Final Year Design Project
Final Report

Project Title:

'A Highly Efficient Solar Powered IoT Based Irrigation System'

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1.1 Introduction

1.1.1 Problem Statement

Agriculture plays a key role in Bangladesh's overall growth. Extensive irrigation, high-yielding crop varieties, more efficient markets, and mechanization, enabled by policy reforms and investments in agriculture research, human capital, and roads have driven agriculture sector's growth. Freshwater is needed for crop and energy production, industrial fabrication as well as human and ecosystem needs. According to AQUASTAT database (AQUASTAT, 2018), in Bangladesh, 87.21% of the total extracted freshwater is used by agriculture sector, whereas 2.147% is used by industrial sector and 10.04% is in used by Municipal segment. Therefore, water can be considered as a critical need in agriculture sector for future global food security. However, continuous increases in water demand from the residential and industrial sectors, as well as increased concerns about environmental quality, have made it difficult for all countries to cut farm water usage while meeting fresh food demand (Florke et al., 2013). As a result, there is a pressing need to develop water-use strategies that are based on science and technology. Industrialists and researchers are attempting to develop efficient and cost-effective automated water management systems in order to cut down on waste. Irrigation is the process of artificially watering land for agricultural purposes. The amount of water required by the soil is determined by soil variables such as moisture and temperature. Irrigation that is effective can influence the entire growth process, and irrigation systems that are automated utilizing contemporary technologies can give better irrigation management. The majority of irrigation systems are operated manually. In order to use the Internet of Things: Usage and Application for water efficiently and effectively, these old irrigation techniques can be replaced by automated irrigation approaches. Farmers willtraditionally be present in their fields to perform the irrigation procedure. However, today's farmersmust balance their agricultural activities with their other jobs. A sensor-based automated irrigationsystem offers farmers a viable alternative in which a farmer's presence in the field is not required during the irrigation process. Arduino is a programmable hardware platform that is used to intelligently control circuits. The main component of an integrated circuit chip that can be programmed using the C++ language lies at the heart of the Arduino interface board. This microcontroller is of the AVR type, which is manufactured by the Atmel company. The device canread the input, process the program, and generate a variety of outputs according on the project's needs. This chapter describes the creation of an automated irrigation system using Arduino microcontrollers. A soil moisture sensor is utilized in this system to detect and monitor the plant'ssoil humidity. The system will allow the water pump to automatically water the plant when the soil is too dry and turn off the water pump when the soil is too wet, based on the soil moisture level. A smart irrigation system is a requirement that must be met on a daily basis. We aim to builda controller system for irrigation system project which will automatically irrigate the plants or crops based on the soil moisture value, by means of fuzzy logic algorithm via Arduino microcontrollers.

1.1.2 Background Study

For years, the farmers of our country are investing their valuable time and in return they are getting very low and ineffective results due to the usage of inefficient irrigation system and therefore we are building an IoT based irrigation project which is efficient, sustainable as well as automated to reduce the hard work of the farmers and also prevent water loss. The economy of Bangladesh mostly depends on agriculture and it plays a crucial role in providing the main source of food, income and employment to their rural populations. It uses 85% of available fresh water resources worldwide and this percentage is increasing day by day because of population growth and increased food demand. Moreover, the farmers of Bangladesh have been using the traditional irrigation system in the farms. We aim for building an IoT based irrigation project which is efficient, sustainable as well as automated to reduce the hard work of the farmers and also prevent water loss. The farmers of our country are investing their valuable time and in return they are getting very low and ineffective results due to the usage of inefficient irrigation system and therefore we have researched and analyzed numerous procedures and requirements as per the condition of the field and environment of the land. We have also researched and analyzed several techniques for soil irrigation and selected the optimal solution for the project. Since efficient water management is the major concern in many farms that is why the project is aimed towards saving the efforts of farmers. Moreover, the need of solar-based systems is increasing every single day. The start of the 20th century has brought about a lot of needs in the requirement of renewable sources as the non-renewable sources are getting depleted every single moment. We have found out that, the farmers are still using the gridline-based system which is still not an efficient way as we can use the solar energy very adeptly in replacement of that. However, nowadays, another method called “Hybrid system” is getting more and more popular in the irrigation fields instead of full on-grid or full off-grid system. The agricultural sector has great importance, for that reason it needs to be developed by building a highly efficient and intelligent solar powered irrigation system.

1.1.3 Literature Gap

For finding the literature gap of the proposed project plan, it is actually necessary to review the papers first. For this purpose, review of the four base papers for our work has been discussed below.

Paper 1:

In this paper, the author described an irrigation system, which is designed to determine the exact time when the crops need water based on the soil moisture state and deliver a controlled amount of water to the roots of the crops using the help of microcontrollers and pump. The system mentioned is completely automated, running 24/7 on solar energy and is of immense importance to the agricultural sector.[1]

Paper 2:
The paper mainly signifies a technical approach based on Artificial intelligence and Fuzzy Logic Based water irrigation system. The authors of this paper have gone for the maximum optimization and minimum wastage on water delivering system on irrigation system based on drip irrigation process and developing a controller based on fuzzy logic algorithm. The crux of this paper is to design and simulate the fuzzy logic controller and simulate using MATLAB (Matrix Laboratory) the water irrigation issue. This study outlines the trends and the development of the agricultural sector with implementation of expert systems, fuzzy logic and artificial intelligence. The authors have studied on symbolizing logic that will solve agricultural problems and develop a sensible system using computer science, mathematical logic and artificial intelligence. [2]

Paper 3:
This paper signifies a new approach for solar powered smart irrigation system in agricultural management using soil moisture sensor, microcontrollers and GSMC. The whole system is running on solar energy, making use of the sensed data from the soil moisture sensors, actuating the motor based on that data and is notifying the user about the current condition of the system. [3]

Paper 4:
The paper gives emphasis on a solar-based off-grid irrigation system, which is completely automated using sensors, AVR microcontroller and Light Dependent Resistors. The solar panel is constantly providing energy for the system and the AVR microcontroller is actuating to turn the motor ON/ OFF based on soil moisture and LDR sensors data. Moreover, the system is also using a GSM system to send a message to the farmers mobile regarding the pump status. [4]

Literature Gap: In this four papers, for every project, they have focused on many aspects on irrigation system through their developed algorithms, some have focused on the watering systems only, some have focused on the maximum optimization and less water usage and even some also used the artificial intelligence method for more complex approach. But none of the papers actually focused on combining all those ideas into a single project, that will run fully on renewable energy, a controller system for systematic and automatic flow of water that will be usable for any type of irrigation field, will be based on automated and IoT system and ensure maximum optimization and ensure less water usage by controlling flow of water altogether through complex algorithm. This proposed project of ours satisfy the above criteria of combining all of the ideas of discussed papers.

1.1.4 Relevance to current and future Industry

Agriculture is the most important this for our country. A sublime, successful and continuous process of irrigation can not only ensure a perfect harvest, but also it will bring smile to farmers and provide well contribution to the economy. Nowadays, many companies, even voluntary companies are also working for ensuring quality irrigation. As the country becoming digital day by day, automation becoming more and more popular among the agriculture sectors. Nowadays, companies like IDCOL and other emerging companies are focusing on irrigation system that runs from renewable systems. Previously, companies like DELL also proposed a plan for automated irrigation project focusing the environment like Bangladesh and Nigeria for quality irrigation. Although, they did not move forward to the project at the end, but only researching with this topic for such big company like DELL proves that many companies are keeping an eye out of this sectors, as it is really an underrated sector to work with. Recently the MD of Walton High Tech Industries Ltd. has expressed his vision to make the company among the top ones in the world within 2030. Almost every sectors they have touched so far in Bangladesh, they have found success and got the market brand, in near future, they might include their future works on agriculture sector in Bangladesh as well, although it is a possibility and vogue guess just for now.

1.2 Objectives, Requirements, Specification and constant

1.2.1. Objectives

In this section, main purpose and target for our smart irrigation project, its specifications and necessary requirements and related constrains, such as- type of field, water-storage requirements, water delivery rate, back up power availability etc. will be presented.

The proposed project has mainly one objective, which notably is making a solar powered IoT based irrigation system using different type of sensors and make use of soil moisture to irrigate the fields and crops. Moreover, it is controlling and saving both water and electricity in the procedure, agricultural production and minimalizing the efforts of the farmers. All these features make these methods sustainable option to be considered to improve the agriculture and irrigation efficiency. The implementation of this project will:

- Reduce the water wastage and logging created due to excessive and untimed irrigation
- Being solar powered, it is saving electricity cost of the farmers by using the sun as a renewable source of energy.
- Simplify the irrigation system by taking control of each and every part of the system.
- Increase agricultural production by developing an efficient algorithm to do timely irrigation of the plants.
- Prevent irrigation at the wrong time by turning the motor ON or OFF.
- The controller will be able to do the whole process. Therefore, it does not need anyone to operate.
- The process is reducing the mistakes of operation when the whole system was operated manually.

1.2.2 Functional and Nonfunctional Requirements

Functional Requirements

1. If the amount of light is low/high and the moisture sensors value give out dry, a signal needs to be sent to the Master microcontroller in order to actuate the pump.
2. The system is run by a total unmanned system so the only factors to be checked by the user is the water level in the main water reserve.
3. The transceiver needs to transmit the data at a perfect rate and efficiently. Hindrance in doing so might cause the whole system to have a failure
4. The solar modules have to be capable of running the whole system.
5. The Master Arduino has to be able to find out the perfect soil moisture value.

Non-Functional Requirements

1. The whole system is very easy to implement and therefore it is quite easy to build. The materials are also very easy to replace and fix.
2. The Arduino IDE is an open source hardware therefore the price needs to be reasonable.
3. The whole system needs to run for a long time that will practically reduce the costing of the system on a whole.
4. Our project comprises of very easy to use components and modifying of the system is easy compared to other parts
5. The system performance needs to be very real time based and the accuracy is of utmost importance as it is a big running factor to the whole project being a success.
6. The system requires manned operation only when there is shortage of water and unavailability of solar energy for a prolonged period of time
7. The cost of the system cannot be too high, as it will create less interest for the customers. The system has to be made as low cost as possible also maintaining the total quality of the system. (i.e reducing the cost of the farmers and also increasing the water efficiency)

1.2.2 Specifications

Now, considering specification, we have divided into two specific phases, one is based on research and analysis phase for real time operation, other one is the prototype demonstration phase for the optimal solution representation.

For the research and analysis phase, we have considered some specific constrains and requirements and based on that, we have done some research on where we are going to implement our project, who are basically our target consumers, how many power to be consumed on the whole system, how many solar PV panel we are going to use, what type of land we are going to choose and what type of crops are eligible to irrigate on our project. For that purpose, we have found that the average 18.5kW size solar pump has the capacity to lift 25-30 lac liters of water per day [5]. It typically can irrigate 130 bighas of land expansion of solar pumps can save millions of foreign currencies [6]. This pump saves 4000 liters of diesel-burning yearly, well reduce emission of 10,072 kg of $CO2$ [7]. Moreover, there are some research one the way regarding the selection of proper soil and field for irrigation based on soil properties and water spreading, penetration time and duration

We have found some papers related to solar pump specifications and testing procedure. For example, if we consider technical specifications of shallow well solar pumping system for surface irrigation system, for a consideration of 900-watt power (Wp) PV solar array, we need to consider 1 HP motor. The shut off dynamic head would be 12 meters and the pump will deliver approximately 81,900 liters per day from a total head of 10 meters. Also, water output figures are on a clear sunny day with three times tracking of SPV panel, under the "Average Daily Solar Radiation" condition of 6.5 KWh/ square meter on the surface of PV array (i.e. coplanar with the PV Modules) [8].

For the prototype phase, we have considered the following specifications and requirements:

a. PV panel

- 12-volt 5-watt solar panel.
- High efficiency A grade solar cells small in size and easy to take.
- Can be applied to varies DC appliance
- Ideal for everyday use.

b. Solar Charge controller

- MPPT Digital LCD Display Solar Charge Controller 12-24V 10A.
- Floating charge voltage: 13.7V (adjustable)
- End-off voltage: 10.7V (adjustable)
- Discharge recover voltage: 12.6V (adjustable)
- USB output: 5V/3A
- Maximum Standby current: <10mA

c. Rechargeable Battery

- 12V 7,5AH Rechargeable Battery with 6.35mm Terminal.
- Float or. Cells Per Unit: 6;
- Voltage Per Unit: 12
- Capacity: 7.5Ah @ 10hr-rate

d. Arduino (Uno)

- Microcontroller: ATmega328
- Operating Voltage: 5V
- Input Voltage(recommended): 7-12V
- Input Voltage (limits): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 40 mADC
- Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB (ATmega328) of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328)
- EEPROM1 KB (ATmega328)
- Clock Speed: 16MHz

e. Arduino (MEGA)

- Model: ATmega2560
- Operating Voltage 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limit): 6-20V
- Digital I/O Pins: 54 (of which 15 provide PWM output)
- Analog Input Pins :16
- DC Current per I/O Pin :20 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 256 KB of which 8 KB used by bootloader
- SRAM: 8 KB
- EEPROM: 4 KB
- Clock Speed: 16 MHz
- Length: 101.52 mm
- Width: 53.3 mm
- Weight: 37 g

f. HC-SR-4 Sonar Sensor

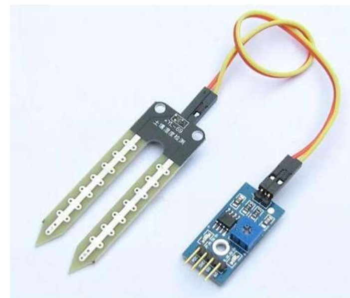
- Power Supply − +5V DC
- Quiescent Current − <2mA
- Working Current − 15mA
- Effectual Angle − <15°
- Ranging Distance − 2cm – 400 cm/1″ – 13ft
- Resolution − 0.3 cm
- Measuring Angle − 30 degree

g. Soil Moisture Sensor/Module, YL- 69 (x8)

The main purpose of this moisture sensor is to uses the capacitance to measure the dielectric permittivity of the surrounding area. Mainly, the dielectric permittivity is the function of determining the water presence of the whole area. This sensor mainly determines the presence of the water presence of the medium and then send the data to the Arduino to start/stop the pump i.e. the irrigation procedure.

Specification of this soil moisture sensor:

- Skillset: General Knowledge
- Number of Batteries: 0 Batteries
- Minimum Age: 1 years
- Material: Epoxy
- Battery Operated: No
- Battery Type: No batteries
- Rechargeable: No



h. LDR Sensor

- Light Sensitive Devices
- Material: Lead or Cadmium
- Sometimes Up to 1mω
- Indicate the Presence or Absence of Light

i. Transmitter and Receiver pair: (NRF24L1+ 2.4GHz)

- I/O can accept 5v level of input
- Low working voltage: 1.9 ~ 3.6 V
- Wireless rate: 1 or 2 MBPS
- SPI interface rate: 0 ~ 8MBPS
- 125 optional channels work
- Transmission distance up to 100 meters in outdoor open occasions

j. Water Pump

- Voltage: 12V DC
- Maximum Rated Current: 1.2A
- Power: 8W
- Max Flow Rate: 10 L/Min
- Max Water Head: 5M

k. Irrigation Water Pipe

- Outside Diameter: 10mm/0.45Inch
- Inner diameter: 8mm/0.32Inch
- Thickness:0.157″
- Lenght: 01M
- Weight:157g

l. 1 Channel 5V Relay Board Module

- 5V 1-Channel Relay interface board and each one needs 15-20mA Driver Current.
- Equipped with high-current relay, AC250V 10A; DC30V 10A.
- Standard interface that can be controlled directly by microcontroller (Arduino, 8051, AVR, PIC, DSP, ARM, ARM, MSP430, TTL logic).
- Indication LED is for Relay output status.
- It activates on low level

m. Solenoid valve magnetic dc 12v water air inlet flow switch

- Material: Metal + plastic
- Voltage: DC 12V
- Inlet and outlet: hose barbs for 1/2" (outer diameter) hose
- Pressure: 0.02- 0.8Mpa
- Max fluid temperature: 100°C
- Operation mode: normally closed
- Valve type: diaphragm (operated by Servo)
- Usage: water and low viscosity fluids

1.2.3 Technical and Non-technical consideration and constraint in design process

There are mainly technical and non-technical consideration when it comes to the requirement phase.

For technical consideration phase, we have researched and analyzed it further and found out some crucial parts. If the amount of light is low/high and the moisture sensors value give out dry, a signal needs to be sent to the Master microcontroller in order to actuate the pump. Moreover, the system is run by a total unmanned system so the only factors to be checked by the user is the waterlevel in the main water reserve. Also, the transceiver needs to transmit the data at a perfect rate and efficiently. Hindrance in doing so might cause the whole system to have a failure. The solar modules have to be capable of running the whole system. Most importantly, the Master Arduino has to be able to find out the perfect soil moisture value. Moreover, as we are working for making a perfect control system for any type of irrigation field, it is also necessary to consider selecting perfect component with perfect rating with perfect connection when it comes to real-time implementation.

For non-technical consideration, it is total come to budget allegation and the requirement set by the stakeholders. As we are targeting an off-grid system-based project, we have to make sure it delivers the best output with the cheapest but effective way possible. Also, if we have to get partnered with a voluntary group or a company (For example: IDCOL), we need to consider their requirement and handle with care so that they can deliver the system for their specific group. By this way, both parties get benefited.

There might be some situation that won't go according to the plan that we've discussed and demonstrated so far. For example, if we think about working alongside a profitable or non-profitable organization on the same project, we need to consider their limitations and requirements. Based on the data they give to us; we might need to work based on the data. The data maybe based on their land estimations, budget allocation and different target people. For that purpose, the estimations we've discussed so far may vary compared to them. The budget may vary as well, it may increase significantly, or may be very less than what we've estimated. Also, the organization may not provide full funding as well.

We have to be prepared for every constrains possible and act accordingly. If the specific organization doesn't provide funds for the project initially, we may need to make some primary negotiations beforehand to get some specific percentage of profit from the overall profit (For example: 60% profit will be provided to us from the profit gained by that organization). In this way, both parties will be benefited by the overall work management as per the company policy and together we can satisfy many farmers and distribute our irrigation project accordingly.

1.2.4 Applicable compliance, standards, and codes
Part-By-Part Standards [According to IDCOL]
Pump/Motor

- The pump needs to be surface mounted or submersible.
- We are specifically using DC pumps but in case of AC pumps. Other measures need to be added.
- The required minimum insulation of motor is to be of 'F' class.
- The efficiency of the pump is to be tested before employment.

Charge Controller

- The controller may/may not have MPPT technology.
- The controller needs to have short circuit and overload protection.
- The controller must have minimum efficiency of 90%
- The controller must be tested and certified against efficiency from IDCOL accredited testing center i.e. (BUET).

PV Panels

- The photovoltaic module should have a peak power output of at least 250Wp
- IEC 61730 for safety equipment.(International Electro-technical Commission)
- IEC 61646: Thin Film Silicon Terrestrial PV Modules Design Qualification and Type Approval.
- IEC 61701 Ed 2.0: Salt mist corrosion testing of PV Modules
- International Electro Technical Committee (IEC) 61215:2005: Crystalline Silicon Terrestrial PV Modules Design Qualification and Type Approval
- Each module must have permanent labeling indicating at a minimum: Manufacturer, Model Number, Serial Number, Peak Watt Rating, Voltage and Current at peak power, Open Circuit Voltage, Short Circuit Current and Cell Efficiency of each module.

Rechargeable battery [Batteries in general, taken from electropaedia] Standard Number Title

• **IEC 60050**	International electro technical vocabulary. Chapter 486: Secondary cells and batteries.
• **IEC 60086-1, BS 387**	Primary Batteries - General
• **IEC 60086-2, BS**	Batteries - General
• **ANSI C18.1M**	Portable Primary Cells and Batteries with Aqueous Electrolyte - General and Specifications
• **ANSI C18.2M**	Portable Rechargeable Cells and Batteries - General and Specifications
• **ANSI C18.3M**	Portable Lithium Primary Cells and Batteries - General and Specifications

- **UL 2054** Safety of Commercial and Household Battery Packs - Testing
- **IEEE 1625** Standard for Rechargeable Batteries for Mobile Computers
- **USNEC Article 480** Storage Batteries
- **ISO 9000** A series of quality management systems standards created by the ISO. They are not specific to products or services, but apply to the processes that create them
- **ISO 9001: 2000** Model for quality assurance in design, development, production, installation and servicing.
- **ISO 14000** A series of environmental management systems standards created by the ISO.
- **ISO/IEC/EN 17025** General Requirements for the Competence of Calibration and Testing Laboratories

1.3 Systematic Overview/summary of the proposed project

In our project called "A Highly Efficient Solar Powered IoT Based Irrigation System" has some distinctive methodology which needs to be handled and maintained with care. The following steps have been given as an overview of the methodology of our project in brief details:

• The power source for the project comes from the renewable energy, and the sun is one of the most commonly used sources for the renewable energy, which is directly converted to electrical energy by using Solar PV Panel.

• After the solar energy converted to electrical energy from PV Panel, the converted electricity follows the path into the PWM charge controller (available with USB port) and the charge controller connected to the battery charges the battery, hence, begin the process to store the electricity to the storage, which in this case, a 12V 7.5AH Rechargeable Battery.

• As from the previous point, one end of the charge controller is connected to the battery and the other parts are connected to the Master Arduino (Arduino MEGA) and the 2x1 relay module, there will be another relay connector to the system for the 12 Volt 1.2 A DC Pump which will actually supply water to an installed overhead tank with the sonar sensor attached to it beforehand on a particular level. 2 solenoid valve is connected to the 2x1 relay module, ready to be powered up 8/24 whenever relay is active and ready to supply water to the field. The charge controller will power up the Arduino and it will also power up the solenoid valve (through the relay module).

• For the sake of the achievement of accuracy and fluency of our project, the whole system has been divided on two different types of Microcontrollers - one is Master Microcontroller and other one is Slave Microcontroller. An overhead tank is installed with sonar sensor attached to a particular level to stop the

• The whole project parts have been divided into three modules: The Sensing Module, The Communication Module and The Control Module.

• Sensing Module is consisted of four sensor components: Eight Soil Moisture Sensors, an Arduino UNO (works as Slave Microcontroller), an LDR sensor and a transceiver (nRf24L01+), used for receiving and sending signals for Master Arduino.
• A Soil Moisture Sensor can measure the accuracy of the soil from number 0 to 1023 and separates the accuracy of the soil based on a predetermined range. The input taking method and division method is hard coded by default on the sensor. For this project, The Soil Moisture Sensors senses the data from the plant soil within the range of 420 to 1023 based on its architecture and moisture content. This data is mainly collected as raw data, which is stored on the Arduino UNO (Slave MCU). It maps the data information to a value between 0 to 100 percent. LDR sensor senses the sunrays of the daytime, converts into the data within the range of 0 to 1023, also hard coded by default, and send the value to the UNO (a range is set for nighttime means no irrigation will occur, will be done manually on programming and implementation phase [5th phase of proposed Gantt Chart]).
• The Arduino UNO then sends the data to the transmitter (nRf24L01+ working as transmitter here), which delivers it to the receiver part of the Master Microcontroller (Arduino MEGA). The receiver (nRf24L01+ working as receiver here) receives the data sent by the transmitter and delivers to the master Controller to do the rest. This is mainly the communication module of the system.
• The control Module consists mainly of an Arduino MEGA 2560 (Master Microcontroller), and LCD display, a receiver (nRf24L01+ transceiver) and a two-channel relay module (above mentioned 2x1 relay module). Those all components are operated by the master Controller (Arduino Mega) which compares the soil humidity values (received from the slave controller via the transmitter) with a set of ranges.
• The Master Arduino is going to run on a special algorithm, which is to be developed by us. This algorithm is going to make use of the soil data and make assumptions that are more precise. The whole system is going to be highly efficient and accurate since it is trained to predict the perfect soil moisture data based on previous data sets of soil moisture.
• The Arduino MEGA will decide when to turn on and off the pump based on the received values and the ranges (previously measured by the above-mentioned algorithm) and continue doing the irrigation process accordingly, which in this case, turn the water pump on and off.
• The pump is mainly used to initiate the irrigation system (watering the plants). • The live data of the soil moisture will be continuously shown at the LCD module. In addition, it will show when the pump is active and when it's not. • From the pump, a set of pipes are connected and scattered throughout the testing field.
• The pipes will be gone through the roots of the plant, considering that the concept of "Drip Irrigation System" is being applied.
• While turning on the pump, the water will be flown through the pipe and directly will be delivered to the roots of the plants, hence completing the cycle of the working procedure of the prototype project. The same cycle will be run continuously and the quality of the soil will be monitored continuously, achieving the maximum efficiency of the irrigation process.

1.4 Conclusion

In this project, as we have already mentioned that our main aim is to develop and IoT based irrigation system which is highly efficient one that can specially help farmers from the rural area where machined irrigation equipment hasn't reached yet. For this purpose, we are building such kind of controller algorithm can be able to measure the soil moisture data through soil moisture sensors on it's own and water the field more efficiently and accurately with lesser wastage of water resource. That's why in this chapter, what we tried to focus is the step by step approach of the project to make the project an efficient one. We are also trying to come to a conclusion with the most optimized solution that would be able to give the outputs that is irrigation of fields more accurately and can be able to match with our expected result. In fact, we can say that, completion of this project in an efficient manner can make a huge difference in the upcoming agriculture systems of our country in a most positive way.

Chapter 2: Project Design Approach [CO5, CO6]

1.1 Introduction

We have identified two different approaches based on our design requirements. Our multiple design approaches are based on the parameters of wireless/non-wireless, PV system differences, Master-Slave/ Non-Master-Slave and algorithm differences. The two systems are containing their own unique criteria and are performing perfectly in their own way.

1.2 Identify multiple design approach

The two multiple designs for our finding a perfect solution are -

1) **Average value based Control System with Direct Coupled PV system**

2) **Fuzzy logic based Control System with Stand alone PV system with battery storage**

1.3 Describe multiple design approach

1) Average value based Control System with Direct Coupled PV system

Direct coupled PV system:

This type of system includes the system where the PV array is connected to a DC load. There can be usage of an MPPT system in order to make the direction and control of the current quite easier and make use of the maximum power output. This type of system is totally an off grid system and therefore the whole system is self sufficient and also the system can be grown as per requirement of the whole design. The specifications of the system does depend on the load requirements. The more the load the more PV panels are required. For example- 1500W Solar panel for a 1hp submersible DC Motor pump (Solar Deep well Pumping Systems).

Average Controller Design:

In our controller design-1, we find the introduction of 10 soil moisture sensors in order to run an Arduino based system where Arduino is taking the values from the sensors, making average of the value and running the pump based on that value. The main design of the system includes the usage of Analog Pins of Arduino. This system is a closed loop control system and therefore can be run completely unmanned. The size of the relay for this system depends on the sizing of the pump and the solar panel.

PV System Design (Average):

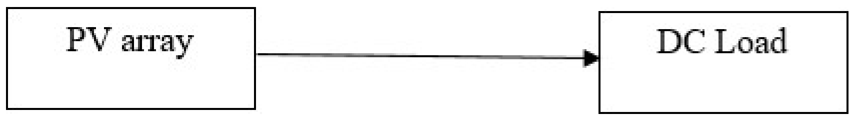


Figure 1 Direct coupled PV system

Controller System Design (Average) :

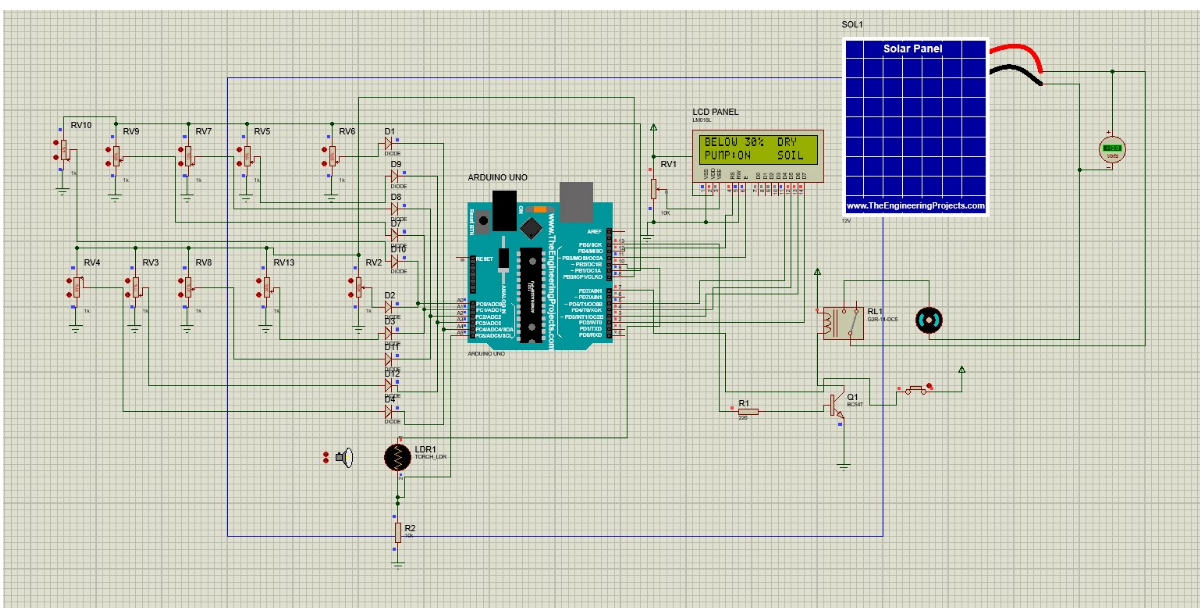


Figure 2: System using average value algorithm and 1 Arduino

Flowchart of system (Average) :

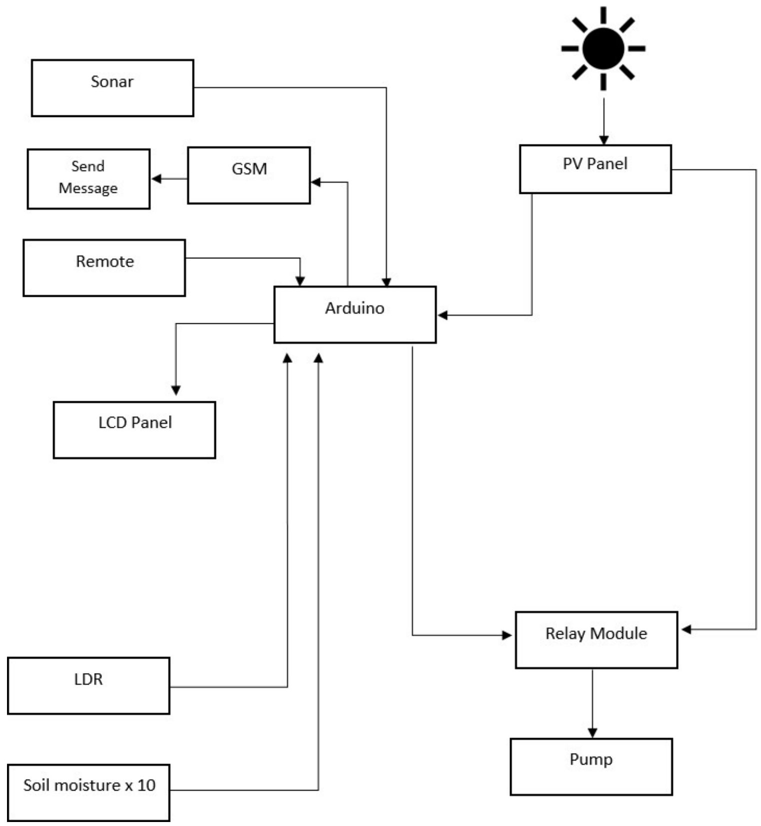


Figure 3: Flowchart of system 1

Algorithm (Average):

Initialization of variables
Initialization of LCD
Initialization of Pin Modes

Turning pin10 high
➔ LDR sensor ON
Reading values from A0, A1, A2, A3, A4, A5
➔ Getting soil moisture values
Making Average of the values

```
Pre-setting a value of threshold1 , threshold2

if (Moisture< threshold1)
        if (LDR==1)
                → LCD write
                → PUMP:ON
        else
                → LCD write
                → PUMP:OFF
if (Moisture>= threshold1 && Moisture<=threshold2)
        → LCD write
        →PUMP:OFF

if (Moisture > threshold2)
        → LCD write
        →PUMP:OFF
```

2) Fuzzy logic based Control System with Stand alone PV system with battery storage

Stand alone PV system with battery storage:

The usage of a battery in order to backup the system and also run AC loads is imminent in this section. Therefore the AC pumps can be connected if needed just in case. This system contains the same specifications to that of direct coupled but the system is making sure to store the power received in a battery. The battery can also invert the power and also supply the AC load when required. We can also understand that this system can be used to supply any type of AC pumps for our requirements.

Fuzzy Controller Design:

This is the second integrated design which is way better and convenient than the previous one. This system includes the system of Master- Slave for our operation. This system is much flexible as the number of Slaves can be increased keeping only one Master, i.e the main Arduino. The biggest and important addition to this system is the addition of valves/ stepper motors for running different lines of water as per requirement. The algorithm for this system is the inclusion of fuzzy logic to dictate our solutions. The fuzzy logic system is consisting of fuzzy membership functions. Fuzzy logic is giving us the output regarding the amount of valve to be opened based on the given moisture values. The slave arduinos send signals as nodes to the main hub and the main valve is turned on. The slave Arduinos are doing the job of controlling the valves/stepper motors.

PV System Design (Fuzzy) :

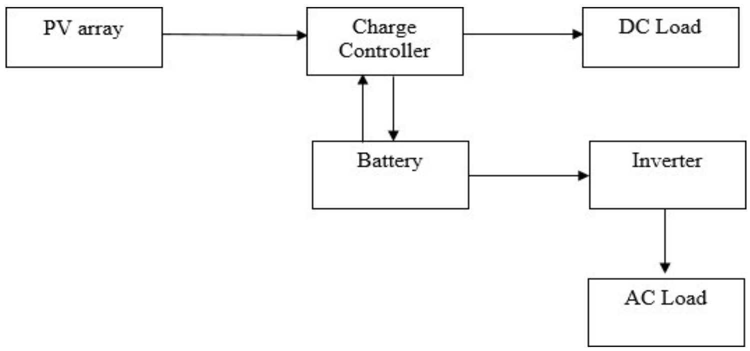


Figure 4: Stand alone PV system with battery storage

Controller System Design (Fuzzy):

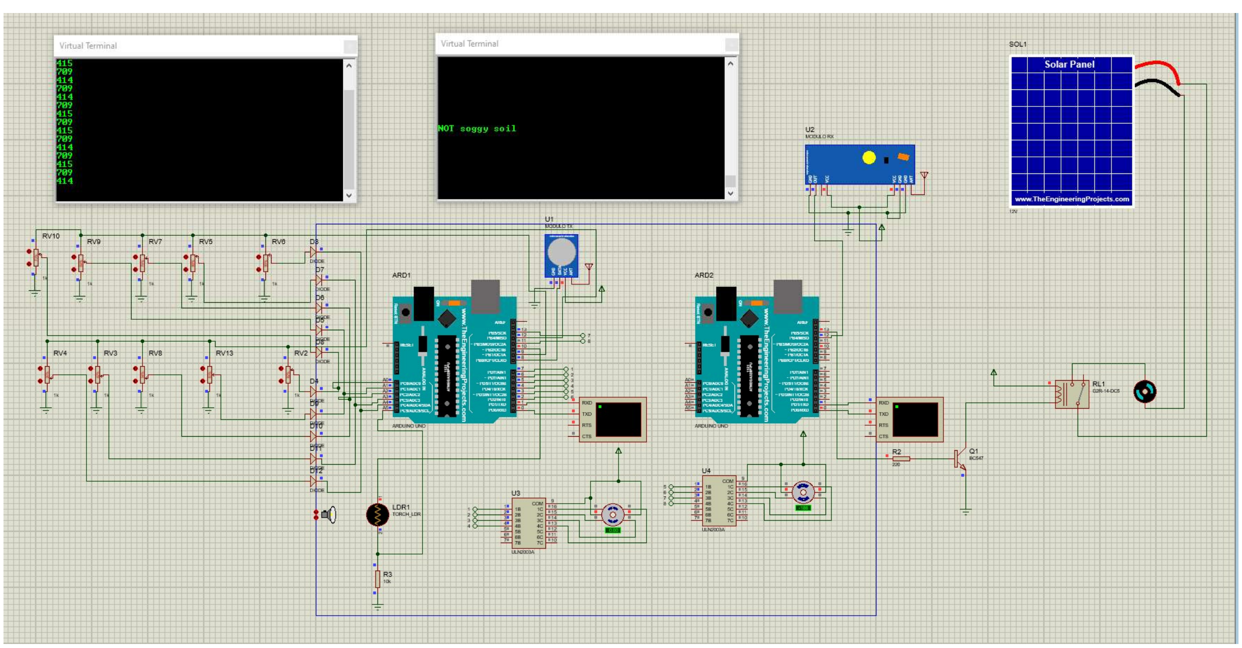


Figure 2 System using fuzzy algorithm and 2 Arduinos

Algorithm (Fuzzy):

```
Initialize variables startComp← false.
    Building fuzzy rule set.

    If attachpin==rising edge do
    Reset lockmost1, lockmost2, setmost1, setmost2 to 0 and
startComp← false.
    Else
            While startComp==false
                    Read value from Moisture Sensor
                            For i=0, i<300, i++;
                                    button = Analog reading from A0 pin.
                                            If button=0 &&setmost 1<100 then
                                                    setmost1++.
                                            Else If button=0 &&setmost 1>0 then
                                                    setmost1--.
                                            Else If button=3 &&setmost 2<100 then
                                                    setmost2++.
                                            Else If button=4 && setmost2 >0 then
                                                    setmost--.
                                            Else button=2
                                                    Fuzzyfication of setmost1.
                                                    Fuzzyfication of setmost2.
                                                lockmost1 = difuzzyfy of setmost1
                                                lockmost2 = difuzzyfy of setmost2

                    startComp = true,
                    Display setmost1, setmost2 and M as Output in LCD
                While startComp = True
                Read value from Moisture Sensor.
                Set M as input for fuzzyfication.
                Output1 = difuzzfy of M.
                Display lockmost1, output1, setmost1, setmost2, level.
                If Output1 => lockmost1 then
                    Motor off.
                            Flag←false.
                Else If Output1 < lockmost2 then
                    Motor On Forward direction.
                    Time_delay = full.
                    Flag←true.
```

If Flag = true &&lockmost2 <Output1 < lockmost1 then
Motor On but water flow decreases slowly.

Flowchart of system (Fuzzy):

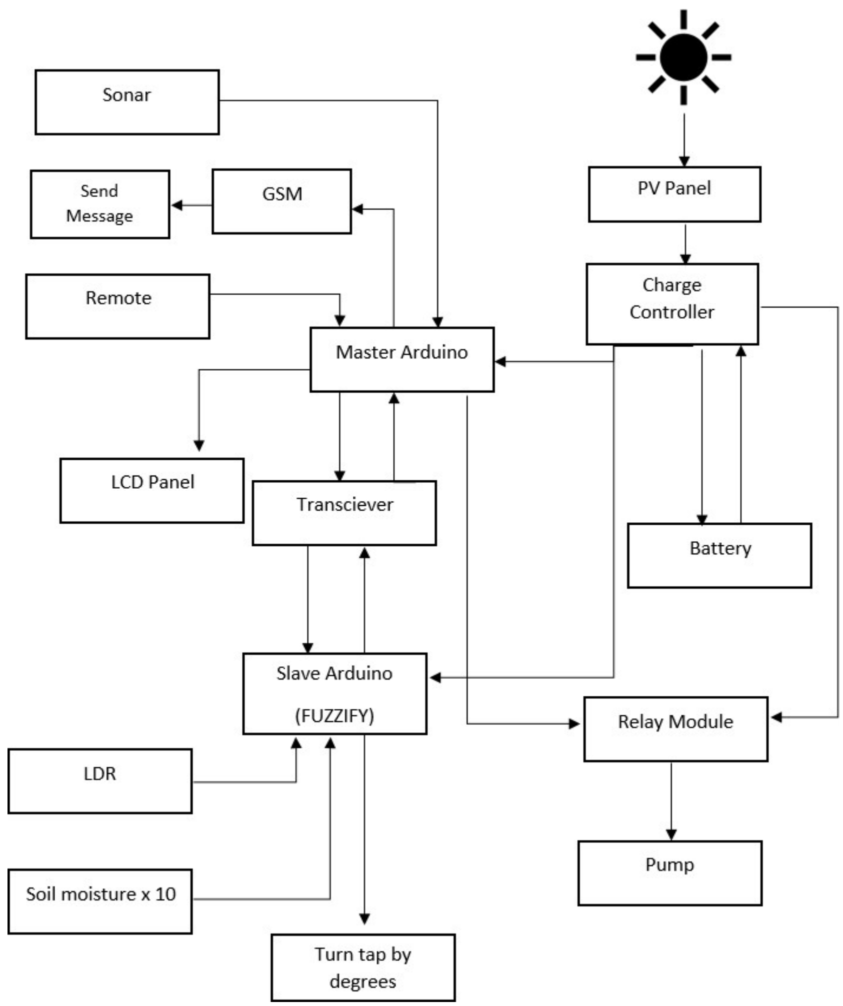


Figure 6: Flowchart of system (Fuzzy)

1.4 Analysis of multiple design approach

Average value based Control System analysis:

PV system analysis:

In this system we see that the PV panel is directly connected to the DC load. Our system was to analyze and turn the DC load on/off based on the requirement of the soil. Stand-alone PV systems are ideal for remote rural areas where other power sources are either impractical or unavailable. Among the different applications of off grid PV systems is the PV pumping system which we are going to use in this Average system analysis. This system is widely used in domestic and livestock water supplies and small-scale irrigation systems, especially those employed for water and energy conservation such as low-head drip irrigation systems. Mostly, PVPS consists of PV array, drive system, and storage element, which can be a water tank. The drive system is composed of a motor pump set and a power-conditioning component to extract the maximum power from the PV panel and drive the motor. The most commonly utilized motor in stand-alone battery-less PVPS is the permanent magnet (PM) DC motor, since it can perform well even under low irradiance level and it is simple in control. In PM DC motor-based PVPS, one or more DC–DC converters are required between the PV panel and the motor for control and drive purposes.

Average Controller system analysis:

The average soil moisture algorithm is working in this case to analyze the condition of the soil. Making average value of all the soil moisture sensors in the system will not be of much avail as abnormalities can happen in any part of the system but the system will not respond to each one of them as the algorithm is running based on the whole average value. The PV panel will always supply voltage but the voltage will not be supplied unless the Arduino is getting the soil moisture value according to the values set by the system. Since the system is getting more and more dense while adding more sensors, so anomaly in a single line or a single plant will not be accessed much, the whole value will get more and more emphasis. Therefore, the average value algorithm is quite undermining in cases for full project implementation.

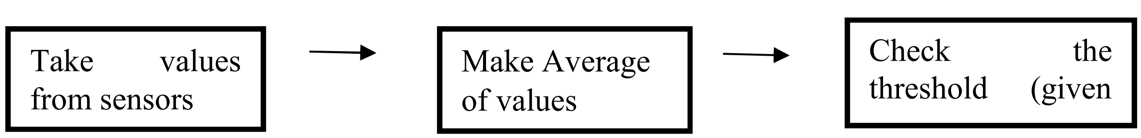


Figure 4 : Average Algorithm Working Principle

Fuzzy logic value based Control System Analysis:

PV system analysis:

The PV system design is chosen as an off-grid system with battery backup because this system does not require the backup of a grid system for operation and for using any type of pump equipment this type of system is the best in terms of all aspects. Due to their financial viability and lower cost, now a day an increased number of people are getting interested in solar irrigation pumps with off grid system. Being dependent mostly on agriculture, solar water pumps are the best sustainable solution in Bangladesh. The sunlight is a renewable source of energy. They are economical, save electricity and fuel and therefore the system is quite reliable and is viable for manufacturing. If we are considering sun staying behind the clouds for days, we can affirm that there is possibility of rain is very high in that place. In addition, the biggest pro is that the system will not turn ON in case of the soil being wet. Therefore we can assure the viability of the system

Fuzzy Controller system analysis:

We selected the system with Master Slave system because we can use a bus in order to increase the number of Slave Arduinos in our system and make out outputs for almost all plants in the system. The average valued algorithm consisted of only less number of sensors and less number of possible increment in number of sensors.

Fuzzy control system:

1. Define the linguistic variables and terms (initialization)
2. Construct the membership functions (initialization)
3. Construct the rule base (initialization)
4. Convert input data to fuzzy values using the membership functions (fuzzification)
5. Evaluate the rules in the rule base (inference)
6. Combine the results of each rule (inference)
7. Convert the output data to non-fuzzy values (defuzzification) [2]

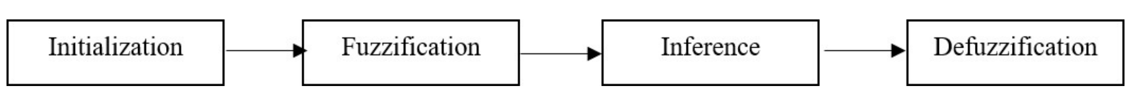


Figure 7: Fuzzy Control System

To ensure the perfect reading hundreds of sensors may be needed which is not feasible. So, like the diagram for each section of land there will be one or two sensors planted in one side of the land and on the opposite side water pipe will be planted with motor-controlled water tap. That tap can be operated in either single step output, or multistep output. In single step, the tap will be shut off instantaneously and in multi-step the valve or tap will be shut off step by step, for example, when the moisture level is reached near to required level the valve position will be close to off state and when the moisture level is finally reached to the required level, the valve will be completely shut off.

We can set multiple cases for the system. The cases are defined below.

Case 01:

The regular flow of water is ensured. The valve will turn ON and maintain the required amount of water in the system and will maintain a perfect time of irrigation which is found from the fuzzy value. The system can be defined according to the need of the crop and therefore the water flow will exactly be maintained and even more efficiently

Case 02:

The valve will turn ON and give lower amount of water needed by keeping the time for valve turned ON lower than Case 01 as the system's moisture is increasing rapidly and will make an outcome of required moisture very fast. So, the biggest importance is to slow down the flow of water to monitor it properly

Case 03:

The valve will turn ON but will stay turned ON for lesser amount of time than Case 02 and therefore lesser amount of water is ensured. In this case, the required amount of moisture is almost reached so the valve will turn off within a few moments.

Case 04:

The valve is completely shut and therefore this line will not allow any water to flow, as this line does not require any amount of water to be given to the plants therefore maintaining the required amount of water for each line.

1.5 Conclusion

Finally, we can understand that the fuzzy system and the average system consisting of their own unique features. The step-by-step configuration of the fuzzy system is considered to be a groundbreaking feature as it is making sure the plants get the perfect amount of water according to the need of the system without turning all of the valves in the system as on, which a major disadvantage in the average value system.

Chapter 3: Use of Modern Engineering and IT Tool. [CO9]

3.1 Introduction

3.1.1 Select appropriate engineering and IT tools

For developing and implementing the prototype of the project, we have used multiple engineering IT tools both software and hardware based. The thing to be noted that, the tools for the prototype is selected based on the element Modern Tools Usage (WK6) of Graduate Attributes chapter (WA5) of Washington Accord. The listings are given below.

Hardware Based:

- Arduino MEGA
- Solar equipment tools
- Breadboard
- Wires
- Soldering Iron
- Glue Gun
- Transceiver Pair
- Input Sensors
- Cutting Tools
- PVC board

Software Tools:

- Arduino IDE
- Proteus
- Arduino Excel Data Logger
- Excel tool

3.1.2 Use of modern engineering and IT tools

Hardware Tools:

● Arduino MEGA	Master Controller in this prototype.
● Arduino UNO	Slave controller in this project, attached on the test bed with the input sensors.
● Solar equipment tools	PV Panel and charge Controller, main source of power. PV rating: 12-volt 5-watt. Charge Controller type: PWM
● Breadboard	a construction base for prototyping of electronics. The Breadboard power supply has 3.3V/5V selectable output on two channels. The maximum current can be drawn is 700mA.
● Wires	Jumper wires for overall wiring done through the breadboard and controller and 2mm wire for PV panel, charge controller, solenoid valve and motor connection.

- Soldering Iron — A hand tool used in soldering. It supplies heat to melt solder so that it can flow into the joint between two work pieces.(Used on wire connection PV panel, motor, solenoid valve)
- Glue Gun — Hot melt easily to use a multi-purpose glue gun for almost all bonding jobs.(Used for placing whole system to the PVC Board)
- Transceiver Pair — NRF24L1+ 2.4GHz
  Used for sending and receiving field data between two controllers.
- Input Sensors — YL-69 Soil Moisture Sensor for taking data-set value from test-bed, Sonar Sensor for overhead tank, LDR Sensor for determining day-night times.
- Cutting Tools — Anti Cutter has been used for initializing cutting jobs.
- PVC board — 20x18 inch board used for placing the whole system altogether.

Software Tools:

- Arduino IDE — The open-source Software (IDE),
  Used for writing codes for the project and upload it to the board.
- Proteus — Simulation based software, developed by Lab-center. Used for simulating the schematic diagram for the overall project at initial phase.
- Arduino Excel Data Logger — A software assigned to collect the serial monitor data to putting it to excel sheet using command prompt and php mechanism.
- Office tool — Microsoft Excel for demonstration of the real time data. Also used for making gantt-chart.
  Microsoft Word for report writing and tabulation purpose.

3.1.3 Conclusion

In this chapter, we have solely focused on demonstrating all the modern IT tools used for the compilation of the project. We had to prepare the prototype of the project within a given time limit, so selecting and using the appropriate IT tools were necessary from the very beginning. Moreover, all of the tools are selected and demonstrated in this chapter by following the international law of graduate attribute of Washington accord, as said before. Based on the direction and guidelines, the listings and descriptions are given above . However, some of the tools were very dangerous to work with as it might cost burning or cutting of the body parts through sharp edges of the objects. That is why we had to work keeping all the precaution in mind.

Chapter 4: Optimization of Multiple Design and Finding the Optimal Solution. [CO7]

4.1 Introduction

The reason why we chose system design 2 is because the system is destined to save water for the irrigation purpose. Wastage of water in irrigation is mainly caused by; first: the use of traditional techniques which are based on timers such as basins and furrows irrigation and second: the water loss through ground evaporation and crop transpiration (so-called evapotranspiration ET) [9]. Fuzzy logic algorithm is destined to save almost 12% water for our systems as the system is directly working for the perfect timing of the system to be shut down and therefore save excess water to be flown. The biggest complexity in this algorithm is running the valve and this system is using the valve in the perfectly coordinated way to shut down the supply of water when there is no necessity. Some tests were run in the literature review that we surveyed. We found out that fuzzy logic can save almost up to 79.2 liters of water and therefore avoid misuse of water in our agricultural farms. [2]. This algorithm can generate multiple values in between the on and off state. In irrigation system there many variables that can change the amount of water needed for a field. For example, soil moisture, temperature, wind speed, salinity of soil, evaporation rate all of these have direct impact on the need of water in the field. So fuzzy logic can be an effective solution to consider all the variables of the system and generate an accurate output.

4.2 Optimization of multiple design approach

Optimization based on cost:

The initial cost of the average value system might be lower than that of the fuzzy logic based one since we are using fewer components in that system. Average system contains only usage of one Arduino and no solenoid valves and transceivers too but the usage of those products are much necessary in order to maintain the whole system performance as our primary objective is to maintain the irrigation of the whole field and make the system more efficient. The fuzzy logic system will ensure the watering of the whole system and therefore the revenue at the end of the work will be much times higher than the fuzzy logic one.

Optimization based on efficiency:

Since, the threshold of the average system is supposed to be an overall value with making use of testing data and selecting the proper threshold for the required amount of soil moisture. Even if we use 50% of soil moisture as the threshold the algorithm will under irrigate the system and therefore the crops might not receive the required amount of water for their health and therefore the proper irrigation will actually fail which is reducing the efficiency of the system. In that case the efficiency of the system will not be efficient as the total output will be for the percentage of the crops on the field. If we increase the threshold of the system the total system will be over irrigated an therefore there will be excess usage of water, the reduction of which is a prime requirement of our system.

However, in fuzzy logic the threshold is not of a headache as the fuzzy logic is making use of each of the lines of data and therefore each of the values are taken into consideration and proper requirement of irrigation is maintained. The making of the system includes the usage of solenoid valves and therefore each of the lines of solenoid valves are being accessed and used. The solenoids are being used in an efficient manner by the Arduino through the means of the battery and making sure that each of the plants are getting the proper amount of water, that is the required time to irrigate the whole field is being maintained. The efficiency in this case is close to perfect and better as this system not only maintains amount of water but also less usage of water.

Optimization based on usability:

The average system is quite underwhelming in this case as the system is being used as the pump as a source and making the whole field irrigated through the usage of pipes. There is a functional weakness in this case as the water pumped is irrigating the fields but there is no storage to the system. Therefore the pump will be turned on more often than usual and therefore that might be a constrain as the battery will be more drained and solar power may not be that much be available at all times in that part of the world.

The usability of this system is the usage of storage tank and the solenoid valves. The water is pumped to the tank and therefore the water is sent through the solenoid valves to the plants. The system is viable a lot in this case because each and every line can be assessed and the solenoid valve will be turned on simultaneously according to the time of irrigation found out by the use of fuzzy logic so each of the lines will get irrigated according to their need, which is quite different than that of the average value system where if only half of the system needs water the whole system will get irrigated for no reason and therefore usability in this case is much better.

Optimization based on manufacturability:

The manufacture of both of the systems are quite the same as both of the systems are running on almost the same components with little less differences. The biggest difference in this occasion is that the fuzzy logic algorithm will have better manufacturability as it is making sure that the system is getting enough amount of water as per requirement but the average system is running just per average system and therefore it is not a viable system as per requirement.

Optimization based on impact, sustainability, maintainability:

Average value system might have an impact on small level irrigations, that is making use of small gardens and small plots of lands for irrigation as the algorithm is not very tough and the maintaining of the system is not tough. The system can also be sustainable and can run for a lot of time in the end for the maintaining of the system for small level irrigations. It is more of a day-to-day use for most people who are just irrigating the fields for grass or other small plots. The system does not include batteries, which is a big problem in this case. As there is no storage, the impacts will be there when there is nothing to run the pump on days when there is no sunlight.

For big level irrigations like people who are commercially very active and are doing irrigation for the livelihood and contributing to the economy of the country, fuzzy logic irrigations is the perfect way to approach. The system will be quite reliable making perfect amount of water to the plants ensuring the proper growth of the crops and therefore the yield at the end of the year will be better. Therefore, the revenue will be quite higher than the usual and thus the trust of the stakeholders and ensuring the output of the system is the best is the actual focus. The maintainability of the system is quite a hassle but every system that is complex will result in better results. The system is complex because the system is making sure of the Et0, that is the crop factor to ensure proper amount of water for any crop at any given time of the season. The increase in parameters of the system will increase the complexity of the system but still since the whole system is being run on Arduino the most usage is being made. This system also uses batteries in order to run the system on times when the solar panels are unable to provide supply, so the maintenance and disposal of battery when the life cycle of the battery is finished is a big factor.

4.3 Identify optimal design approach

The approaches in order to find the perfect solution for our need are-

1) Best use of given components in the given market

   The markets is swarming with a lot of recent technologies in order to support our case and therefore the usage of modern tools is a must. We can see that the fuzzy logic algorithm will make use of the AI system and use the performance of the system to find out the better performance of the whole system repeatedly. The fuzzy system will also be using the solenoid valves and transceiver system as a connecting agent between two nodes of the system and therefore more and more number of systems can be implemented in the same field for better irrigation management. The average system is lagging in this case because the system is consisting of nothing other than just an Arduino where all the number of sensors and wiring is a limitation.

2) Perfect usage of water and reduction in wastage

The system is to be considered the best system in considering the water management and making the lowest reduction in water wastage. The water is a valuable resource for us and therefore making sure that the water is not wasted for unnecessary reasons are a must. The trust worthy factor in the case of finding out the amount of water required for any size of land is the Et0 factor, which is calculated based on some parameters.

Basic formula for the calculation of crop water requirements is:
ET_{crop}- kc × Et_o

where:

ET_{crop} = the water requirement of a given crop in mm per unit of time

kc = the "crop factor" [17]

SI	Crop	Kc(initial)	Kc(medium)	Kc(end)	Max Crop Height (h) (m)
1	Corn	0.8	1.15	0.15	1.5
2	Sugar Cane	0.4	1.25	0.75	3
3	Rice	1.05	1.2	0.9	1
4	Tomato	0.45	1.15	0.80	2
5	Cucumber	0.45	0.9	0.75	1.5

Table 1: Crop factor of different crops according to height

Now, kc of tomato in middle growth is =1.15 (average among different kinds of them) [15].

ET_o = the "reference crop evapotranspiration" in mm per day

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

Table 1: Crop Factor Values

Where,

ET_o- Reference evapotranspiration [mm day]
Rn- net radiation at the crop surface [MJ m day-]
G- soil heat flux density [MJ m' day ']
T- air temperature at 2 m height [°C],
u2- wind speed at 2 m height [m s^{-1}],
es- saturation vapour pressure [kPa],
ea- actual vapour pressure [kPa],
es - ea - saturation vapour pressure deficit [kPa],
D- slope vapour pressure curve [kPa °C-1],
G- psychometric constant [kPa °C-1].

ET_0 varies place to place. According to a research from Bangladesh Agricultural University the ET_0 value of Mymensingh District of April is 5.5. Since our project is being done at the moment in Mymensingh so we are considering the water required as per the Et_0 of Mymensingh.

ET_{crop} (for tomato) = 5.5*1.15 = 6.32

So in a 100m2 area of land requires:
10 × 10 × 0.0063 = 0.63 m3 = 630 liter/per day. (this is done for a draft field)

We are to calculate the size of our field and based on that field we are to calculate the amount of water saved

4.4 Performance evaluation of developed solution

According the instructions provided to us we had our tests on a bed consisting of 6 sensors and two lines of solenoid valves. The solenoid valves were running independently and therefore the average system was enabling the solenoid valves to run at once and the fuzzy system was making sure that each solenoid valves were operating according to the need of that line. The parameters that we got from the bed are as follows

Sensor value scenario for Average value algorithm:

Sensor 1	Sensor 2	Sensor 3	Sensor 4	Sensor 5	Sensor 6	Average Value	Valve 1 Condition	Valve 2 Condition
992	985	978	975	988	991	984.8	ON	ON
990	985	978	976	987	1009	987.5	ON	ON
989	985	979	978	989	325	874.2	ON	ON
990	986	978	984	988	276	867.0	ON	ON
991	991	984	982	1023	296	877.8	ON	ON
991	991	984	987	140	237	721.7	ON	ON
990	991	984	981	164	261	728.5	ON	ON
990	990	983	981	174	271	731.5	ON	ON
989	988	980	293	194	292	622.7	ON	ON
988	987	979	293	194	292	622.2	ON	ON
989	987	979	294	195	293	622.8	ON	ON
990	984	980	294	195	293	622.7	ON	ON
989	201	977	295	195	292	491.5	ON	ON
989	202	976	296	196	294	492.2	ON	ON
990	203	978	297	197	295	493.3	ON	ON
1007	215	313	307	207	305	392.3	OFF	OFF
1006	215	313	308	208	305	392.5	OFF	OFF
313	212	313	309	209	306	277.0	OFF	OFF
313	213	313	310	209	306	277.3	OFF	OFF
310	209	309	306	206	303	273.8	OFF	OFF

Table 2: Average value system working data log

Sensor value scenario for Fuzzy logic algorithm:

Sensor 1	Sensor 2	Sensor 3	Sensor 4	Sensor 5	Sensor 6	Fuzzified Value 1	Fuzzified Value 2	Valve 1 Condition	Valve 2 Condition
992	984	977	974	988	991	32.00	32.00	ON	ON
991	984	977	974	988	991	32.00	32.00	ON	ON
992	985	978	975	988	991	32.00	32.00	ON	ON
990	985	978	976	987	1009	32.00	32.00	ON	ON
989	985	979	978	989	325	32.00	32.00	ON	ON
990	986	978	984	988	276	32.00	32.00	ON	ON
991	991	984	982	1023	296	32.00	32.00	ON	ON
991	991	984	987	140	237	32.00	32.00	ON	ON
1009	205	1001	298	198	296	32.00	0.00	ON	OFF
1002	203	297	296	196	293	32.00	0.00	ON	OFF
1004	209	304	301	201	298	32.00	0.00	ON	OFF
1005	210	307	303	203	300	32.00	0.00	ON	OFF
1006	211	309	304	204	301	32.00	0.00	ON	OFF
1005	212	309	305	204	302	32.00	0.00	ON	OFF
1006	212	310	305	205	302	32.00	0.00	ON	OFF
211	120	217	216	116	212	0.00	0.00	OFF	OFF
213	121	219	218	118	213	0.00	0.00	OFF	OFF
214	122	220	218	118	214	0.00	0.00	OFF	OFF
215	123	221	220	119	215	0.00	0.00	OFF	OFF
216	124	222	221	120	216	0.00	0.00	OFF	OFF

Table 3: Fuzzy value system working data log

After implementing the hardware prototype, we have tested a bed of 175.75 cm^2 for consecutive four days and after implementing both the Average value and Fuzzy logic algorithm in the project, the comparative water requirement analysis is given below:
Tabular data for operating time per days of experiment:

Algorithm	Day 1 (sec)	Day 2 (sec)	Day 3 (sec)	Day 4 (sec)
Average Value	80.28	99.41	91.31	105.98
Fuzzy Logic	30.46	31.30	31.12	32.01

Table 4: Run times of two algorithms

From the measurement, with the water flow of 2.57 mL/Sec, the time required to fill a 500mL water bottle was 194.60 sec.
Therefore, by doing the unitary method of calculation, finally amount of water needed for these particular amounts of area are:

Parameters	Day 1 (mL)	Day 2 (mL)	Day 3 (mL)	Day 4 (mL)	Total (mL)
Average Value	206.27	255.43	234.60	272.23	968.53
Fuzzy Logic	78.28	60.24	79.96	70.66	289.14
Saved water	127.9	195.19	154.64	201.65	679.39

Table 5: Water used by two algorithms

From the Calculations, Total amount of water saved in four days of experiment will be,

(127.9 + 195.19 + 154.64 + 201.65) mL
= 679.39 mL of water.

Comparative Bar chart for water requirement for both Average and Fuzzy Logic scenarios;

Where the blue bar represents the Average Value and orange bar represents the Fuzzy Value Algorithm.

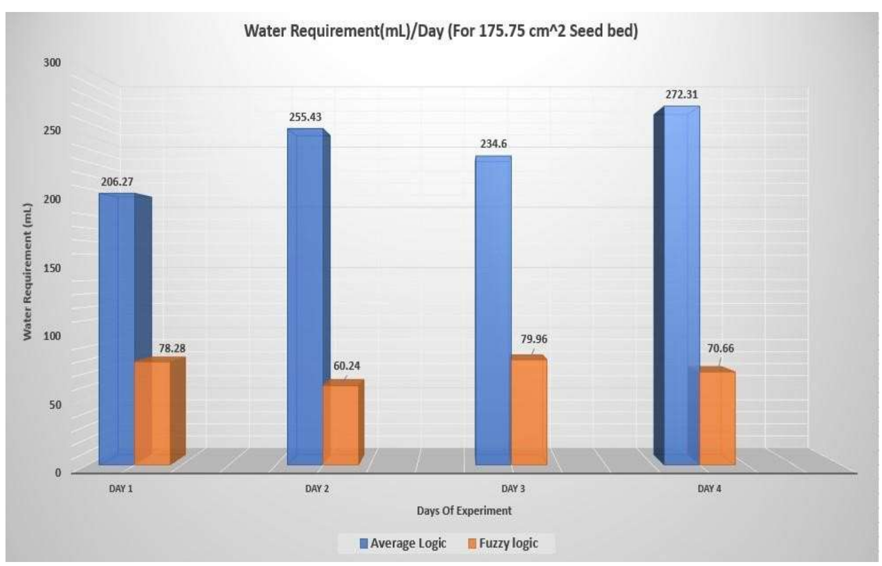


Figure 7: Bar graphical representation of water used by two algorithms

Now, if we represent them in graphical representation than the water requirement as well as the saved amount of water that we have got will be;

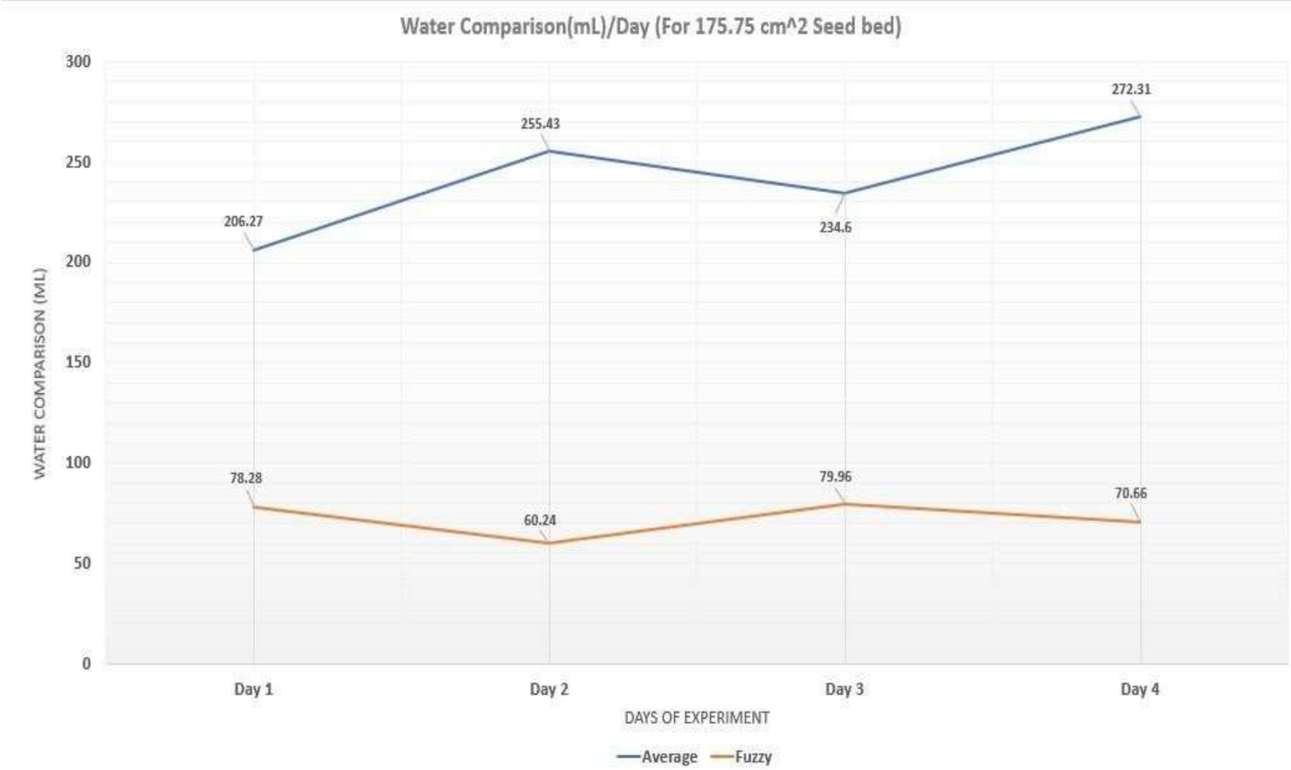


Figure 8: Graphical representation of water used by two algorithms

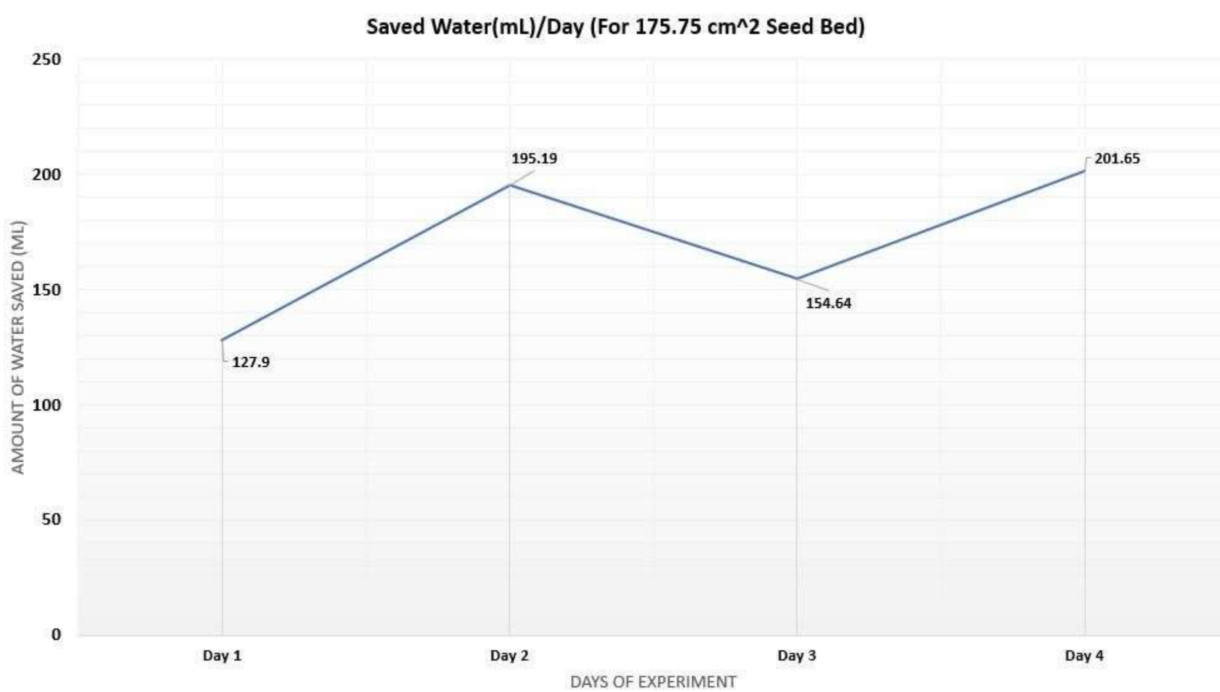


Figure 9: Bar graphical representation of water saved by Fuzzy

From all the representation and necessary calculations, we can say that, Fuzzy Logic Algorithm is superior than the Average Value Algorithm.

4.5 Conclusion

We had some errors found in our experiments but the output that we included is the perfect indication of how our system is working and how it is generating the required output. We can understand from the given data that the Fuzzy logic is making an impact by controlling each valve according to the need of the field. On the other hand, the Average logic since it works on a definite threshold and on the whole field data, the system is quite the running of the whole system together without the valves, the valves does not matter in this case.

Chapter 5: Completion of Final Design and Validation. [CO8]

5.1 Introduction

We have completed the total design of the system within a period of the middle of EEE400D to the end of EEE400C and therefore managed to complete the final design of the system to our own needs. The systematic and theoretical problems were faced quite a lot and we did trouble-shooting in order to find out the major difficulties we were facing and come up with practical solutions in order to support our case

5.2 Completion of final design

Final Design:

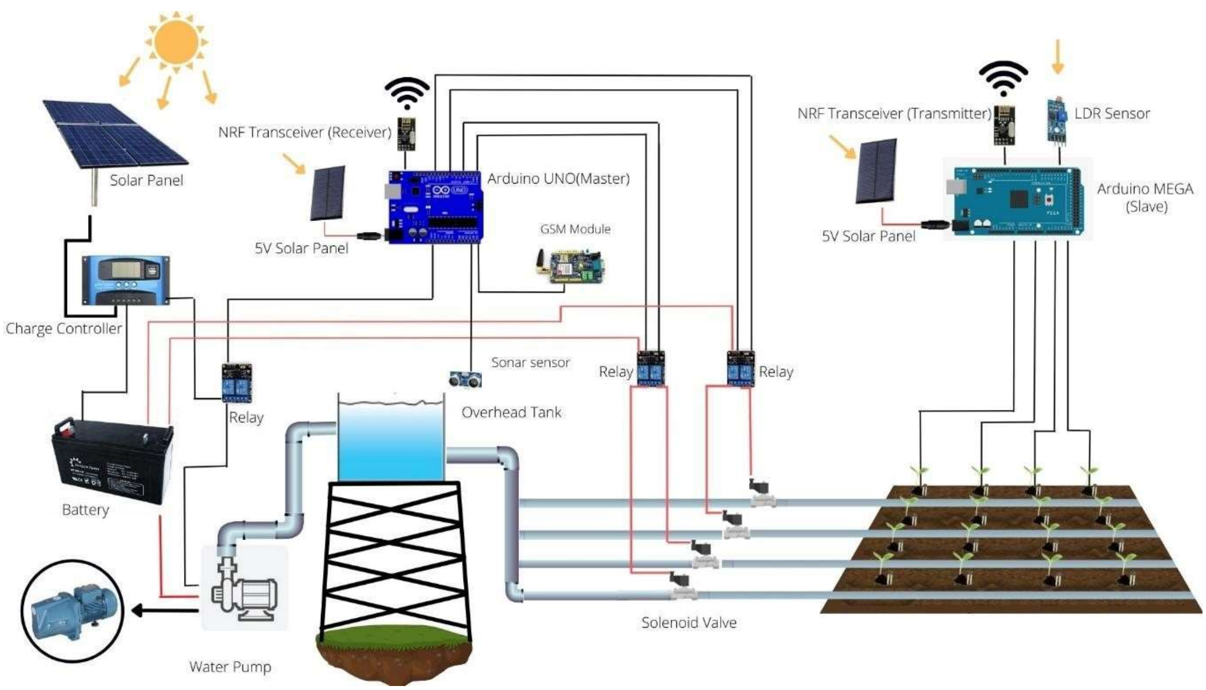


Figure 10: Overall system design

The proposed project has mainly one objective, which is making a solar powered IoT based irrigation system using different type of sensors and make use of soil moisture to irrigate the fields and crops according to their water needs. Moreover, it is controlling and saving both water and electricity in the procedure, agricultural production and minimalizing the efforts of the farmers. All these features make these methods sustainable option to be considered to improve the agriculture and irrigation efficiency.

The project mainly focuses on the algorithm part and can be used for any size of field for our requirement. The size of relay will be varying in the main field in that case. The water pump is pumping the water into the tank and therefore the controller is making use of the solenoid valves in order to pump water into the fields. The transceiver modules are doing the work of passing the command of turning solenoid pumps to the receiver module (UNO) and the relays are being activated by the Arduino and water is being delivered. The time for which the solenoid will be turned ON will be accessed by the fuzzy logic and corrected by itself by a learning algorithm. The 5v solar panels in the end of the Arduino are working for turning ON the Arduino, we will also be requiring some breadboards to support our connections and make effective connections so that they might not create hindrances for our system.

5.3 Evaluate the solution to meet desired need

The system we are using is tending to make the whole system support our needs.

Timed and perfect water irrigation:

The system is found to be perfectly working according to the needs of our design and requirements. Our prime requirement was to arrange a system which will make the perfect amount of water flow to the exact line of crops by making use of the time in our case since we are not able to use stepper motor in order to control the amount of flow of water. So the solenoid valves will maintain the flow of water by fixing the amount of time it will be turned ON. The required time is being calculated from the fuzzy logic and will be applied in order to do our works.

Inclusion of Overhead tank:

For our first design we didn't have any overhead tank and the pump was directly connected to the system. This system was not feasible for us as the purpose of tank must not be only to support the case of irrigation, it might also be used for other purposes and also if we run the motor for that amount of time the loss will be excessive. There is also a possibility of more problems occurring and therefore leading to more maintenance costs. The inclusion of overhead tanks is making the system more practical and making the pump run for less hours ensuring proper irrigation through overhead tank and solenoid valves. Therefore, the system becomes more complete and practical.

Making the system systematic and stable:

The main problem of implementing this whole project is to make the best use of thecomponents inside the constants. After implementation the system had problems like distance of the transceiver, big field issue, budget limitation.

Distance of the transceiver:

For our purpose the distance of the transceiver is a big issue as the far away the field is the more problems we will face as the transceiver might not get the range and therefore might not work. The transceiver we used in our case will support quite the necessary amount of distance, but in case of more requirement, transceivers that are more powerful.

Big field issue:

Big field issues is an undoubted problem for our project as the project, if implemented, will not be for a small field, it will be for a huge size of field. In case of big fields, the sensors number will be a lot more. In response to that, the options we have in our case are many, we can make up to 16 analog pins from one analog pin through a 16 to 1 multiplexer and therefore increase the number of sensors. Also we can use the digital pins of the soil moisture and therefore run the soil moisture using the digital pins and change the threshold in it by the potentiometer inbuilt.

Budget limitation:

For a fixed budget, the number of solar panels and other will have to be fixed. The budget cannot be lower than that, it will cause problems in our work and also make a big issue for our project. The number of soil moistures might have to be reduced and also the stakeholders need to be convinced about the savings they are getting by using our system and how much feasible our system is with respect to the traditional system.

5.4 Conclusion

Therefore, we can conclude that the system we are hoping to build is quite fulfilling the requirements that we previously decided. The power system will be making usage of the solar power in order to run the pump, and the other 5v systems will be making the Arduino run accordingly. The biggest achievement to the whole system will be if we can properly ensure the required amount of water with 0% error to the plants and make sure each of the plants get enough amount of water for it's particular growth period.

Chapter 6: Impact Analysis and Project Sustainability. [CO3, CO4]

6.1. Introduction:

Sustainability is the capacity to be maintained at a certain level in order to maintain overall standard as well as to ensure the durability of any particular system. In this study, sustainability refers to project management's economic, environmental, and social impacts of a designed project. Sustainability is an integral part of project management practices that maintain the economic, environmental, and social impacts. In this chapter, we have discussed about the three kinds of sustainability and impacts of our automatic irrigation project.

Firstly, economic sustainability encompasses financial costs and benefits and it also refers to practices that supports long term economic growth without negatively impacting social, environmental and cultural aspects of the community. Secondly, social sustainability mainly covers the part of social acceptance, equity and impact of any particular machinery or any new innovative technologies that will lead to a better-quality life. Mainly, this sort of sustainability indicates the trust issues, benefits, distributive fairness as well as cost efficiency of that particular program. Some prime key factors that have a huge impact on this issue are given below as described. Finally, environmental sustainability is defined as responsible interaction with the environment to avoid depletion or degradation of natural resources and allow for long-term environmental quality. We have identified following factors which are key determinants of environmental impacts of our project.

6.2. Evaluation of the impacts and sustainability:

Economic Sustainability and Impact

- **Water Requirement**

  The water requirement for irrigation depends on the crop type, climatic factors and irrigation efficiency. The microcontroller used in our project has to be pre-defined to work in each crop type, as for each crop the requirement of water for every different crop is different. Researchers show that, the specific drip irrigation for brinjal and tomato crops have been considered to use less amount of water and therefore reduce water requirement [10]. However, for climate and irrigation efficiency, the project is quite sustainable as it is working based on soil moisture, which is being affected by both the factors.

- **Depth or distance from water source**

The depth and distance from water source matters as there are places with both high-water level and low water level present everywhere. The project proposed by us requires the lowest amount of water required as it will be using the correct value of soil moisture to operate. Therefore, there is no chance of exploitation of water in places with low water levels.

- **Quality of the system**

The poor quality of components can lead to a lot of system breakdowns, repair and maintenance costs and complains from farmers. Therefore, it is highly necessary to keep the operation and maintenance costs low keeping in mind the quality of the whole irrigation system. The components used in our case has to be of perfect quality taking into consideration that the system has to be yielding perfect outputs…

- **Repair and maintenance services**

High amounts of dust and pollution can affect the performance of our solar panel, which is the main power source of our system. The farmers are found to clean the panels 2-4 times a week and therefore the system might face failure in this case. The motivation to keep the panels and the microcontrollers clean once per week is required highly. Moreover, the requirement of technically sound personnel is high, as the cleaning of these parts require skilled technicians.

- **Purchasing capacity of the farmers**

The high capital cost of solar microcontroller-based irrigation system is the biggest barrier to the whole project. They have quite low asset ownership and face major difficulties while raising finances from the government and private sources. The farmers doing cultivation at a commercial scale may purchase the project but still it may require external finance asit depends on the scale of farming and also the purchasing power. State backed financial support schemes by IDCOL in Bangladesh may provide customary solutions, also provide debt, equity, and grant facilitations [10].

- **Cost of alternative solutions**

  Solar-based microcontroller-controlled irrigation system is more economical than the manual irrigation using diesel pumps as there is no need of physical labor, no chances of excess irrigation, wastage of water and wastage of diesel cost. The refueling of diesel generators can be highly in conventional in a lot of places and therefore using a renewable source of energy is saving the farmers from those costs. Though the whole system has a high initial investment cost, but the fact that it is totally automated and cost effective in the long run compared to the diesel and gridline based manual irrigation system is to be considered the most attractive point of the whole system.

Social Sustainability and Impact:

- **Public awareness**

  As the project we are trying to develop is a very new and uncommon technology, it is obvious that the common people, especially the farmers tend to have less knowledge about the project and they would not want anything in their fields that they do not understand. For that purpose, rising public awareness through different types of demonstration, trainings and campaigns can lead them to understand the benefits of using the project in their field and they will be eager to use this project in their field. By following these steps, the farmer as well as other stakeholders will show interest in using the project in their irrigation purposes.

  Distributive fairness/equity is also a crucial term to implement the awareness in the people. While doing the campaigns, we must ensure that they will get equal machineries with equal efficiency so that any conflicts in trust would not happen while implementing the project.

- **Human Resource Utilization**

  Being a modern irrigation technology, this project tends to help many people to make their field more efficient of cultivation. So, if we also give our importance in the under privileged region which are still lagging behind in case of technology implementation as well as having under irrigated lands, we might be able to enhance the overall geographical equity of tour country with more efficient cultivate lands.

  Other than this, by implementing the project, the women in that region will also be able to the play a role in cultivating the crops/grains which will eventually turn them into a valuable human resource as well as this will also enhance the gender empowerment.

- **Government policies and incentives**

  As this project is basically an uncommon to not well renowned, it is obvious that people might not gain much trust about its overall performance. So, to build up the trust as well as to facilitate the project among the farmers and other users, government incentive would be well required in terms of subsidy, financing and market support. This will lead the people to know about the system more briefly and will make them understand the benefits of using the system.

- **Threats to safety and security**

  PV panels plays the main role in maintaining a swift and efficient smart irrigation system and it almost covers half of the overall cost. Causing any physical damage or risks of theft plays a very negative role in implementing the project and to gain the trust of the users. So, to eradicate these risks, some insurance can be made base on the innovative products so that this could cover some of the financial issues. Other than this, some safety measures can be taken such as fencing around the product, implementing the security alarm system or monitoring system which will be able to reduce the treats to safety and security issues.

Environmental Sustainability and Impact:

- **Water use efficiency**

  There are some concerns regarding water usage efficiency of a solar based irrigation system. Excess use of water could lead into issues such as waterlogging, land degradation etc. In our project, we are checking the moisture of the soil very accurately and based on that data we are watering the plants. Since we are going to use the water very effectively, there will not be any chance for the problems causing because of excessive water usage.

- **Abatement of carbon emissions**

  This kind of solar based system could considerably reduce GHG emissions and other pollutants as compared to electric or diesel pumps, both of which are highly carbon intensive. In the context of climate change, solar-based irrigation not only offers an opportunity for preventing GHG emissions, but also to make farmers more resilient against the erratic rainfall patterns caused by climate change [10]. Going forward, the opportunity to abate carbon emissions through solar based irrigation systems could help the economic stability further.

- **End of life disposal**

  Solar pumps have several components with varying technical life. Effective management strategies for each component at its end of useful life would be imperative to ensure environmental sustainability from a lifecycle perspective. The issue is pertinent for components such as solar panels, controllers and inverters, which are classified as e-waste, and their improper disposal could adversely affect the environment.

  Improperly disposed batteries contribute to water and air pollution. When depleted batteries are tossed into the trash, they end up in landfills where they decay and leak. As batteries corrode, their chemicals soak into soil and contaminate groundwater and surface water. Our ecosystems contain thousands of aquatic plants and animals and they are compromised when filled with battery chemicals. This means that when we drink from tap water faucets, we could be ingesting dangerous metals. According to the Agency for Toxic Substance & Disease Registry, if human body consumes nickel and cadmium from the leaked batteries, it will act as an agent which will cause cancer and there can be also severe medical issues because of them [10]. As a result, it is very important for us to dispose the batteries correctly, whereas our project is also more environmentally sustainable because we are using rechargeable batteries which consume less nonrenewable resources than the other kind of batteries. One huge positive of using rechargeable batteries is that due to their ability to recharge, fewer batteries are needed to provide the same amount of energy and this translates to fewer resources being consumed during the manufacturing process.

6.3. Conclusion:

In this chapter, we have evaluated the impacts as well as the sustainability of our designed project. This chapter tries to bring together all the key factors, which could influence sustainability of solar-based irrigation. Future research could explore, which factors amongst those identified are most critical through surveys, for example, in determining technology adoption by farmers and economic viability of solar pumps.

Chapter 7: Engineering Project Management. [CO11, CO14]

7.1. Introduction:

Projects are comprehended to be a means through which modern societies achieve social and economic ends to generate new standards. The importance of good project management in delivering engineering projects to fulfil predetermined objectives has been well established. Project management is the practice of building a project from inauguration through to delivery, applying the necessary skills and knowledge to keep the project on time, on budget and aligned with all the related specifications. For engineers, project management (PM) includes cautious planning and complete communications of that plan to a team of engineers. PM is a crucial process for any engineering project because without it, the unexpected can arise and derail the work of dozens or even hundreds of people.

In our Final Year design Project (FYDP), we have planned, managed and completed the project within the given timeframe with the help and suggestions of our instructors. Moreover, the timeframe was approximately 1 year which includes 3 separate courses in 3 separate semesters and the courses are called EEE400P, EEE400D, EEE400C respectively. We have distributed our tasks properly and the project tasks and the timeframe are shown in the project plan as well as in the Gantt chart in the following sections of this chapter.

7.2. Project Plan:

In this project plan, we have broken down every task activity and when the task was performed by our team in details from the very beginning to the end.

Timeline	Task	Start	End	Duration
	Problem Identification	14-Mar-21	1-Apr-21	18
	Topic Review and Finalization	2-Apr-21	10-Apr-21	8
EEE400P	Concept Note Preparation	11-Apr-21	4-May-21	23
	Project Presentation Preparation	5-May-21	20-May-21	15
	Final Project proposal preparation	4-May-21	18-May-21	14
	Algorithm Development	20-May-21	3-Jun-21	14
	Optimal Algorithm Selection	3-Jun-21	17-Jun-21	14
	Multiple Solution	17-Jun-21	3-Jul-21	16
	Optimal Solution Selection	3-Jul-21	24-Jul-21	21
	Component Selection and Buying	25-Jul-21	15-Aug-21	21
EEE400D	Programming and Implementation(Algorithm - 01)	9-Aug-21	23-Aug-21	14
	Circuit and sensor simulation	17-Aug-21	24-Aug-21	7
	Component testing and troubleshooting	25-Aug-21	8-Sep-21	14
	Prototype design Part I	26-Aug-21	9-Sep-21	14
	Prototype testing Part I	10-Sep-21	17-Sep-21	7
	Design Report	30-Aug-21	17-Sep-21	18
	Programming and Implementation(Algorithm - 02)	18-Sep-21	12-Nov-21	55
	Prototype design Part II	6-Nov-21	20-Nov-21	14
	Progress Report writing	12-Nov-21	25-Nov-21	13
EEE400C	Prototype testing Part II	21-Nov-21	12-Dec-21	21
	Completion of Prototype	12-Dec-21	5-Jan-22	24
	Final Project Report writing	12-Dec-21	6-Jan-22	25

Figure 11: Tabular Planner

Gantt chart:

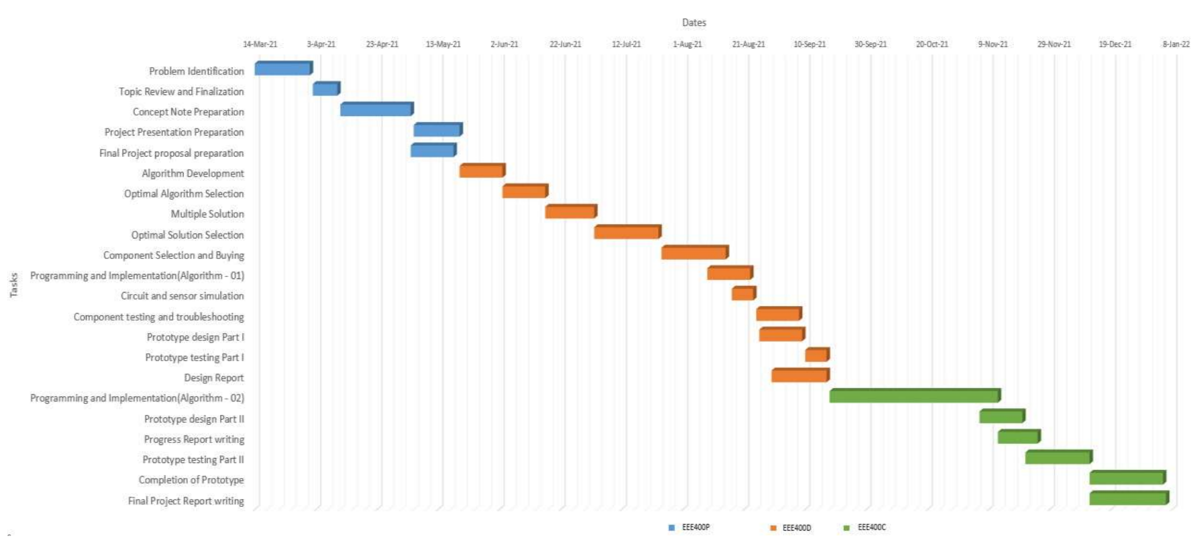


Figure 12: Gantt Chart

7.3 Evaluation of project progress:

By properly executing all activities, each of the components is achieved, and by managing the components as planned, the objectives are reached. Furthermore, if the objectives are attained, a major contribution towards the goal is made and our goal was to successfully complete the project by the proposed timeline. In our perspective, if we see from the very beginning to the end of this project, it is crystal clear that we have successfully followed the project plan and we have completed our project accordingly. Although, a few times, because of some inconveniences, we had to make necessary changes into our project plan and we had submitted it again to our instructors for evaluation.

Our project started from 14th March,2020 and our plan was to finish the project as well as the report by 6th January,2021 according to our Project Plan. Every one of us has given their best and participated actively in every task given to them in this project and we have successfully followed the instructions given to us by the respected ATC members and the FYDP committee. Moreover, we have successfully met all the deadlines and we have completed all the tasks including the hardware project and the final report by the proposed timeline.

7.4. Conclusion:

Lastly, in this chapter, we have demonstrated the knowledge and understanding of engineering project management principles, we have also provided the project plan along with the Gantt chart of our project. Furthermore, we have evaluated the project progress as per the given project plan. Finally, it can be said that, project management has become one of the main components of an engineering project, when it’s done right, it helps every part of the engineering project run more smoothly. It has also allowed our team to focus on the work that matters, free from the distractions caused by the tasks going off track or budgets spinning out of control.

Chapter 8: Economical Analysis. [CO12]

8.1 Introduction

To know whether any technological project is efficient enough or not mostly depends on the overall project feasibility in financial aspect. So, in order to build a good hardware project, the engineers as well as the entrepreneurs must have to focus on the feasibility of the project so that the general people as well the farmers who need this hardware setup can afford this with their money.

8.2 Economic analysis

As the project that we have already built is a prototype, if we implement this project in larger scale that is in real field basis, there would be a separate investment for this purpose. Though the budget for the prototype that we built is basically low budget project, but in case of the real field scenario, the budget will be more as the cost of PV panel and the Motor are the two important components that differ from size to size.

Below is the overall cost scenario for the prototype the we have already built for our project purpose;

Components Name	**Unit Price in BDT (Tk)**	**Quantity**	**Total Price**
12volt 20watt solar panel	Tk 850	01	Tk 850
24/12V 10A PWM Adjustable Solar Charge Controller	Tk 550	01	Tk 550
12V 7 AH Rechargeable Battery	Tk 715	01	Tk 715
Arduino Uno R3 Original with Cable	Tk 650	01	Tk 650
Arduino MEGA 2560 R3	Tk 950	01	Tk 950
YL-69 Soil Hygrometer Humidity & Soil Moisture Detection Sensor for Arduino	Tk 130	08	Tk 1,040
LDR Sensor Module big (10MM)	Tk 65	02	Tk 130
NRF24L01+ 2.4GHz Wireless Transceiver Module	Tk 200	01	Tk 200
Ultrasonic sensor HC- SR04	Tk 100	01	Tk 100
12 Volt 2A DC Submersible Pump	Tk 585	01	Tk 585
Soft & Clear PVC Tubing Hose Pipe for DC Pump (9fit)	Tk 40	01	Tk 40
1N4007 Diode	Tk 1	10	Tk 10

2 Channel 5V Relay Module	Tk 125	3	Tk 375
12 v Solenoid Valve	Tk 450	2	Tk 900
LCD Display 16*2 with Female Header	Tk 175	1	Tk 175
Sub Total:			**Tk 7,270**
Miscellaneous Cost			**Tk 1,000**
Total Budget			**Tk 7,920**

Table 6: Prototype Budget

But in case of the real field scenario, the overall price for the controller unit will always be same as the microcontrollers and the other electronic equipment are as same for all types of lands. But based on the pump requirement, the overall cost for the power unit will vary.
The overall estimation for the controller unit design will be;

Components Name	**Unit Price in BDT (Tk)**	**Quantity**	**Total Price**
Arduino MEGA 2560 R3	Tk 950	02	Tk 1,900
YL-69 Soil Hygrometer Humidity & Soil Moisture Detection Sensor for Arduino	Tk 130	50	Tk 6,500
LDR Sensor Module big (10MM)	Tk 65	02	Tk 130
NRF24L01+ 2.4GHz Wireless Transceiver Module	Tk 200	02	Tk 400
Ultrasonic sensor HC- SR04	Tk 100	01	Tk 100
LCD Display 16*2 with Female Header	Tk 175	1	Tk 175
2 Channel 5V Relay Module	Tk 125	5	Tk 625
12 v Solenoid Valve	Tk 450	10	Tk 4,500
Sub Total:			**Tk 14,330**
Miscellaneous Cost			**Tk 670**
Total Budget			**Tk 15,000**

Table 7: Controller Unit budget for field

For smaller overhead tank, where the only purpose of implementing this tank will be to supply necessary water for only irrigation purpose, we are considering 0.5 HP water pump which will be efficient enough to fill up the tank properly without any complexity. For this case, the budget estimation will be;

Components Name	Unit Price in BDT (Tk)	Quantity	Total Price
RFL Water Pump Centrifugal 1"X1"-0.5HP (RCm-130)	Tk 4869	1	Tk 4,869
40/50/60A MPPT Solar Charge Controller 12V/24V/48V Auto U	Tk 23,300	1	Tk 23,300
SOLAR PANEL (900WATT)	Tk 31,500	1	Tk 31,500
HAMKO HPD 200Ah IPS Battery (2 piece)	Tk 4,400	1	Tk 4,400
Microtek Solar PCU 1435 / 12V Inverter	Tk 17,000	1	Tk 17,000
Magnetic Contactor (LS GMC-22) (1 piece)	Tk 395	1	Tk 395
ABB MCB DP 16A 6KA (3 piece)	Tk 1,073	3	Tk 3,219
Soft & Clear PVC Tubing Hose Pipe for DC Pump (9fit)	Tk 40	10	Tk 400
Sub Total:			**Tk 85,083**
Miscellaneous Cost			**Tk 1,917**
Total Budget			**Tk 87,000**
Total Budget including controller unit			**Tk 102,000**

Table 8: 0.5 HP budget for tank unit

But if we talk about the bigger overhead tank, where the tank will not only supply water for irrigation system, but also will be used for daily necessary need for household activities the size of the pump will be 1 HP. In that case, this will pump will be efficient enough to pull the water from ground fill up the tank properly. In that case, the overall budget estimation for this scenario will be;

Components Name	Unit Price in BDT (Tk)	Quantity	Total Price
Pentax CM-100 ~1 Phase 1.00HP 0.75KW 20-90L/min 32-25M Head 1″ Suction 1″ Delivery Water Pump	Tk 11,000	1	Tk 11,000
40/50/60A MPPT Solar Charge Controller 12V/24V/48V Auto U	Tk 23,300	1	Tk 23,300
SOLAR PANEL (1500WATT)	Tk 52,500	1	Tk 52,500

HAMKO HPD 200Ah IPS Battery	Tk 4,400	1	Tk 4,400
Microtek 2550 VA Hybrid Solar Inverter	Tk 23,000	1	Tk 23,000
Magnetic Contactor (LS GMC-22)	Tk 395	1	Tk 395
ABB MCB DP 16A 6KA	Tk 1,073	3	Tk 3,219
Soft & Clear PVC Tubing Hose Pipe for DC Pump (9fit)	Tk 40	10	Tk 400
Sub Total:			**Tk 1,18,214**
Miscellaneous Cost			**Tk 1,786**
Total Budget			**Tk 1,20,000**
Total budget including controller unit			**Tk 1,35,000**

Table 9: 1 HP budget for tank unit

8.3 Cost benefit analysis

As the system that we intend to build is basically a hybrid system, solar power will be the main connection here through which the whole system will work on. For that reason, we are using solar pumps which are much more beneficial for saving currency in the long run as we all know that, the traditional diesel engine pump that the farmer uses in their field costs more than that of the solar pump. The brief comparison between these two pumps is shown below;

Pump Parameters	**Diesel Pump**	**Solar Pump (Centrifugal)**
Power	1HP	1HP
Discharge	150,000 L/day by 760 mm discharge pipe	150,000 L/day by 760 mm discharge pipe
Diesel consumption	1,440 L/year	-
Operation time (4 h/day, 3 crops per year)	4,380 h	4,380 h
Life span	10 years with engine overhauling after 5 years	25 years with possibly no overhauling
Installation cost	US$ 512	US$ 769

Table 10: Comparison of cost between diesel pump and solar pump

As we all know that,
Per liter price for diesel fuel at present is US$ 0.946.
So, diesel consumption per year for diesel pump will be = US$ (0.946 * 1,440) = US$ 1362.24/ year
Now,
US$ 1.00 = Tk 85.57
if we consider this in BDT, then the cost will be = Tk (85.57 * 1362.24) = Tk 1,16,566.88
here, we can see that, by only omitting the cost for diesel we can save up to this amount of money per year.
Other than this, being a hybrid system, this pump also is also very much feasible in all ways than that of diesel engine.
Finally, as the life span for this solar based centrifugal pump is 25 years, the overall save in these 25 years will be = Tk (1,16,566.88 * 25) = Tk 29,14,171.92
From above calculation perspectives, we can say that, solar pump irrigation system is far better in comparison with the traditional diesel engine pump.

8.4 Evaluation in case of economic and financial aspects

In this project building, from all the calculation point of view, we can see that, though the initial cost for installing this hardware setup is a bit high but in the long run it saves a heavy amount of money.
So, from all points of view and all the estimations, the overall money that the solar pump will save is Tk 29,14,171.92 but if we also consider the tax and other terms with this then the overall estimation of currency in this context will be almost around Tk 33-35 lakhs which is a huge amount of money we will eventually save.

8.5 Conclusion

As we all know that, the project that we are basically building is an innovative and uncommon technology-based project, making it a feasible one is one of the most important points that we had to keep in mind. For this reason, we mainly focused on the solar based machineries which will eventually be able to save necessary amount of money. From the above calculations and estimations that we have already done, we can say that, if we can properly introduce this project in larger scale that is the real field, it would definitely save a lot amount of money for the general consumers especially the farmers who sometimes struggle to gather that significant amount of money to run their traditional irrigation system.

Chapter 9: Ethics and Professional Responsibilities CO13, CO2

9.1 Introduction

The whole project that we are trying to build and to implement is basically a two-focused project that is the project is both product focused and process focused. We call this project as 'Product-focused' in that sense because we are building a scale model to act as a proof of concept and to assess design parameters and outputs. 'Process-focused' in that we are developing mathematical models that can be applied to a variety of irrigation needs outlining the necessary hardware requirements. Other than this fact, while building this project on our own, we have tried to make our duties as well as responsibilities very professional in both ethical and righteous way.

9.2 Identify ethical issues and professional responsibility

We all know that, while building any innovative engineering project, doing it in ethical/ righteous way is always a major point of consideration to make it more professional and trustworthy to general people. In that case, from building this project part by part till writing any major report regarding this project, maintaining integrity should always be one's first priority. That is why, while building this project, we have tried our best to maintain proper guidelines from all sorts of ethical guidelines and codes of conduct in writing the report as well as project building.

- Ethical/ Professional codes of conduct for building and implementation of project:

  As we all know that, the main purpose/ target of any engineering project is to make a sustainable and trustworthy with highly efficient hardware setup which can change the general people's points of views and to also to make their daily life easier and smoother. But, to ease these people's lives, ethical codes and responsibilities should also be kept in mind as engineers so that people can maintain their trust consistently in the projects that the fresh engineers or any entrepreneurs intend to build or supply them.

  In this context, 'Expensive equipment validation', 'Maintenance of equity among normal people', 'Overall project efficiency validation', 'ensuring safety and security to general public' should and would always be engineer's biggest priority in ethical codes to imply directly while building any specific projects.

  Other than this, professional responsibilities like 'Handing over projects in time', 'Upholding client vs stakeholder relationships', 'Risk management planning' and 'Project optimization from time to time' should also kept in mind as building any innovative and uncommon technology needs a lot of professionalism so that people can believe engineer's goals and trust them in developing the country technologically.

- Ethical/ Professional codes of conduct for writing any major project report:

  First of all, if we talk about the ethical codes of conduct while writing the report and project assignments, some major issues that always comes forward is 'Plagiarism', 'Copy right issue', 'Using of bias and offensive language' might create a huge negative impression in the eyes of audiences/ general people. Henceforth, considering these problems while writing the project reports would always strengthen the report quality as well as the overall representation of argument that we intend to present to the whole world. These standards also satisfy the standards of professional responsibilities, which is also a major issue in building a fruitful report with excellent standard.

9.3 Apply ethical issues and professional responsibility

To build a proper project with maintaining the codes of conduct in both ethical and professional ways is not always an easy road to go. But, as an engineer and piler of future generation of this country, upholding these codes in daily working life will be able to raise the standard the projects/ideas as well as this would give vast recognition even in the whole world.

- Expensive equipment validation

  Now if we talk about the risks while building the project for the actual field, getting proper equipment for the project might create an issue for implementing the project to the field. We know that, solar panels and water reservoir are the two most important parts for building an effective project. Other than this, these parts almost carry most of the expense of the overall project. So, maintaining the safety and security of these parts is mandatory as validating these equipment rating will enhance the overall performance of any field project and according to codes of conduct, ensuring the safety of the project as well as the people is one of the important rule/ codes to follow for any engineers. Other than this, if we talk about the other parts that is microcontroller, sensors these are also very important for the overall efficiency and maintenance should be done properly for these parts.

- Maintenance of equity among normal people

  Another important thing that the engineers and all the entrepreneurs should always follow is to endure quality-based components in all the areas that the product/project has been delivered. If this thing is not followed properly, general people will not be able to trust in implementing this project and our whole hard work will remain unseen. Therefore, if we can ensure equity in supplying the product, then people uphold their trust on us and we can make the country more efficient in irrigation.

- Overall project efficiency validation

  To operate this project properly, it is mandatory to maintain all the equipment of the project in proper order. Because, as the whole project depends on each of the equipment, if any failure occurs in any of the components, the whole project might be stopped. Since we are creating mathematical and scale models that can be utilized for full-scale implementation. While we are not specifically designing these structures, we still see the importance in analyzing all risk that could be associated with future designs and constructions. These considerations will need to be considered in more detail in before construction takes place.

- Ensuring safety and security to general public

  Despite of being a total off grid system as well as a green project, we need to make sure that the project is totally harmless to the general people who will be in charge of that project. In that case, proper introduction and working demonstration campaign will totally ease off the situation for the consumers at a great extent. Other than this, supplying good quality products in making the overall set up will definitely lessen the risks of getting any unnecessary problem of failures or damaging which will eventually satisfy the safety and security issue for the general people.

Alongside of ethical issues, professional responsibilities also need to be maintained as this professionalism while doing any project or presenting anything to the outworld would create a positive impact and respect that every engineer should be acquainted with.

- Handing over projects in time

  One of the main codes of conduct the all the engineers as well as the entrepreneurs should always abide by is the potentiality of handing over any promised project in time. Maintenance of time is always a very important thing that one should follow. By this manner, general people will gain trust in using our project and by this the relationship between client and supplier will also get strong.

- Upholding client vs stakeholder relationships

  As mentioned earlier, maintaining trust of the general people in implementing this project is a key point in recognition of the project as the project that we intend to build is an uncommon and innovative technology the country didn't use before. In that case, we need to maintain our professionalism in every aspect so that the general people uphold their belief in us and get motivated in using our project in their fields.

- Risk management planning

  The whole project that we are trying to build and to implement is basically a two-focused project that is the project is both product focused and process focused. Product-focused in that we are building a scale model to act as a proof of concept and to assess design parameters and outputs. Process-focused in that we are developing mathematical models that can be applied to a variety of irrigation needs outlining the necessary hardware requirements. So, as this project is based on hardware components, there is a chance of getting unnecessary damage in the overall project which will affect the efficiency of the project. For this purpose, Proper checking validation of Expensive equipment, Upholding Trusts and Beliefs of a Consumer, Validation of quality raw materials for Reservoir and lastly Ensuring individual components to be quality Products should be ensured while implementing the project.

- Project optimization from time to time

  As the present world is the world of competition, it is obvious that, from time to time this project will get better and better with more advanced algorithms and components. So, it is the sole duty of engineers as well the entrepreneurs to work on the optimization from time to time so that the consumers can get the highest efficiency in their field project. By this, the relation between the stakeholders and the consumers will also remain intact and they will maintain belief in us which will be very beneficial for our project's future.

9.4 Conclusion

As we all already know that, the project that we are developing is basically an innovative and uncommon technology that can revolutionize the future aspects of irrigation system. But in order to do so, being an engineer as well as an entrepreneur it is our sole duty to maintain all the codes of conduct that one engineer should follow both ethically and professionally. By maintaining these codes, people will definitely be motivated in implementing this project for their daily irrigation purpose as well it will definitely improve the relationship between the clients and the stakeholders which will eventually be beneficial for our project recognition.

Chapter 10: Conclusion and Future Work.

10.1 Conclusion and Difficulties

Being a totally new and uncommon project, this one took a long time to be an efficient project and to make this project an efficient one, a lot of trial and error, troubleshooting, proper wiring, implementing the hardware tools had to be done which took a lot of time. Talking specifically about the microcontrollers, we have to say that, multiple devices were connected to the Arduino for which wires connection have been complexes to connect. Furthermore, the batteries of this project drain quickly in use, Sequence of system scenario has been not easy to decide to function as well because of the battery drainage problem. The controllers to the Arduino were quite challenging, because of a single mistake can damage any electrical part. It was not easy to write the software for the Smart Irrigation System and upload it in Arduino to run the water pump and opening valves with six sensors, but with the help of Arduino library, the program was completed and we've been able to get perfect results. Although the project building was much difficult to do, we did our best and we've finally achieved our desired goal.

10.2 Future work

If we specifically talk about the future work the main aim that we have for this project is to implement this project on a large-scale situation like in real fields. As too much wiring for this project will unnecessarily risk the overall efficiency, we will try to make this whole project as less wiring as possible, even if possible, PCB designing of the controller board can be an effective future work of this project. Other than this, on large scale application, we will introduce a mobile notification-based alarm system through which farmer can be easily notified if any sudden emergency arrives in their field under any necessary means. Lastly, the main aim that we have for this project is to get proper recognition for this project which will eventually introduce this project in business level also.

Chapter 11: Identification of Complex Engineering Problems and Activities.

Attributes of Complex Engineering Problems [Explanation]:

Depth of knowledge:

We have studied and researched various papers and we also gathered enough knowledge regarding the PV systems, required sensors, wireless communication system, design process and finally we also gathered deep theoretical knowledge of tools required to develop the design.

Range of conflicting requirements:

We have designed our system and there are no conflicts regarding the cost of the project or the budget so far.

Depth of Analysis required:

We have researched and studied various solutions and we have come up with two multiple solutions to design this project and finally we have chosen one optimal solution which will give us the best results.

Familiarity of issues:

As the project that we are trying to implement is basically an innovative agricultural project, it is obvious that we have to go outside of the box that is to gather information about agricultural issues that the farmers face in their traditional irrigation system and make an efficient project solving those issues. Despite of having knowledge on the electrical circuit operations we also gave to consider the real field scenarios and exceptions while implementing the project in the open field.

Extent of applicable codes:

Being an agricultural enhancement based project, we have tried to follow the ratings and validations done by IDCOL (Infrastructure Develop Company Limited) so that in the real field operation time s that neither the project doesn't fail to perform properly nor any particular component get damaged due to unwanted causes.

Extent of stakeholder involvement and needs:
Due to our current pandemic situation, though we weren't been able to have any direct interaction with the farmers or the stakeholders dealing with these projects but we tried to build our project based on different calculated ratings done by different researchers in different papers that are made

based on our country soil qualities and conditions. Other than this, we tried to take the threshold values of soil from surrounding places in spite of taking real vegetative fields as it was not that much possible for us to go for that process.

Interdependence:

We see that the whole system does depend on each other. The controller does depend on the PV system to power it or else the whole system might not work. The required voltage 12v is maintained in order to carry out our whole system power up.

Attributes of Complex Engineering Activities [Explanation]:

Range of resource:

The range of resource in our project were carried out according to the need of the system. The funding, equipment required for this project in order to undergo the whole system have been analyzed and they go perfectly with our requirements.

Level of interaction:

The engineering problems or issues related to the system was the implementation of system for the big project. The risks assessed have been explained in the risk management part of the report.

Innovation:

We are trying to innovate a new way on irrigation system in Bangladesh not only by implementing an automated and IoT based way for efficient irrigation, we are also introducing a way to consider renewable energy to the system along with the already existed automated and IoT based system. Our project is a complete package of less contamination on environment, less wastage on power and water management, less involvement of manpower and ensuring the maximum efficiency on the irrigation process on the rural areas of the country.

Consequences for society and environment :

We have provided necessary research and analysis on our draft related to consequences for society and environment. We always ensure the minimum consequences and impact for the society and environment and ensure maximum safety for farmers and the irrigation fields. Introduction to renewable energy on our project an effective way to ensure less contamination on environment so the farmers have to deal with less risk factors and can work accordingly without spending at all.

Our project is also a way to introduce technology to the rural society and ensure providing necessary knowledge to them regarding automation and IoT so that they get the inspiration to innovate themselves and contribute to the society and the country for better future

Familiarity:

The components used in our system (PV/Arduino/Battery etc.) are quite available and known to everyone. The whole system is quite impactful and very easy to implement for everyone except for the algorithm used which can be improvised with the help of a technician.

Attributes of Complex Engineering Problems (EP)

	Attributes	**Put tick (√) as appropriate**
P1	Depth of knowledge required	√
P2	Range of conflicting requirements	√
P3	Depth of analysis required	√
P4	Familiarity of issues	√
P5	Extent of applicable codes	√
P6	Extent of stakeholder involvement and needs	√
P7	Interdependence	√

Note: Project must have P1, and some or all from P2-P7

Attributes of Complex Engineering Activities (EA)

	Attributes	Put tick (√) as appropriate
A1	Range of resource	√
A2	Level of interaction	√
A3	Innovation	√
A4	Consequences for society and the environment	√
A5	Familiarity	√

Note: Project must have some or all of the characteristics from attributes A1 to A5

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Fuzzy Transmitter

```
#include <Fuzzy.h>

#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>

int i=0;
int j=0;
RF24 radio(7, 8); // CE, CSN
const byte address[6] = "00001";
int button_state = 0;



const int ldr_pin = 6;




int m=0;
int m1=0;

// Instantiating a Fuzzy object
Fuzzy *fuzzy = new Fuzzy();

void setup()
{

  Serial.begin(9600);


radio.begin();                          //Starting the Wireless communication
radio.openWritingPipe(address); //Setting the address where we will send the data
radio.setPALevel(RF24_PA_MIN); //You can set it as minimum or maximum depending on the distance between the transmitter and receiver.
radio.stopListening();


  randomSeed(analogRead(0));

  FuzzyInput *moisture = new FuzzyInput(1);
  FuzzySet *soggy = new FuzzySet(0, 187, 187, 375);
  moisture->addFuzzySet(soggy);
  FuzzySet *moist = new FuzzySet(325, 400, 400, 475);
  moisture->addFuzzySet(moist);
  FuzzySet *less_moist = new FuzzySet(425, 550, 550, 650);
  moisture->addFuzzySet(less_moist);
```

```
  FuzzySet *dry = new FuzzySet(625, 912, 912, 1200);
  moisture->addFuzzySet(dry);
  fuzzy->addFuzzyInput(moisture);


  FuzzyOutput *valve = new FuzzyOutput(1);
  FuzzySet *slow = new FuzzySet(0, 10, 10, 15);
  valve->addFuzzySet(slow);
  FuzzySet *average = new FuzzySet(15, 20, 20, 30);
  valve->addFuzzySet(average);
  FuzzySet *average_faster = new FuzzySet(30, 40, 40, 50);
  valve->addFuzzySet(average_faster);
  FuzzySet *fast = new FuzzySet(50, 70, 70, 80);
  valve->addFuzzySet(fast);
  fuzzy->addFuzzyOutput(valve);


  FuzzyRuleAntecedent      *ifMoistureSoggy      =      new
FuzzyRuleAntecedent();
  ifMoistureSoggy->joinSingle(soggy);
  FuzzyRuleConsequent      *thenSpeedSlow      =      new
FuzzyRuleConsequent();
  thenSpeedSlow->addOutput(slow);
  FuzzyRule *fuzzyRule01 = new FuzzyRule(1, ifMoistureSoggy,
thenSpeedSlow);
  fuzzy->addFuzzyRule(fuzzyRule01);

  FuzzyRuleAntecedent      *ifMoistureMoist      =      new
FuzzyRuleAntecedent();
  ifMoistureMoist->joinSingle(moist);
  FuzzyRuleConsequent      *thenSpeedAverage      =      new
FuzzyRuleConsequent();
  thenSpeedAverage->addOutput(average);
  FuzzyRule *fuzzyRule02 = new FuzzyRule(2, ifMoistureMoist,
thenSpeedAverage);
  fuzzy->addFuzzyRule(fuzzyRule02);

  FuzzyRuleAntecedent      *ifMoistureLessMoist      =      new
FuzzyRuleAntecedent();
  ifMoistureLessMoist->joinSingle(less_moist);
  FuzzyRuleConsequent    *thenSpeedAverage_faster    =    new
FuzzyRuleConsequent();
  thenSpeedAverage_faster->addOutput(average_faster);
  FuzzyRule      *fuzzyRule03      =      new      FuzzyRule(3,
ifMoistureLessMoist, thenSpeedAverage_faster);

  fuzzy->addFuzzyRule(fuzzyRule03);
  FuzzyRuleAntecedent      *ifMoistureDry      =      new
FuzzyRuleAntecedent();
```

```
  ifMoistureDry ->joinSingle(dry);
  FuzzyRuleConsequent       *thenSpeedFast       =       new
FuzzyRuleConsequent();
  thenSpeedFast->addOutput(fast);
  FuzzyRule  *fuzzyRule04  =  new  FuzzyRule(4,  ifMoistureDry,
thenSpeedFast);
  fuzzy->addFuzzyRule(fuzzyRule04);
}

void loop()
{


//if( digitalRead( ldr_pin ) == 0){


  int M0 = analogRead(A0); //Read Moisture Sensor Value
  int M1 = analogRead(A1); //Read Moisture Sensor Value
  int M2 = analogRead(A2); //Read Moisture Sensor Value
  int M3 = analogRead(A3); //Read Moisture Sensor Value
  int M4 = analogRead(A4); //Read Moisture Sensor Value
  int M5 = analogRead(A5); //Read Moisture Sensor Value
  float value1[3]={M0,M1,M2};
  float value2[3]={M3,M4,M5};
  int min1=0;
  int min2=0;
  Serial.println("First");
  for (i=0;i<3;i++){
    if (value1[i]>min1){
      min1=value1[i];
      }
     Serial.println(value1[i]);
    }
   Serial.println("Second");
   for (j=0;j<3;j++){
    if (value2[j]>min2){
      min2=value2[j];
      }
     Serial.println(value2[j]);
    }



  int input1 = min1;
  int input2 = min2;
  if ((min1>625) && (min2>625))
{

button_state = 11;
```

```
radio.write(&button_state, sizeof(button_state));
Serial.println("HIGH HIGH");
Serial.println(min1);
Serial.println(min2);
delay(5000);

}

else if ((min1>625) && (min2<625))
{

button_state = 10;
radio.write(&button_state, sizeof(button_state));
Serial.println("HIGH  LOW");
Serial.println(min1);
Serial.println(min2);
delay(5000);

}

else if ((min1<625) && (min2>625))
{

button_state = 01;
radio.write(&button_state, sizeof(button_state));
Serial.println("LOW  HIGH");
Serial.println(min1);
Serial.println(min2);
delay(5000);

}

else if ((min1<625) && (min2<625))
{

button_state = 00;
radio.write(&button_state, sizeof(button_state));
Serial.println("LOW LOW");
Serial.println(min1);
Serial.println(min2);
delay(5000);

}

 delay(1000);

  Serial.println("\n\n\nStart: ");
  Serial.print("\t\t\tMoisture: ");
  Serial.println(input1);
```

```
  Serial.println(input2);

  fuzzy->setInput(1, input1);

  fuzzy->fuzzify();

  float output = fuzzy->defuzzify(1);
  Serial.println("Result1: ");
  Serial.print("\t\t\tFuzzified value: ");
  Serial.println(output);


}
```

Fuzzy Receiver

```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>
int trigpin=A5;
int echopin=A4;
float distance;
float duration;
int led1 = 10;
int state = 0;
RF24 radio(7, 8); // CE, CSN
const byte address[6] = "00001";


void setup() {

Serial.begin(9600);
radio.begin();
radio.openReadingPipe(0, address);
radio.setPALevel(RF24_PA_MIN);     //You can set this as minimum
or maximum depending on the distance between the transmitter and
receiver.
radio.startListening();
pinMode(2, OUTPUT);
pinMode(4, OUTPUT);//This sets the module as receiver
pinMode(trigpin, OUTPUT);
pinMode(echopin, INPUT);
  pinMode(led1, OUTPUT);

}
void loop()
{
```

```
  digitalWrite(trigpin, LOW);

delay(2);
digitalWrite(trigpin, HIGH);
delayMicroseconds(10);

digitalWrite(trigpin,LOW);

duration = pulseIn(echopin,HIGH);

distance = (duration*0.034)/2;
Serial.print(distance);
Serial.println("cm");

if   (distance <= 18)
{

    digitalWrite(led1, HIGH);

    Serial.println("PUMP OFF");
    Serial.println("Water level filled");




}
else if (distance > 28) {


    digitalWrite(led1, LOW);
    Serial.println("PUMP ON");
    Serial.println("Water level low");

  }
else{
  digitalWrite(led1, LOW);
  Serial.println("PUMP OFF");
    Serial.println("Water level okay");
  }



delay(2000);
if (radio.available())
//Looking for the data.
{
  int t=6;

int text = 0;                  //Saving the incoming data
```

```
radio.read(&text, sizeof(text));
//Reading the data

if(text==11 ){
Serial.println("HIGH HIGH ");
digitalWrite(2, HIGH);
digitalWrite(4, HIGH);

}

else if (text==00 ){
Serial.println("LOW LOW");
digitalWrite(2, LOW);
digitalWrite(4, LOW);
}
else if (text==01 ){
Serial.println("LOW HIGH");
digitalWrite(2, LOW);
digitalWrite(4, HIGH);
}
else if (text==10 ){
Serial.println("HIGH LOW");
digitalWrite(2, HIGH);
digitalWrite(4, LOW);
}
delay(2000);


}


}
```

Average Transmitter

```
#include <Fuzzy.h>

#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>

int i=0;
int j=0;
RF24 radio(7, 8); // CE, CSN
const byte address[6] = "00001";
int button_state = 0;



const int ldr_pin = 6;



int m=0;
int m1=0;

// Instantiating a Fuzzy object
Fuzzy *fuzzy = new Fuzzy();

void setup()
{

  Serial.begin(9600);


radio.begin();                  //Starting the Wireless
communication
radio.openWritingPipe(address); //Setting the address where we
will send the data
radio.setPALevel(RF24_PA_MIN); //You can set it as minimum or
maximum depending on the distance between the transmitter and
receiver.
radio.stopListening();
```

```
}

void loop()
{


//if( digitalRead( ldr_pin ) == 0){


  int M0 = analogRead(A0); //Read Moisture Sensor Value
  int M1 = analogRead(A1); //Read Moisture Sensor Value
  int M2 = analogRead(A2); //Read Moisture Sensor Value
  int M3 = analogRead(A3); //Read Moisture Sensor Value
  int M4 = analogRead(A4); //Read Moisture Sensor Value
  int M5 = analogRead(A5); //Read Moisture Sensor Value
  int min1=0;
  int min2=0;

  min1=(M0+M1+M2+M3)/4;
  min2=(M4+M5)/2;




  int input1 = min1;
  int input2 = min2;

  if ((min1>300) && (min2>300))
{

button_state = 11;
radio.write(&button_state, sizeof(button_state));
Serial.println("HIGH HIGH");
Serial.println(min1);
Serial.println(min2);
delay(5000);

}

else if ((min1>300) && (min2<300))
{
```

```
button_state = 10;
radio.write(&button_state, sizeof(button_state));
Serial.println("HIGH  LOW");
Serial.println(min1);
Serial.println(min2);
delay(5000);

}

else if ((min1<300) && (min2>300))
{

button_state = 01;
radio.write(&button_state, sizeof(button_state));
Serial.println("LOW  HIGH");
Serial.println(min1);
Serial.println(min2);
delay(5000);

}

else if ((min1<300) && (min2<300))
{

button_state = 00;
radio.write(&button_state, sizeof(button_state));
Serial.println("LOW LOW");
Serial.println(min1);
Serial.println(min2);
delay(5000);

}


  Serial.println("Avg1: ");
  Serial.println(input1);

  Serial.println("Avg2: ");
  Serial.println(input2);

}
```

Average Receiver

```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>
int trigpin=A5;
int echopin=A4;
float distance;
float duration;
int led1 = 10;
int state = 0;
RF24 radio(7, 8); // CE, CSN
const byte address[6] = "00001";


void setup() {

Serial.begin(9600);
radio.begin();
radio.openReadingPipe(0, address);
radio.setPALevel(RF24_PA_MIN);       //You can set this as
minimum or maximum depending on the distance between the
transmitter and receiver.
radio.startListening();
pinMode(2, OUTPUT);
pinMode(4, OUTPUT);//This sets the module as receiver
pinMode(trigpin, OUTPUT);
pinMode(echopin, INPUT);
  pinMode(led1, OUTPUT);

}
void loop()
{
  digitalWrite(trigpin, LOW);

delay(2);
digitalWrite(trigpin, HIGH);
delayMicroseconds(10);

digitalWrite(trigpin,LOW);

duration = pulseIn(echopin,HIGH);
```

```
distance = (duration*0.034)/2;
Serial.print(distance);
Serial.println("cm");

if   (distance <= 18)
{

    digitalWrite(led1, HIGH);

    Serial.println("PUMP OFF");
    Serial.println("Water level filled");




}
else if (distance > 28) {


    digitalWrite(led1, LOW);
    Serial.println("PUMP ON");
    Serial.println("Water level low");

  }
else{
  digitalWrite(led1, LOW);
  Serial.println("PUMP OFF");
    Serial.println("Water level okay");
  }

if (radio.available())
//Looking for the data.
{
  int t=6;

int text = 0;                  //Saving the incoming data
radio.read(&text, sizeof(text));
//Reading the data

if(text==11 ){
Serial.println("HIGH HIGH");
digitalWrite(2, HIGH);
digitalWrite(4, HIGH);
```

```
digitalWrite(led1, LOW);
}

else if (text==00 ){
Serial.println("LOW LOW");
digitalWrite(2, LOW);
digitalWrite(4, LOW);
digitalWrite(led1, HIGH);
}
else if (text==01 ){
Serial.println("LOW HIGH");
digitalWrite(2, LOW);
digitalWrite(4, HIGH);
digitalWrite(led1, LOW);
}
else if (text==10 ){
Serial.println("HIGH LOW");
digitalWrite(2, HIGH);
digitalWrite(4, LOW);
digitalWrite(led1, LOW);
}
delay(2000);


}


}
```