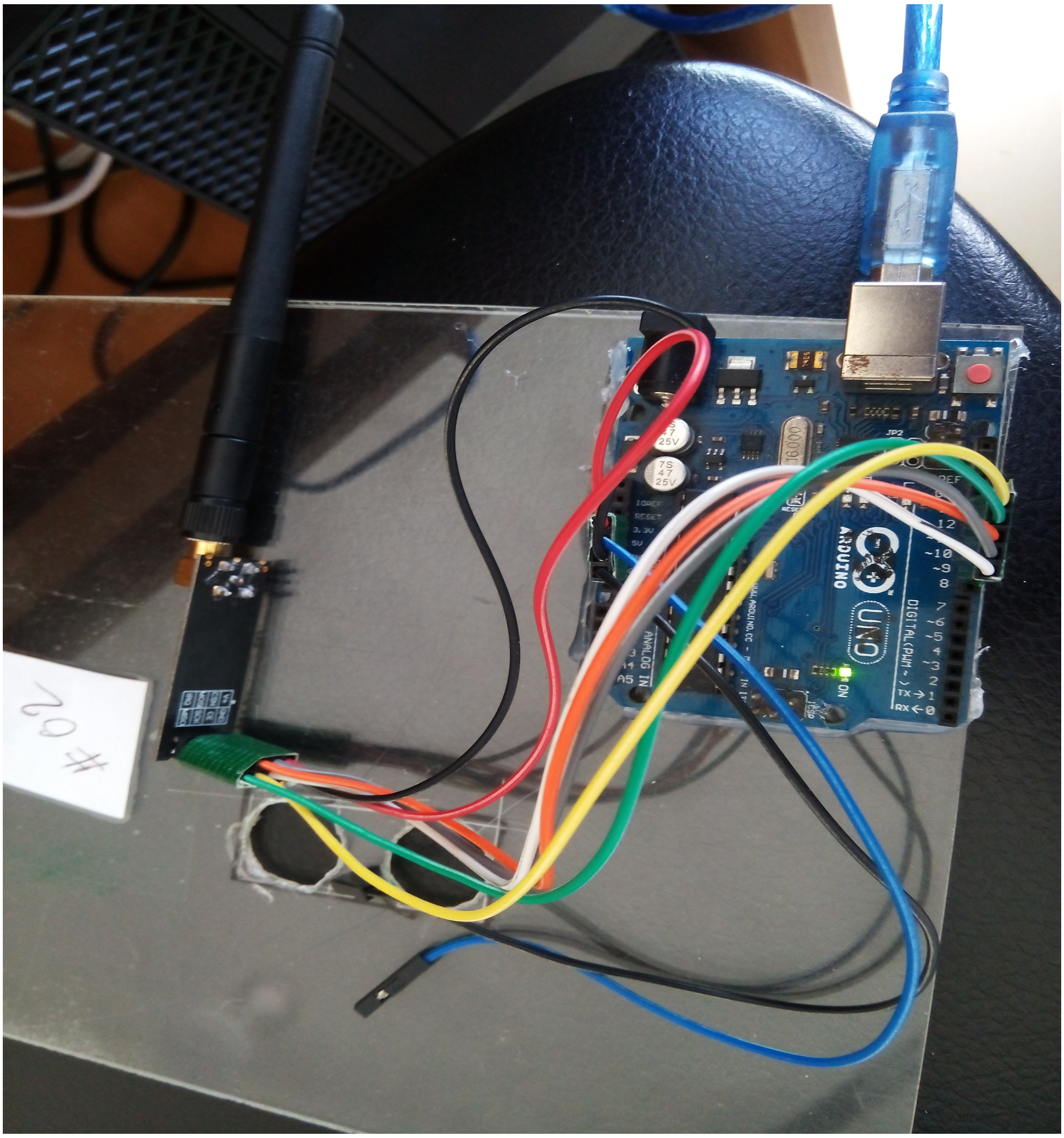


Figure 4.12: Receiver Side Using Arduino UNO Ver. 1.0

4.2.2 Hardware Evaluation for V2.0

Since implementing V1.0 in unrealistic we have found a better solution for our transmitter device. We select the Arduino Pro mini as the processing unit. It is small and has almost the same compatibility of the Arduino UNO. However, We faced some problems with this device as well that are discussed in the next section.

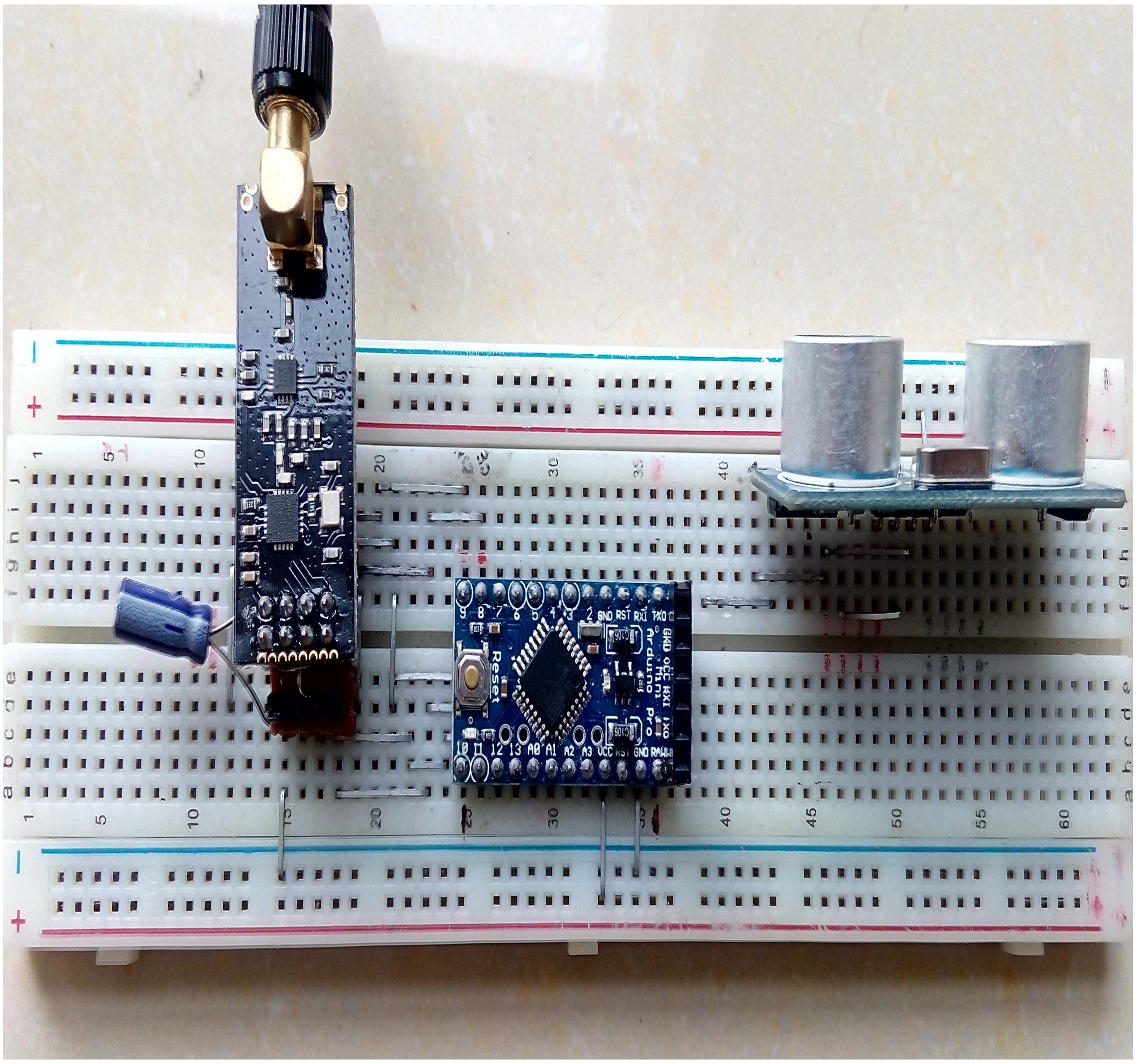


Figure 4.13: Transmitter Side Using Arduino Pro Mini Ver. 2.0

We also reduce the size of the transmitter device as well. Still, the device is not reliable to some extent. As we can see the display is not showing anything at all. Check the next section for an explanation.

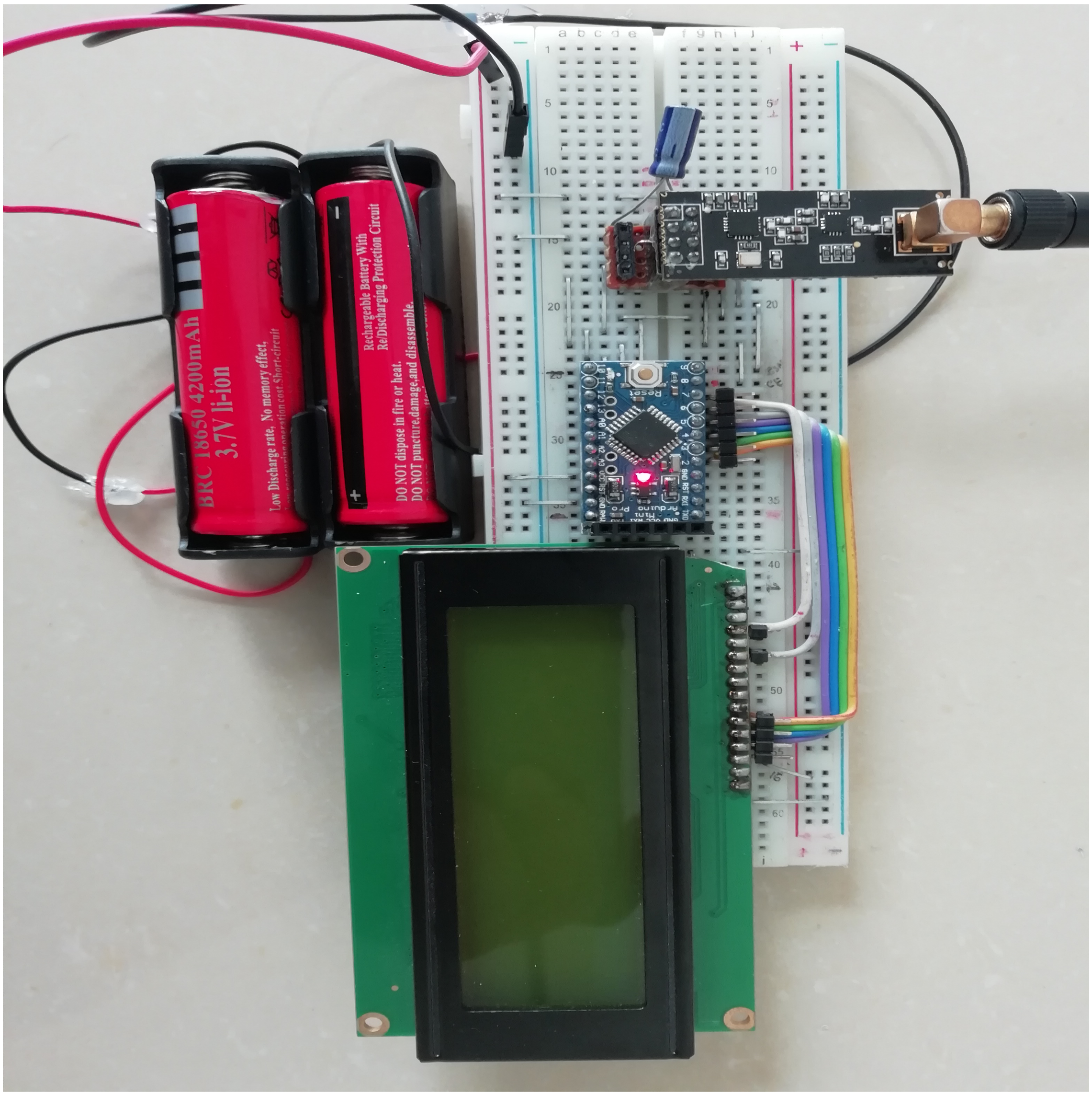


Figure 4.14: Receiver Side Using Arduino Pro Mini Ver. 2.0

4.2.3 Hardware Evaluation for V3.0

After doing the PCB design most of the previous problem was solved. We are capable of making a device that will be small enough to implement inside the perforated PVC pipe of the AWD technology. The Device width is 2.5 inch and the height is 2.2 inches.

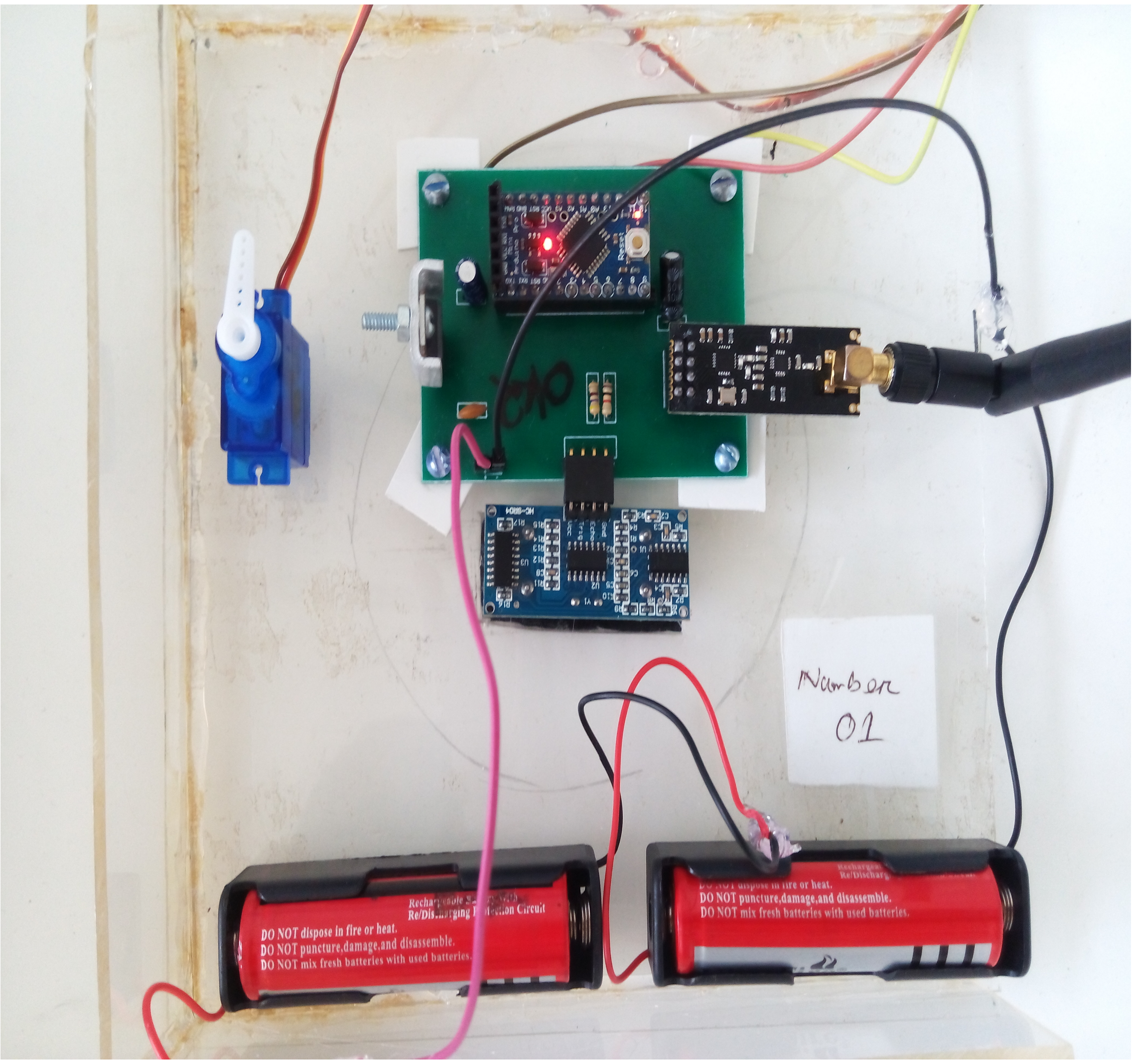


Figure 4.15: Transmitter Side Using Arduino Pro Mini Ver. 3.0

The Receiver side device is capable of uploading the information in a local server as well as into the cloud platform. The device also monitors the water level of all the fields and control the motor.

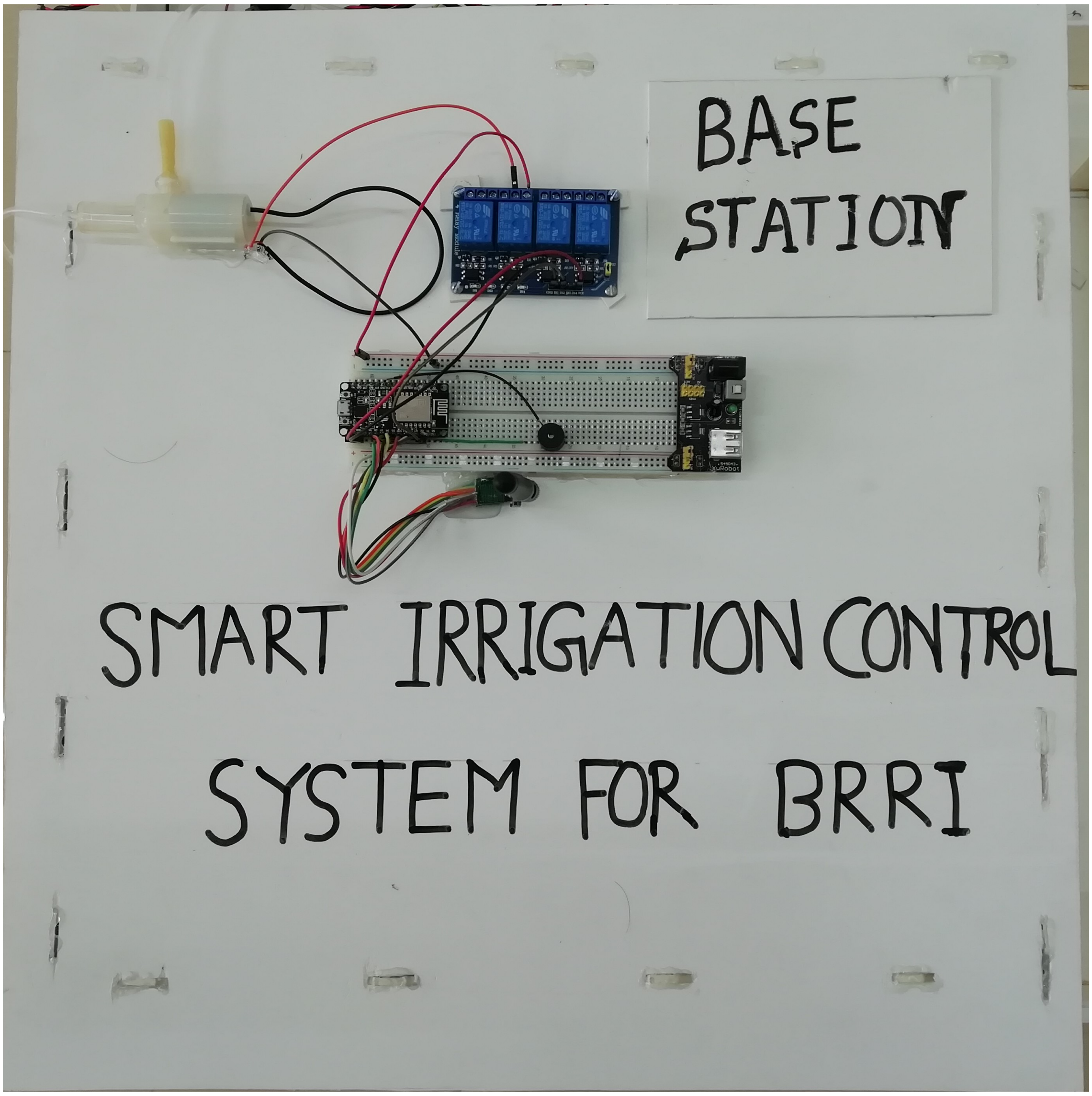


Figure 4.16: Receiver Side Using NodeMCU Ver. 3.0

4.2.4 Hardware Evaluation Full Prototype

After doing the PCB design most of the previous problem was solved. We are capable of making a device that will be small enough to implement inside the perforated PVC pipe of the AWD technology. The Device width is 2.5 inch and the height is 2.2 inches.

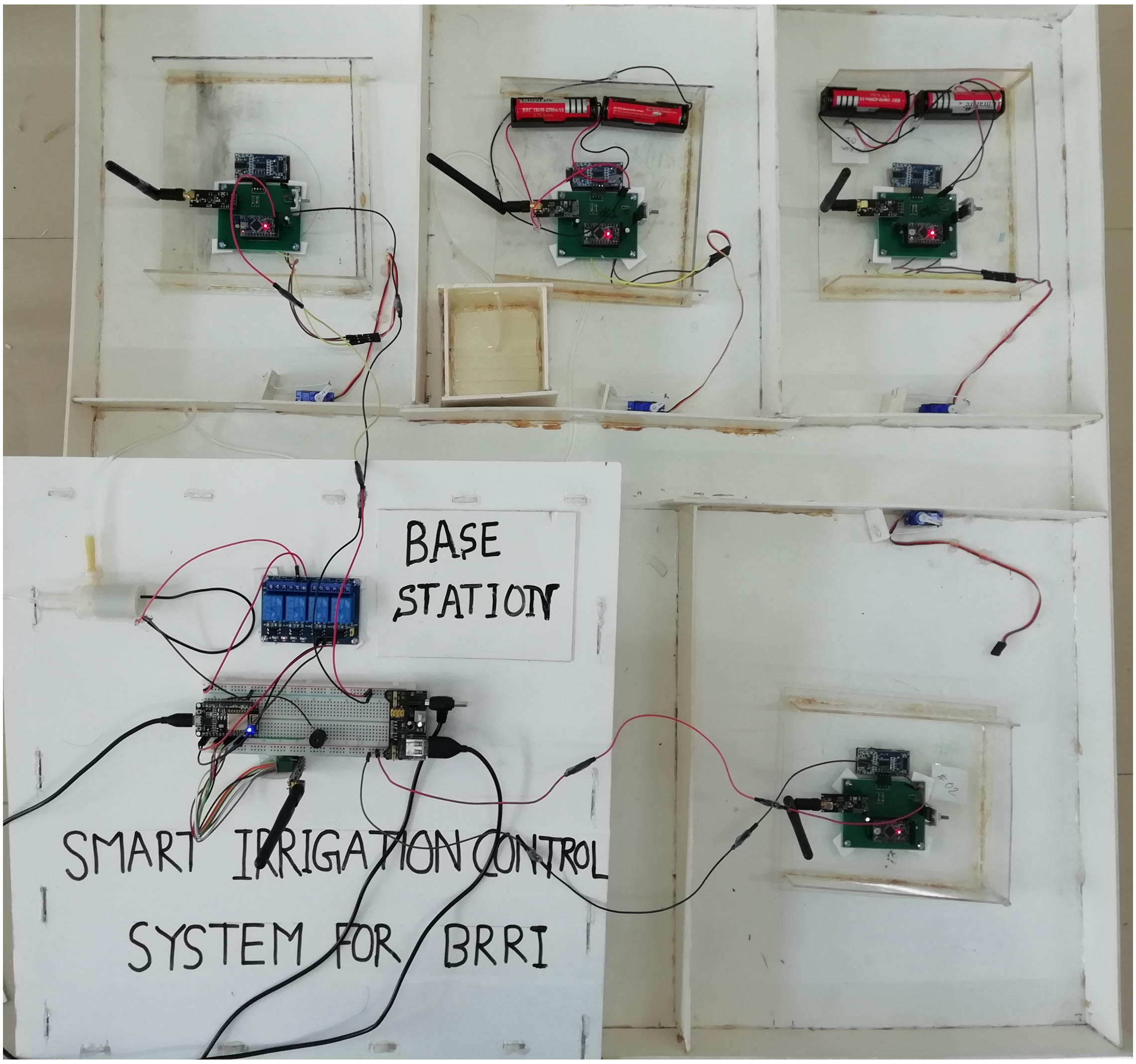


Figure 4.17: Transmitter Side Using Arduino Pro Mini Ver. 3.0

4.3 Results and Discussion

4.3.1 Result and Discussion for V1.0

It is quite clear that we are receiving the data from the transmitter to the receiver from the following image below. However, from a realistic point of view, it is not applicable. We collect data from our transmitter and showed the result, which we received via the receiver in a graphical interface. The following images are the result of our successful data receiving via the RF module.

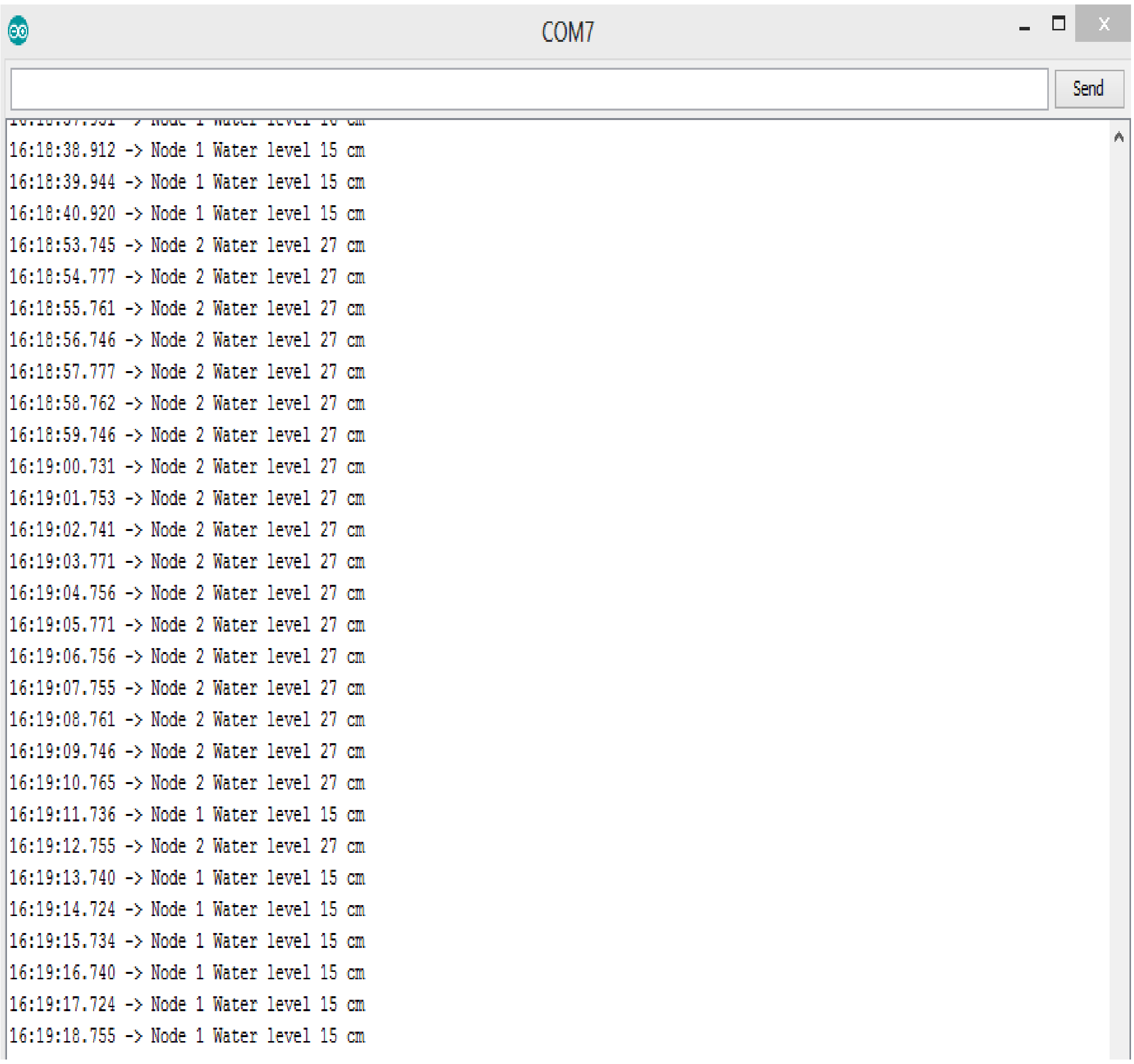


Figure 4.18: Data Receiving From Transmitter Device.

Discussion: After proper evaluation, we decided to change and remodel our both transmitter and receiver device from scratch.

4.3.2 Result and Discussion for V2.0

As we have evaluated the V2.0 device before, the device is not acting accordingly. Sometimes the device either gets hanged or fully stop working. The receiver side device has a major issue. The device does not have any dedicated 5V or 3V our RF module got burned due to an excessive amount of voltage and current flow.

After moving to Arduino Pro Mini we faced so many problem at the time of implementing the same hardware architecture. Since, pro mini does not have any dedicated power source; a universal power source is not capable of providing the required voltage and current for both Sonar Sensor (HC-SR04) and RF Module (nrf24l01). The Following table addresses all the problem we faced so far.

Problems	Description	Solution
Power Source	The provided power source is not capable of providing enough power for the devices.	Increase the power source (Up to 6v – 7v battery) and control the power using the Voltage Regulator (7805), capacitors.
Arduino Pro Mini (Hanged)	The main processing unit was hanging after implementing.	After controlling the power amplifier (PA) level of the RF module the problem was solved. Also we control the outgoing voltage of the power source with the help of 100nF and 1uF capacitor.
RF module's voltage and current sensitivity	RF Module is sensitive to voltage fluctuation. Exceeding 5V will potentially harm the device itself.	One way to control the ongoing power of the RF module is to implement a capacitor across VCC and GND of the device to control the voltage and current flow.
Sonar Sensor	Sonar is not capable of working under 3.7V. Since we are using a universal power source it is not receiving the proper amount of power for itself.	The problem was solved using the resistor. Since, ECHO always consumes higher voltage sorting it with GND and resistors helps controlling it and balancing the power consumption.

Table 4.3: Problems with hardware implementation.

Discussion: An excessive amount of voltage or current burns the RF module. We have to control the voltage and current rate across all the devices. The solution will be provided in the next version.

4.3.3 Result and Discussion for V3.0

The final version removes all the preexisting problem of our project. The transmitter and receiver side is working perfectly. The data is safely recorded and stored in the local server as well as the cloud server. However, we are still facing a minor problem from our transmitter side. The RF module does work at 5V. Unfortunately, if the RF module keeps using the 5V for a longer period the device life cycle will reduce quicker than the expected time.

Discussion: RF module works best at 3.3V. For that purpose, we have to remodel the PCB design and include a 3.3V voltage regulator to regulate the incoming voltage for the RF module.

4.4 Web Application

Data Visualisation is a major part of our project. The collected data must be shown in a proper manner that makes it easier for people to visualize the data. The following image shows the control panel where we can see the current water level of each field.

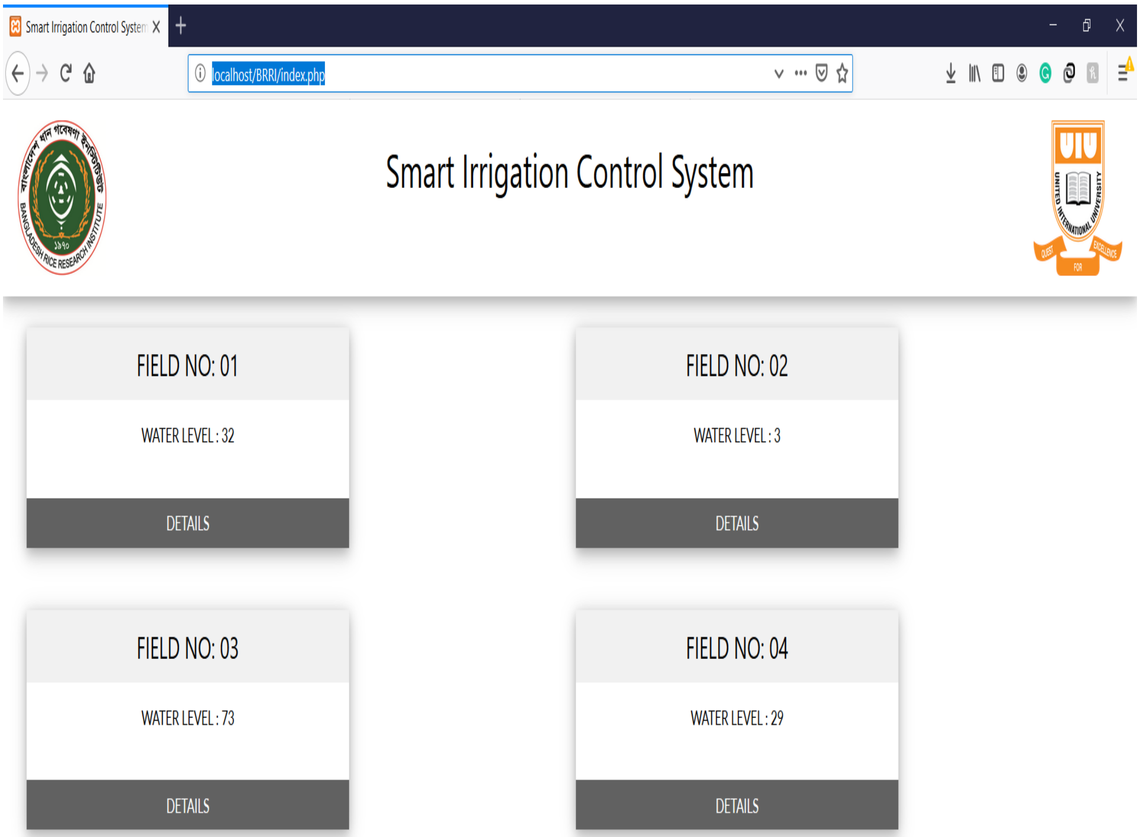


Figure 4.19: Web Application home page.

4.4.1 Field Information

The following images show the last 10 collected information about a specific field. This data can be seen by simply clicking the "DETAILS" button of the previous image.

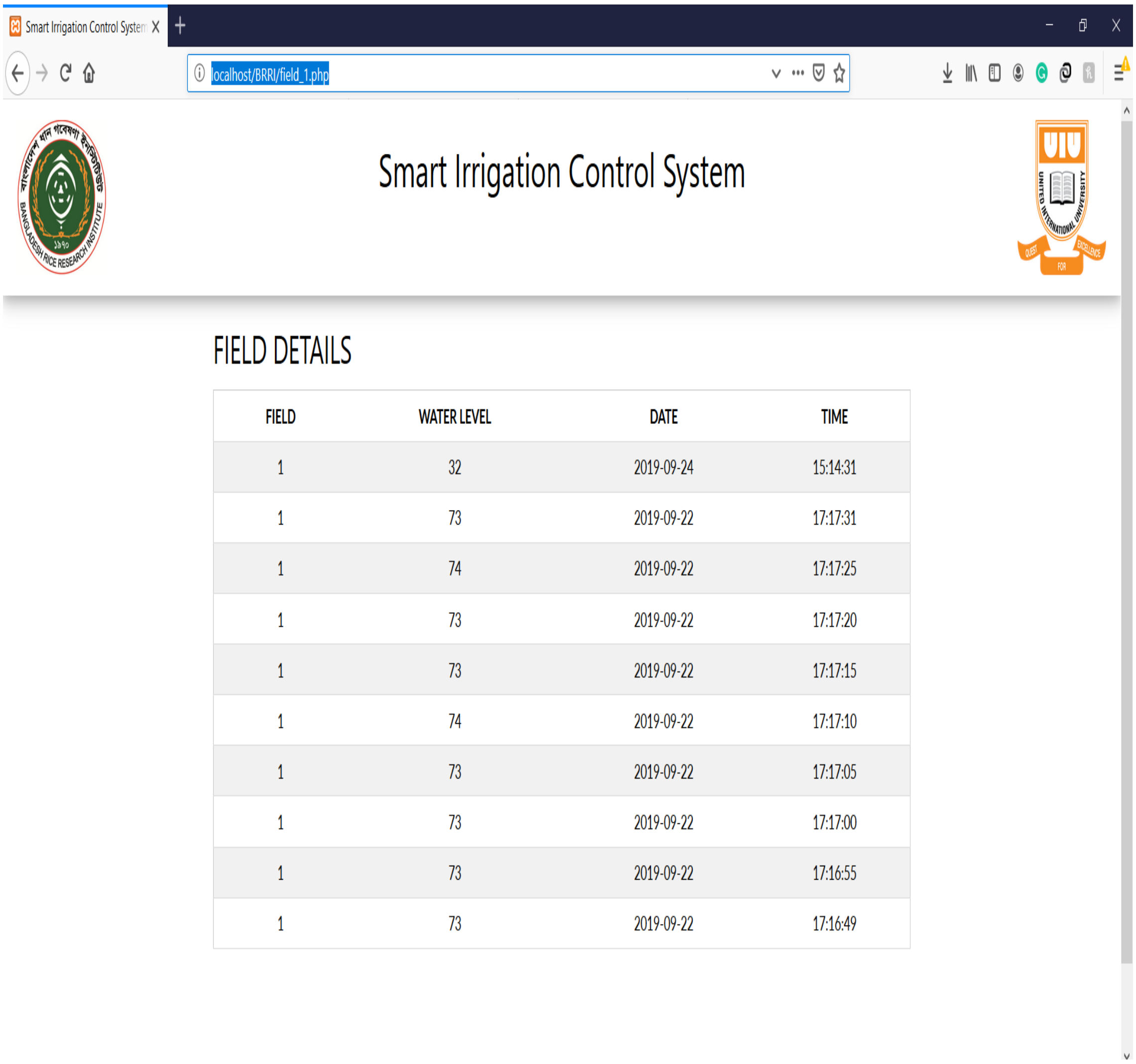
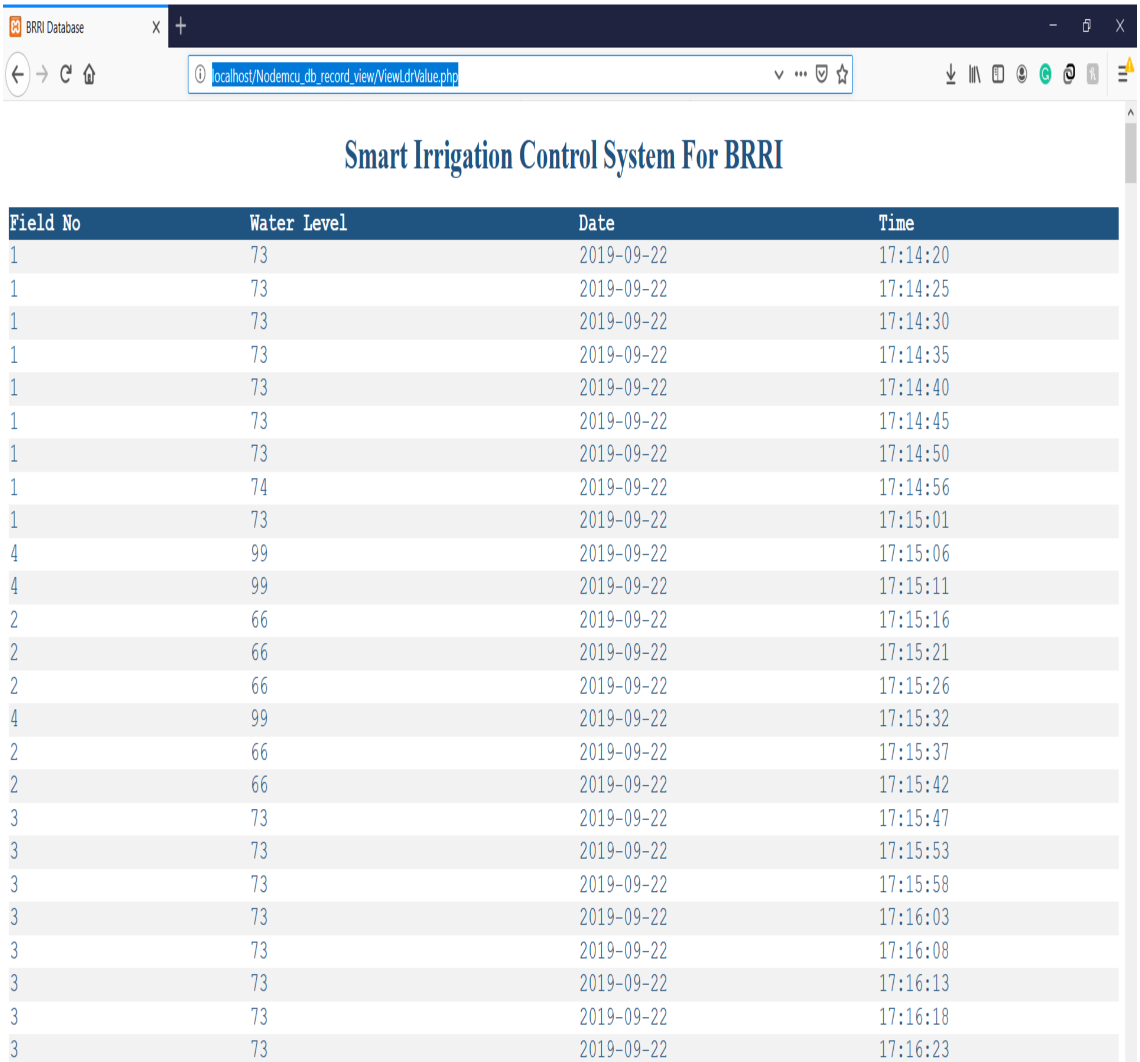


Figure 4.20: Viewing 10 data list of an specific Field.

4.4.2 Live Database

Here all the collected information is shown live. It will show all the relevant data about all the fields. It will collect data and show it as long as the system is running and the transmitter is sending data to the receiver. The system can be shut down if wanted. Starting the system again will automatically connect to the database and start collecting information.



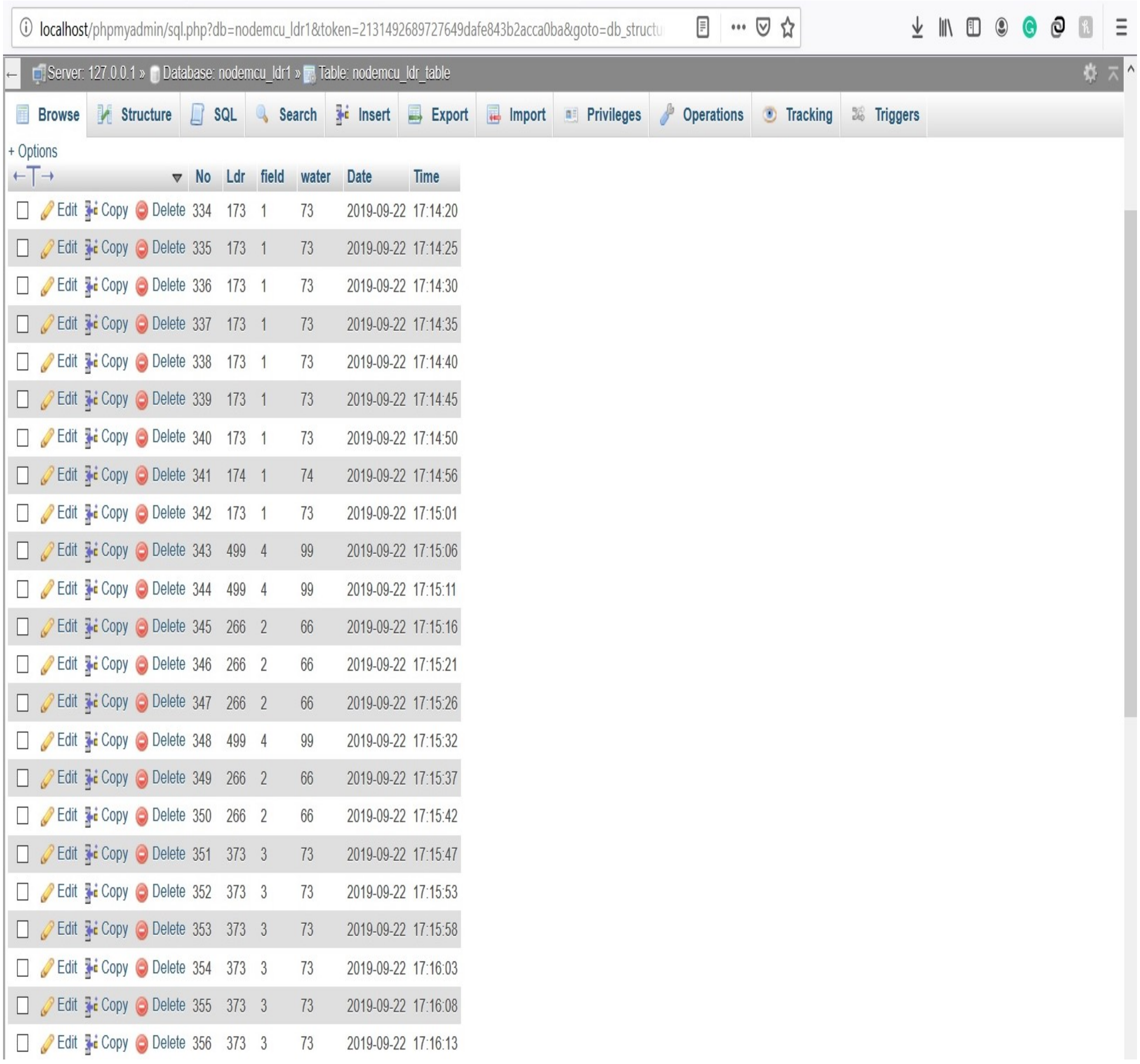
Smart Irrigation Control System For BRRI

Field No	Water Level	Date	Time
1	73	2019-09-22	17:14:20
1	73	2019-09-22	17:14:25
1	73	2019-09-22	17:14:30
1	73	2019-09-22	17:14:35
1	73	2019-09-22	17:14:40
1	73	2019-09-22	17:14:45
1	73	2019-09-22	17:14:50
1	74	2019-09-22	17:14:56
1	73	2019-09-22	17:15:01
4	99	2019-09-22	17:15:06
4	99	2019-09-22	17:15:11
2	66	2019-09-22	17:15:16
2	66	2019-09-22	17:15:21
2	66	2019-09-22	17:15:26
4	99	2019-09-22	17:15:32
2	66	2019-09-22	17:15:37
2	66	2019-09-22	17:15:42
3	73	2019-09-22	17:15:47
3	73	2019-09-22	17:15:53
3	73	2019-09-22	17:15:58
3	73	2019-09-22	17:16:03
3	73	2019-09-22	17:16:08
3	73	2019-09-22	17:16:13
3	73	2019-09-22	17:16:18
3	73	2019-09-22	17:16:23

Figure 4.21: All the available data of the fields.

4.4.3 Database Back-end

The following image shows how we are collecting and storing data in our localhost database.



	No	Ldr	field	water	Date	Time
Edit Copy Delete	334	173	1	73	2019-09-22	17:14:20
Edit Copy Delete	335	173	1	73	2019-09-22	17:14:25
Edit Copy Delete	336	173	1	73	2019-09-22	17:14:30
Edit Copy Delete	337	173	1	73	2019-09-22	17:14:35
Edit Copy Delete	338	173	1	73	2019-09-22	17:14:40
Edit Copy Delete	339	173	1	73	2019-09-22	17:14:45
Edit Copy Delete	340	173	1	73	2019-09-22	17:14:50
Edit Copy Delete	341	174	1	74	2019-09-22	17:14:56
Edit Copy Delete	342	173	1	73	2019-09-22	17:15:01
Edit Copy Delete	343	499	4	99	2019-09-22	17:15:06
Edit Copy Delete	344	499	4	99	2019-09-22	17:15:11
Edit Copy Delete	345	266	2	66	2019-09-22	17:15:16
Edit Copy Delete	346	266	2	66	2019-09-22	17:15:21
Edit Copy Delete	347	266	2	66	2019-09-22	17:15:26
Edit Copy Delete	348	499	4	99	2019-09-22	17:15:32
Edit Copy Delete	349	266	2	66	2019-09-22	17:15:37
Edit Copy Delete	350	266	2	66	2019-09-22	17:15:42
Edit Copy Delete	351	373	3	73	2019-09-22	17:15:47
Edit Copy Delete	352	373	3	73	2019-09-22	17:15:53
Edit Copy Delete	353	373	3	73	2019-09-22	17:15:58
Edit Copy Delete	354	373	3	73	2019-09-22	17:16:03
Edit Copy Delete	355	373	3	73	2019-09-22	17:16:08
Edit Copy Delete	356	373	3	73	2019-09-22	17:16:13

Figure 4.22: All the available data of the fields.

4.4.4 Mobile Application

The following image is the mobile application of our project. This application shows the real-time water level changed data that is being stored in cloud storage.

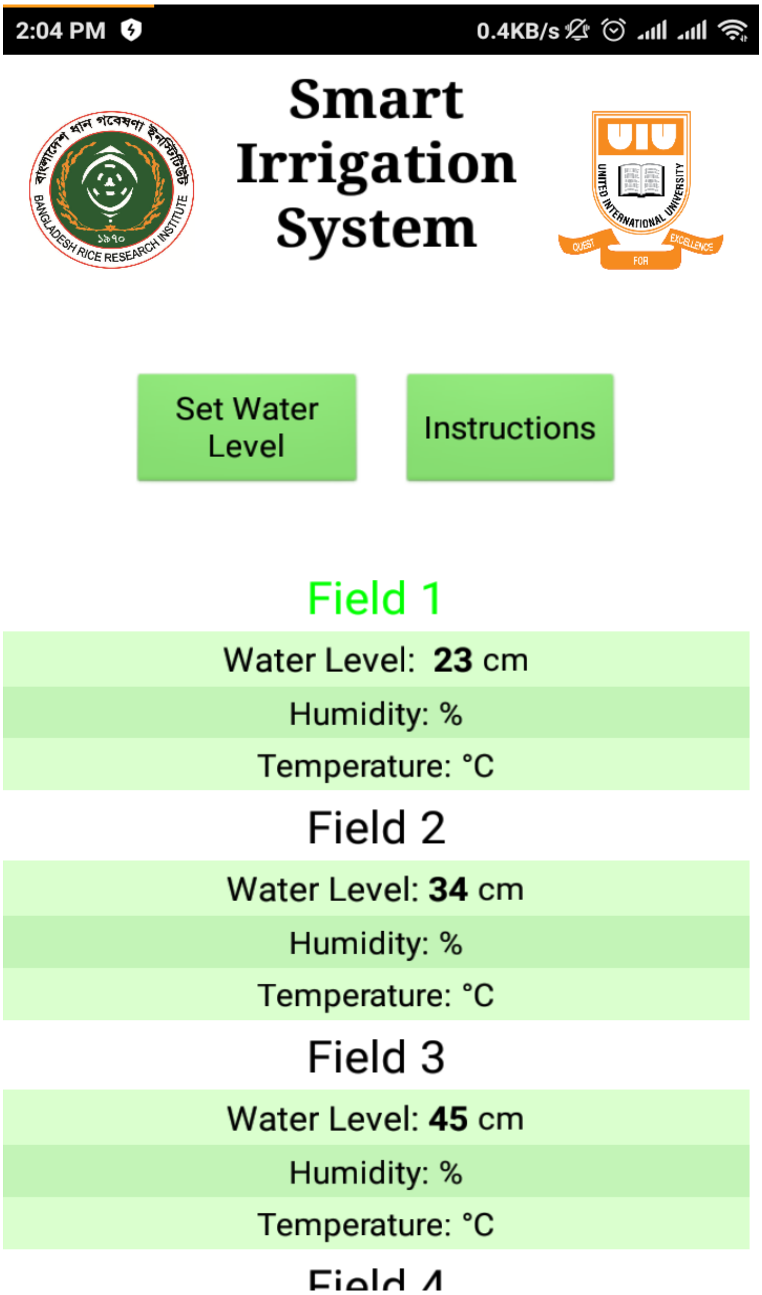


Figure 4.23: Mobile Application

4.5 Summary

This chapter explains all the existing problem results and a brief discussion of what decided to solve those problems. We also showed our project web application and the result information here in this chapter.

Chapter 5

Standards and Design Constraints

In this chapter we are describing the impact and constrains of our project.

5.1 Compliance with the Standards

Before approaching the making of the project, we have to make sure we are not breaking any rules and regulation. These days we have to make sure we are not making anything that is illegal and not following any standards.

5.1.1 Technical

Table 5.1: Technological Standards

programming language	C / C++
Data formats	Radio Frequency
Programming software	Arduino IDE
Simulation software	Proteus
Documentation	Overleaf
Others	Photoshop, Premier Pro, Illustrator

5.1.2 Hardware Standard

ISO/IEC 12207 - International Organization for Standardization and International Electrotechnical Commission combined published this standard for software engineers. This standard promotes not to develop any device or application that might harm human, animal, the environment in any harmful manner.

5.2 Impacts & Constraints

5.2.1 Impacts

5.2.2 Economic Impact

The economic impact of our project may vary. The device will be cheap and maintaining it will cost a low amount; it is safe to say less investment is required every once in a while. The device will help the farmer grow rice properly. It helps the farmer to grow more rice than before. The device is a feasible solution for farmers. Farmers often lease water from the water supplier and have to pay for it at the end of the day. The device will help them use less water, so they have to pay less. The increase in crop production will help the farmer financially.

5.2.3 Environmental Impact

Water is a valuable commodity nowadays. In our country, we use a tremendous amount of groundwater for irrigation which is a leading cause for lack of groundwater for daily use. During the winter season, the water level reaches a record low. The device will help monitor the proper use of water. It will be an efficient way to use water for irrigation and help us save both water and electricity.

5.2.4 Ethical Impact

There is no ethical impact of our project.

5.2.5 Health and Safety Impact

The impact of health and safety is not an issue with the project. The device will neither harm people nor damages their health. In this project, we are using a very low-frequency device for transferring the data to the system so that it is user-friendly and does not affect any humans or animals. On other hands, a farmer can get proper rest at night without worrying about irrigating his fields. It is also safe on that sense that a farmer would not go to their field for water in the middle of the night in the rural area. Sometime they may face difficulties.

5.2.6 Social Impact

Farmers will be financially self-sufficient. However, There are some problems with the farmers who have a concern about the new technologies. Rural people often have the superstition about using technologies for daily life. The acceptance of this device among the farmers may take some time. The improvement in crop production by using this device might make them interested in using the device.

5.2.7 Political Constraint

The parts we are using for this device will not cause any issue at all. People in our country widely use all these parts for different purposes. There is hardly any restriction by the government about using these components. There is no rules and regulation from the government about not using this type of devices.

5.2.8 Manufacturability and Cost Analysis

Our device is a tiny and compact device. The production cost of this device is meager. Building it at a large number will not consume a considerable amount of money. Safe to say that it is financially efficient. The device will be able to merge with future technologies as long as those technologies are compatible with this device working environment.

5.2.9 Sustainability

Our device is self-sustainable. A PVC pipe will protect this device. The pipe will protect it from any external damage. We are also making sure not to do any wrong data inputs. The device might work differently based on the environmental condition. High heat and humidity may cause the device to work irrationally from time to time. The device will not receive that much of an update unless there is a new rice type invented by BRRI or BINA.

5.3 Licensing

GNU GENERAL PUBLIC LICENSE (Version 2, June 1991)
Copyright (C) 1989, 1991 Free Software Foundation, Inc.
59 Temple Place, Suite 330, Boston, MA 02111-1307 USA

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

GNU LESSER GENERAL PUBLIC LICENSE (Version 2.1, February 1999)
Copyright (C) 1989, 1991 Free Software Foundation, Inc.
59 Temple Place, Suite 330, Boston, MA 02111-1307 USA

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.
This is the first released version of the Lesser GPL. It also counts as the successor of the GNU Library Public License, version 2, hence the version number 2.1

5.4 Our Licensing

The project we are doing is a government project. We can not share the information of our project with others. We are going to use proprietary licensing for our project. The information and data will not be accessible by others without any proper permission.

5.5 Summary

In this chapter, We focus on the impacts and constraints that our project has on different aspects of our social and economical life of a farmer and their surroundings.

Chapter 6

Conclusion

In the chapter, We are explaining the limitation of our project. The chapter also includes the future possibilities of the project.

6.1 Summary

To sum it up, we are happy to say that we manage to successfully create a prototype for the base station as well as a field monitoring device. After completing the prototype, we do some testing, and we receive a positive response from the prototype every time. We implement the method in a real-life situation to see the outcome it provides. We are making a finished prototype model for implementing it at the rice field.

6.2 Results

The followings are the results we achieved so far from our project.

6.2.1 Cost Estimation

Cost estimation is a major part of our project. A cheaper device will be efficient for our farmers. so we worked keeping that in mind.

The cost estimation was done based on a 24000 transmitter device and 5000 receiver device. We used aliexpress.com online store for making the cost estimation.

1. Arduino Pro Mini **Price: $580**
2. Node MCU **Price: $2600**
3. RF Module (nrf24l01) **Price: $8600**
4. Sonar Sensor (HC-SR04) **Price: $850**
5. PCB Design **Price: $6500**
6. Total **Price: $19130**

The estimation was done based on foreign currency. After calculation we came to realization that a single device will cost **$0.80 cents or 68 Taka.** The estimation excludes the shipping cost of the components.

6.2.2 Device Capability

- The Device is capable of transmitting data from 300 meter distance.
- The device is capable for running for several days without changing battery.
- A single device can cover up to 65 acre land.
- Current prototype will be able to cover a total of 325 acre land easily.

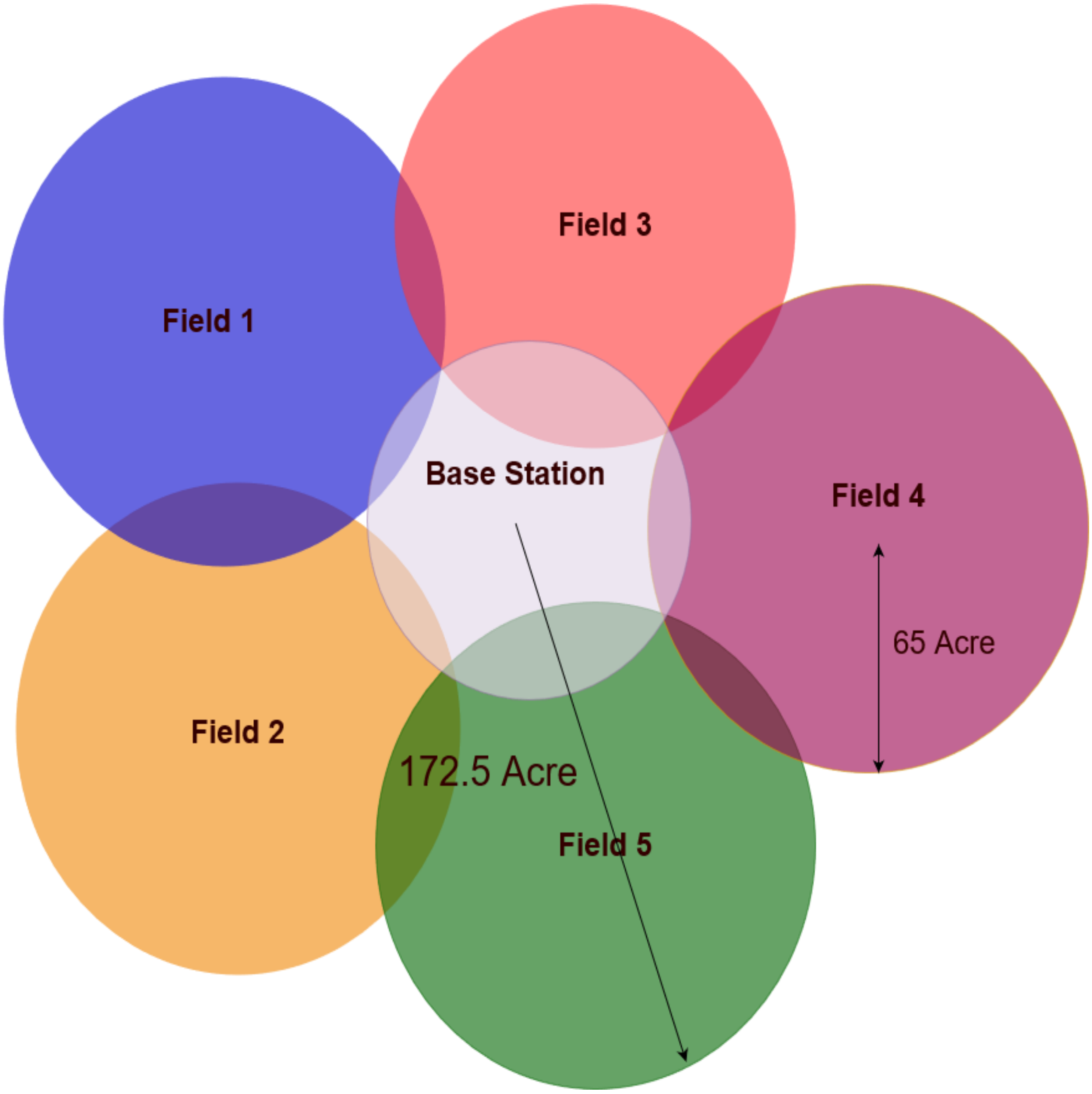


Figure 6.1: Area covered by the devices.

6.3 Limitation

There are a lot of limitation we have in our project at this phase.The limitations are given below.

- The NodeMCU is not strong enough to compute beyond a expected amount of workload.
- We have limitation with the power source we are using.
- Due to excessive pressure on NodeMCU, The LCD will not work at the same time of uploading data to server. we have to choose one or the other.
- The Web application that we made has some limitation as well. We are showing the data locally. No one can check the data remotely.
- Cloud Data server has its limitation of storing up to 1GB of data. More than that data will cost financially.
- A certain amount of data fail to transmit during the transmission.
- RF module can stop working due to excessive amount of shake.
- The device is not water proof. We made it water resistant to some extent.

6.4 Future Work

In future we want to make a all in one integrated device. By doing so will solve the issue of certain failure. We also want to make a smartphone application which we are currently working on. We will showcase the application if we are capable of finishing it before the deadline.

We also want to add more device such as humidity sensor, pH sensor, soil moisture sensor, temperature sensor to our project. We can collect all the data from all the sensor and use artificial intelligence to predict the exact time when the rice field might need irrigation.

References

[1] B.A.M Bouman, R.M Lampayan, and T.P Toung. Water management is irrigated rice coping with water scarcity. los banos (philippines): International rice research institute. 54 p. *ISBN 978-971-22-0219-3*, 2007.

[2] Md. Redwanur Rahman and Sheikh Helena Bulbul. Effect of alternate wetting an drying irrigation for boro rice cultivation in bangladesh. *Agriculture, Forestry and Fisheries. Vol.3, No.2, 2014, pp. 86-92. doi: 10.11648/j.aff.20140302.16*, 2014.

[3] M. Shahe Alam, M.S. Islam, M.A Salam, and M.A Islam. Economics of alternate wetting and drying method of irrigation: Evidences from farm level study. *ISSN-1729-5211*, 2009.

[4] Romeo Cabangon, Ruben Lampayan, Bas Bouman, and To Phuc Tuong. Water saving technology for rice production in the asian region. 5 2014.

[5] ChellaMarie D. Valdivia, Zenaida M. Sumalde, Florencia G. Palis, Ruben Lampayan, Christian Umali, and Grant R. Singleton. Effect of alternate wetting an drying on rice farming in bohol, philippines. *Philippine Journal of Crop Science (PJCS) December 2016, 41 (3):50-56*, December 2016.

[6] Dr. Ekkehard Kurschner, Christian Henschel, Tina Hildebrandt, Ema Julich, Martin Leineweber, and Caroline Paul. Water saving in rice production - dissemination, adoption and short term impacts of alternate wetting and drying (awd) in bangladesh. *ISSN 1433-4585, ISBN 3-936602-45-X*, December 2010.

[7] Debjit Roy and M. Abdus Sattar. Promoting alternate wetting and drying method in selected locations at sadar upazilla of kushtia. *The Institution of Engineers, Bangladesh, Vol. 37/AE, December 2009*, December 2009.

[8] Susan Kelly, Richard Langford, and Bill Biggs. Aligning western australia's sustainability strategy with safety, health and environmental outcome in the mining industry. October 2004.

[9] Prof. Rashmi Jain, Shaunak Kalkarni, Ahtesham Shaikh, and Akash Sood. Automatic irrigation system for agriculture field using wireless sensor network (wsn). *e-ISSN: 2395 -0056, P-ISSN: 2395 -0072*, April 2016.

[10] G. Parameswaran and K.Sivaprasath. Arduino based smart drip irrigation system using internet of things. *ISSN 2321 3361, 2016 IJESC*, May 2016.

[11] Pavankumar Naik, Arun Kumbi, Vishwanath Hiregoudar, Chaitra N K, Pavitra H K, Sushma B S, Sushmita J H, and Praveen Kuntanahal. Arduino based autometic irrigation system using iot. *ISSN 2456-3307*, June 2017.