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Group Members Name:

SL No.	Name	ID
1	Mohammad Mahbubul Haque	12321017
2	Mahbubur Rahman Khan	12201075
3	Raihana Ismat Ruhi	13101010
4	Md. Fuad Hasan	12201076

Supervisor's Name: **Amitabha Chakrabarty**

Thesis Title:

Implementation of Fuzzy Logic in Autonomous  
Irrigation System for Efficient Use of Water

Supervisor's Sign:

# Implementation of Fuzzy Logic in Autonomous Irrigation System for Efficient Use of Water



Inspiring Excellence

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**SUBMITTED BY:**

Mohammad Mahbubul Haque(12321017)

Mahbubur Rahman Khan (12201075)

Raihana Ismat Ruhi(13101010)

Md. Fuad Hasan (12201076)

School of Engineering and Computer Science

**Supervisor:**

**Amitabha Chakrabarty, Ph.D**

Assistant Professor

Department of Computer Science and Engineering

## **Declaration**

We, hereby declare that this thesis is based on results we have found ourselves. Materials of work from researchers conducted by others are mentioned in references.

### **Signature of Supervisor**

---

**Amitabha Chakrabarty, Ph.D**

Assistant Professor

Department of Computer Science and Engineering

BRAC University

### **Signature of Authors**

---

**Mohammad Mahbubul**

**Haque (12321017)**

---

**Mahbubur Rahman Khan**

**(12201075)**

---

**Raihana Ismat Ruhi**

**(13101010)**

---

**Md. Fuad Hasan**

**(12201076)**

## **ABSTRACT**

This project is focused on application of fuzzy logic to control an automatic irrigation system. In organic way, an experienced human farmer can manage the irrigation system by sensing soil moisture by fingertip and decide the estimated timing as well as water flow rate for irrigation. This system will do everything on behalf of human. The moisture sensor of the irrigation control system has a nonlinear response and a significant time delay; it can be difficult to get satisfactory results by using a regular feedback control system. As fuzzy logic system is able to mimic human reasoning and decision making, it can improvise the regular feedback system for decision making. Data from soil moisture sensors will be used as inputs to the system. The fuzzy control system will process the estimated soil moisture contents from multiple section of land. It will use linguistic knowledge to produce a control output that is sent to a motor which controls the water flow rate from a static water source to the land of cultivation. The control unit will also control a pump which will fill up the source/water tank. A data set will also be used to make different output for different plants. In many researches, efficiency of the fuzzy logic control system has been measured and got the satisfactory output.

## **Acknowledgement**

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# **CHAPTER 1**

## **Introduction**

Fuzzy logic is extension of traditional Boolean logic. It allows expressing logical values between true and false. It describes the uncertainty of the real world. It has been used in many sectors like agriculture, biomedical, environment, artificial intelligence, industrial control system and many more. It gives opportunity to utilize real world attributes in computing. Fuzzy logic makes control system precise, accurate and efficient. It also reduces implementation time. In this research work we are presenting automatic irrigation system using fuzzy logic. We are controlling water flow according to water requirement through fuzzy logic.

Water is a basic component of all life and it plays a dramatic impact in cultivation. And water is also very precious natural resource which should not be wasted. An efficient irrigation system is which reduces water and electricity waste and provides a healthy plant life. Therefore, an automatic and efficient irrigation system is considered.

Our key goal is to save water from being wasted due to lack of information about the moisture level of the field. Here, our system measures the soil moisture and takes decision in real time. Upon that decision making water flow is controlled to maintain the optimum level of soil moisture for the crop in the field.

Reviewing other works on fuzzy logic and irrigation we came up with the idea to control the water flow to the field based on the moisture level. If the system is implemented, it is certain that it will help to save a significant amount of water than current systems. Our irrigation system will run on the basis of soil moisture level. Here soil moisture is the input and at the output we will find an automated action that controls irrigation to the field based on the given moisture level.

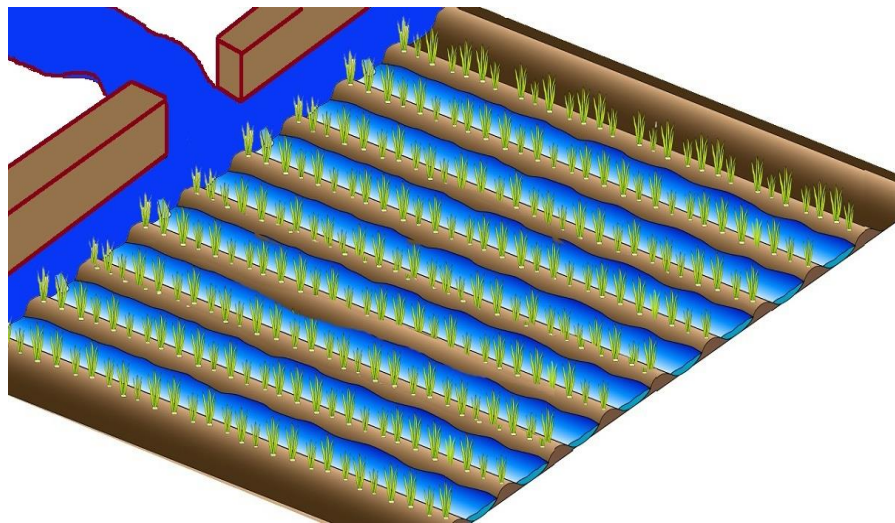


Figure 1 Current Irrigation Method

## 1.1 Motivation

Agriculture is one of the most important parts for survival of the people around the world. For Bangladesh agriculture is the main source of livelihood. Water is a basic component of all life and it plays a dramatic impact in cultivation. Bangladesh has suffered serious drought several times in between the year 1960 and 1991. In these years droughts have naturally

affected 53% of the population and 47% area in Bangladesh[1]. Recent research shows the ground water level of Bangladesh is decreasing day by day. If it continues another big disaster will be coming to us in near future. So, from now on we have to be very careful about wasting our ground water. That's the reason we are trying to reduce water wastage as much as possible. At the time of irrigation every time some portion of water evaporate and directly lost from that region by effect of wind. That is completely wastage for that particular region. This is one of the reasons of drought. Our need is to conserve electricity also, as electricity is mainly used to pull up water from ground.

## **1.2 Objective**

The key behind an efficient irrigation system is to reduce water waste and provide correct balance for optimal plant life. Our project aims to develop an irrigation system which considers soil moisture and provides water according to the needs. As the water flow rate is being controlled, therefore, the chance of excessive flow of water to the field is going down as well as the crop will not die due to lack of water as the moisture sensor is continuously monitoring the moisture level.

### **1.2.1 Why Fuzzy Logic**

From past few years different researches are going on to implement fuzzy logic in the irrigation system because it is easier to get accurate values

from multiple inputs if we use fuzzy logic. 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. Here we are going to use only one factor the moisture level to demonstrate the system.

### **1.2.2 Thesis Overview**

This thesis paper is divided in to six chapters. The outline of each chapter is given below.

Chapter 1 contains an introduction to automated irrigation system, its motivation and objectives. It also contains the reason behind use of fuzzy logic in our system.

Chapter 2 contains the works we have studied to come up with our system. The benefit of our system along with the components we have used, operations and circuit structure.

Chapter 3 is the description of Fuzzy Logic and Fuzzy Control System and the advantage of using it.

Chapter 4 describes the steps of the implementation of our algorithm using in the system.

Chapter 5 discusses result of our system compared with traditional system.

Chapter 6 is the conclusion and future work. Here we summarized our idea and provided the scope for improvement in the future.

# CHAPTER 2

## Background Study

Fuzzy logic theory was first proposed on 1963. After huge research finally, fuzzy logic was implemented in Japan. In 1998 Japan established the laboratory of international engineering which is also known as LIFE, a cooperative arrangement between 48 companies to pursue fuzzy research. Being inspired from them this research is also proceeding in the United States and Europe [2].

Including fuzzy expert systems and irrigation of fuzzy logic with neural network so called adaptive “genetic” software systems with the ultimate goal of building “self-learning” fuzzy logic systems, these systems can be employed to control complex, nonlinear dynamic plants, for example, human body. In Bangladesh in the year 2014 a research paper was published from North South University based on fuzzy logic based automated irrigation system. It will give four output using fuzzy logic system, shading, no shading, irrigation, both [3]. In 2015 a research paper was published based on the research about implementing fuzzy logic in irrigation system. In this research they used humidity, temperature and salinity to control the flow of water. The system can control the energy system (turning energy systems on or off). They took soil and evaporation rate to calculate the water needed for a field [4].

In next year a research was conducted in Pakistan which is based on fuzzy logic implementation in irrigation that emphasis more on saving power energy. They used fuzzy logic to design their system with solar

system, power grid system and hybrid system. This system turns on and off the irrigation system from there [5].

Here, in our project we are going to take multiple values of single type of input factor and making result by using fuzzy logic to the values. Our only input factor is soil moisture level and with this value we are controlling the position of water valve so that water flow rate remains under control and water usage becomes efficient.

## **2.1 Benefit**

Our proposed system has huge technical and economic advantage in the perspective of our country as well as other countries where agriculture is hugely used

### **2.1.1 Economic impact of agriculture**

In any country agriculture has huge impact on their economy. The performance of this sector has a great impact on major macroeconomic objectives like employment, poverty reduction, security etc. According to a study conducted by the World Bank, over 87% of rural people are actively or passively connected with agricultural [6]. So, it has a huge contribution on our gross domestic product (GDP) [7]. Technological up gradation in agriculture can play a vital role economy of our country.

### **2.1.2 Technological up gradation in irrigation**

Like all other sectors the usage of technology on agriculture is increasing with time. Farmers need technological advancement to fulfill this



demand. Like other sections, irrigation method should be upgraded as it is one of the most significant parts of cultivation. Traditional methods are less efficient, need more man power and makes wastage of water. An automated irrigation system can be installed to overcome all the problems.

### **2.1.3 Increasing efficiency of farmer:**

In traditional irrigation there is no limit of water or soil moisture for each crop. All crops get similar amount of water which may not be perfect for them. Sometimes they are getting dry and sometime over flooded. In automated irrigation system each crop will get the exact amount of water what they require. Thus, crops will grow healthy and farmers profit will increase along with country's economy.

### **2.1.4 Reduce water wastage**

Automated irrigation system will calculate needs of water according to moisture level and will provide that exact amount of water which is needed. So, there will be no wastage of water.

### **2.1.5 Ease of management**

It will automatically provide water whenever moisture level will go down. It will also help a farmer to look after several fields without any hustle.

### **2.1.6 Benefit to research institutes**

Government as well as non-government agricultural research institutes can use it for quality control and maintenance for their agricultural research fields.

## **2.2 Components and Circuitry**

For developing system, hardware part is very component. It is built by integrating all the components according to the need. Components are mentioned bellow:

### **2.2.1 Components:**

- I. Arduino
- II. Soil Moisture Sensor
- III. DC Motor Driver
- IV. High Torque Gear Motor
- V. LCD Display
- VI. Push Buttons

### **Arduino**

Arduino comprises of both a physical programmable circuit board (frequently alluded to as a microcontroller) and IDE (Integrated Development Environment) that runs on PC, used to compose and transfer



Figure 2.2.1 (a) Arduino

PC code to the physical board. Not at all like most past programmable circuit board, the Arduino does not require a different equipment to stack new code onto the board. Furthermore, the Arduino IDE utilizes a simplified version of C++ to make it easy [8].

### **Motor Driver**

A motor driver is a little current amplifier; the contribution of motor drivers is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor. It allows to control a DC motor rotate in any direction. It can also control motor speed from taking command from micro-controller (in our case, from Arduino), though we don't need to vary speed.



Figure 2.2.1 (b) Cytron Motor Driver

We cannot connect motor directly to the controller, therefore we need motor driver [9].

### **Soil Moisture sensor**

Moisture Sensor can recognize the dampness of the soil around the sensor.

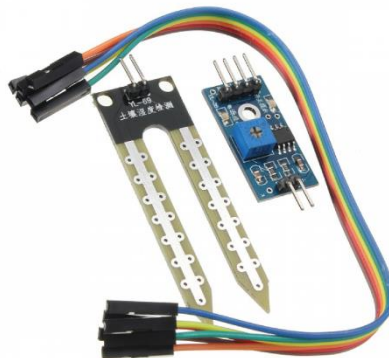


Figure 2.2.1 (c) Soil Moisture Sensor

It can be exceptionally easy to utilize, simply embed it into soil and the connect cables with microcontroller. This sensor utilizes the two probes to go current through the soil, and after that it reads that resistance to get the dampness level. More water improves the conductivity between two probes, while dry soil conducts less current [10].

### **20x4 LCD display**

A liquid-crystal display (LCD) is an electronic visual display of flat surface that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly.



Figure 2.2.1 (d) LCD Display

Here, in our project we have used a monochromatic 20x4 alphanumeric LCD. Here 20x4 denotes that 20 characters can be displayed in each row and there are 4 rows in the 20x4 LCD, thus a total of 80 characters can be displayed by taking command from micro-controller [11].

**DC motor:**

The DC motor is a mechanism that transforms electric voltage into mechanical manifestation. Its movement is produced by the physical behavior of electromagnetism. There are some sets of inductors in DC motors, which produce the magnetic field.



Figure 2.2.1 (e) DC Motor

That field interferes with a set of permanent magnets installed inside the motor and generates rotation. We have used 30 rpm (rotation per minute), 12 volt high torque dc motor. There is a set of gear installed in the rotor of the motor, thus its speed has been decreases and torque has been increased [12].

## **Push Buttons**

Push Button Switches comprise of a straightforward electric switch component which controls some part of a machine or a procedure. Catches are normally made out of hard material, for example, plastic or metal [13].



Figure 2.2.1 (f) Push Buttons

### **2.2.2 Circuit:**

Circuitry is the description of circuit connection which is the basic model of the prototype.

Total system is divided into three sections:

#### **1. Input**

This is the section from where the system will get information from outer environment. In our system moisture sensor and couple of push-button are in this section. Moisture sensor is taking analogue values from the soil and

directly transfers it to main system-hub. Push buttons takes input (physical contact) to set the desired high state and low state.

## 2. Processing Unit

We have used Arduino as processing unit. There is a micro-controller from Atmel Company in the Arduino. All the data processing takes place in this section. It generates corresponding output to the motor driver.

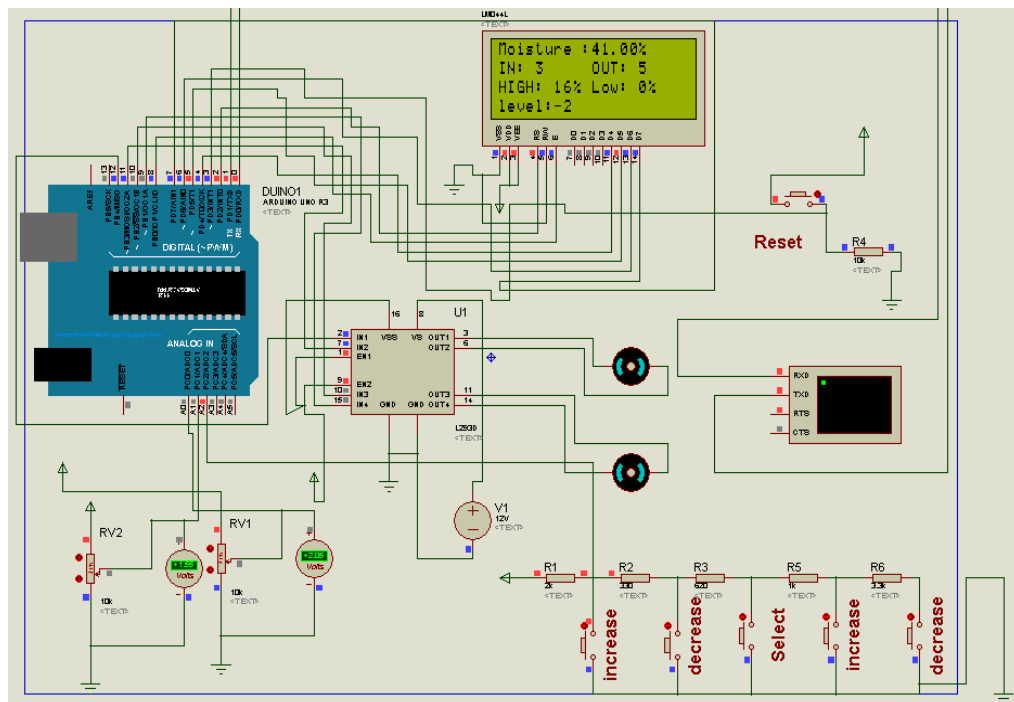


Figure 2.2.2 (a) Circuit Diagram

## 3. Output

There is a single low current control signal comes out from Arduino as output which takes motor driver and makes it high current signal. That high current directly connects with dc motor. Dc motor rotates the water tap which is used as valve.



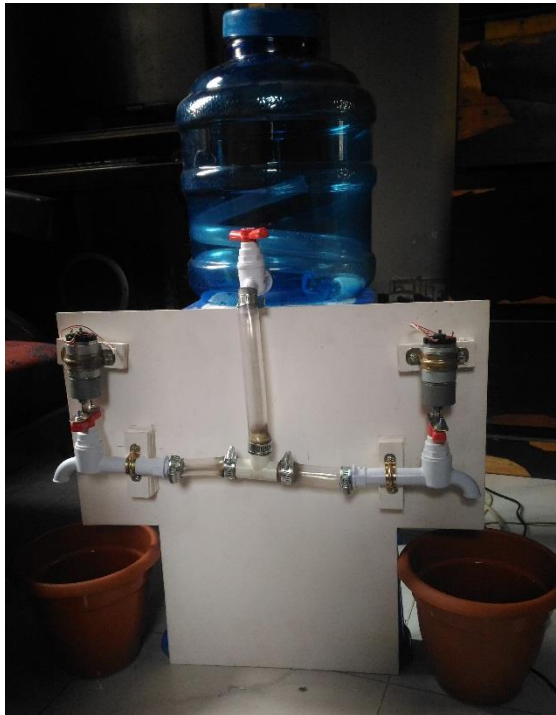


Figure 2.2.2 (b) Implemented Demo System



Figure 2.2.2 (c) Motor With The Tap/Valve

# CHAPTER 3

## Fuzzy Logic

Fuzzy logic is basically representation of logic with many values. These values can be any real number between 0 and 1. In Boolean logic, the input of true and false are represented by 1 or 0. Therefore, fuzzy logic is engaged to manage partially truth situation where true value is perhaps in between the range of completely true and completely false [14].

### 3.1 Fuzzy control system

A fuzzy control system is a control system based on fuzzy logic. Basically, a control system is a set of mechanical or electronic devices that alter and regulates another physical system so that this system acts certain desired characteristics by computerized way. In fuzzy control system output approach depends on fuzzy algorithm based on fuzzy logic. There are some reasons behind using fuzzy control system. At the time of applying traditional or Boolean control, knowledge about the model is needed and the objective function formulated has to be in exact terminology. This makes it difficult. Moreover, by applying fuzzy logic for control we can use the human experience for designing this controller. Furthermore, the fuzzy control rules build basically based on the IF-THEN rules, which makes the control more efficient [15].

### 3.2 Advantages of Fuzzy Logic Control

There are many advantage of using fuzzy logic control. Developing model-based controller are relatively more expensive in terms of

performance. Moreover, fuzzy controls are stronger than proportional–integral–derivative (PID) controllers because of their ability to handle a huge variety of functioning conditions. Lastly, they are easily customizable at the time of integrating different types of factors.

### **3.3 Algorithm of 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)

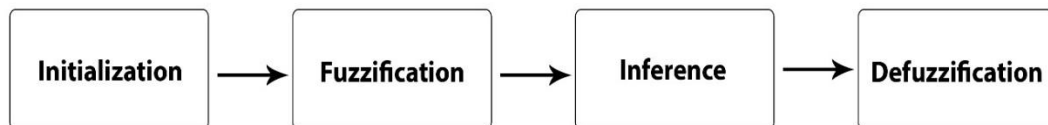


Figure 3.3 Fuzzy Control System Flow

### **3.4 Fuzzy Control in Our System**

Reading values from soil moisture sensor is a non-linear approach. It changes abruptly in every second. In classical algorithm the controlling of water flow can vary according this change, which is not quite efficient. To make the process efficient it is necessary to introduce a system which will not only observe the soil moisture level but also handle the multi-step output according to the multiple input values varying with time.

# **CHAPTER 4**

## **Operation Description**

The automated irrigation system is not a new topic in this era of technology. Many models have their policy and ways to regulate and operate irrigation in automated way.

### **4.1 System Overview**

At the beginning the sensor will read the soil moisture and send the reading to system. This is a continuous process, meaning the moisture reading will be sent to the system in every second. System will then take the value and put it into the processing of fuzzy logic. With the output of the calculation the value will generate a control method based on the moisture level and that control method will rotate a valve at the end of water supply line. The water will be supplied from a static overhead tank from one side of the field. The whole irrigation will be done between a low and a high desired preset value. When the moisture level is found at low state the system will start the irrigation at full rate. Once the irrigation is started, the moisture level will increase gradually. With this increasing moisture level, the system will continuously generate a new step by compilation of fuzzy logic for the motor to rotate the valve accordingly. For later steps the valve will gradually begin to close to stop water flow until the moisture level is reached to its desired high state. Again, at the high state the system will not stop taking reading of moisture level rather it will continue to take result and keep stand by until the moisture level reaches its lower value again.

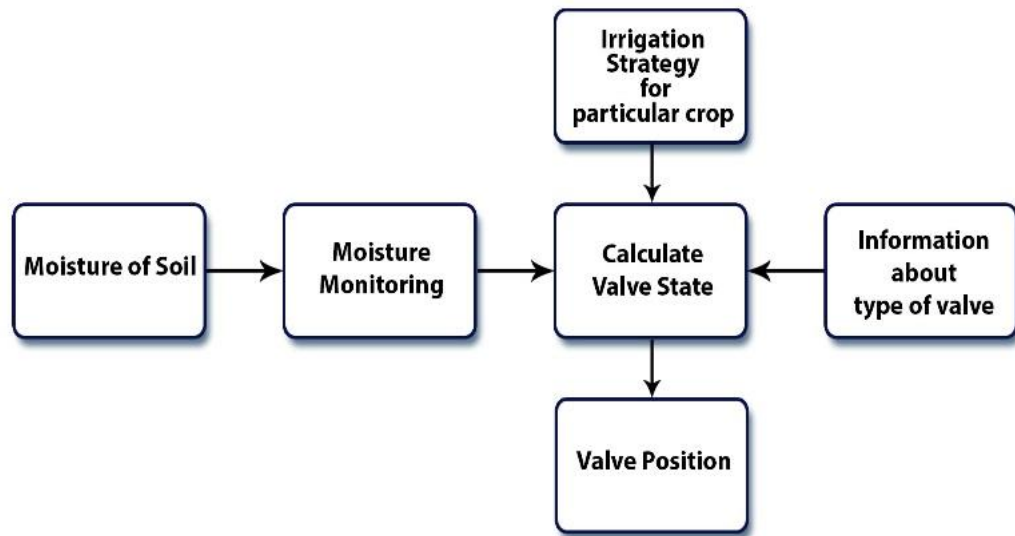


Figure 4.1 Block Diagram of the System

#### 4.2 Comparison between multi steps and single step output:

We need the water covering the land uniformly. 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.

### **4.2.1 Single-step output:**

In this method, the supply will remain completely on till required moisture level. In that situation, three cases can be happened:

Case-1: Regular flow will be maintained. The system will be always checking the moisture level. Whenever desired condition comes, flow will be off. However, already there will be extra water in the supply end of the land as soil will not get enough time to soak out and diffuse the water. As a result, wastage of water occurs.

Case-2: Water flow rate will be in lower state. Like the case-1, the system will be always checking the moisture level. Whenever desired condition comes, flow will be off. In this case the soil will get enough time to soak out and diffuse water uniformly. However, then it will take huge time to reach desired moisture level. As a result, no water will be wasted but the crops health will be compromised due to the delayed reaching of water.

Case-3: In this case to ensure less water wastage as well as high flow of water, multiple sensor can be planted in single section of land. The system will take analogue values from the sensors and make them average and act according to that. However, the feedback response of the system will be delayed. As a result, we will get less efficient system. For using of multiple sensors in single section, the field will become clumsy and cost of the total system will increase.

#### 4.2.2 Multi-step output:

In this case the sensor will be planted at opposite side of the supply end like case-1 and 2. At first water flow rate will be regular when moisture level will be at its critical point. Gradually moisture level will start to increase and step by step the valve position will start to close. As a result, irrigation time isn't compromise as well as no water will be waste. Therefore, we have chosen this multi-step operation.

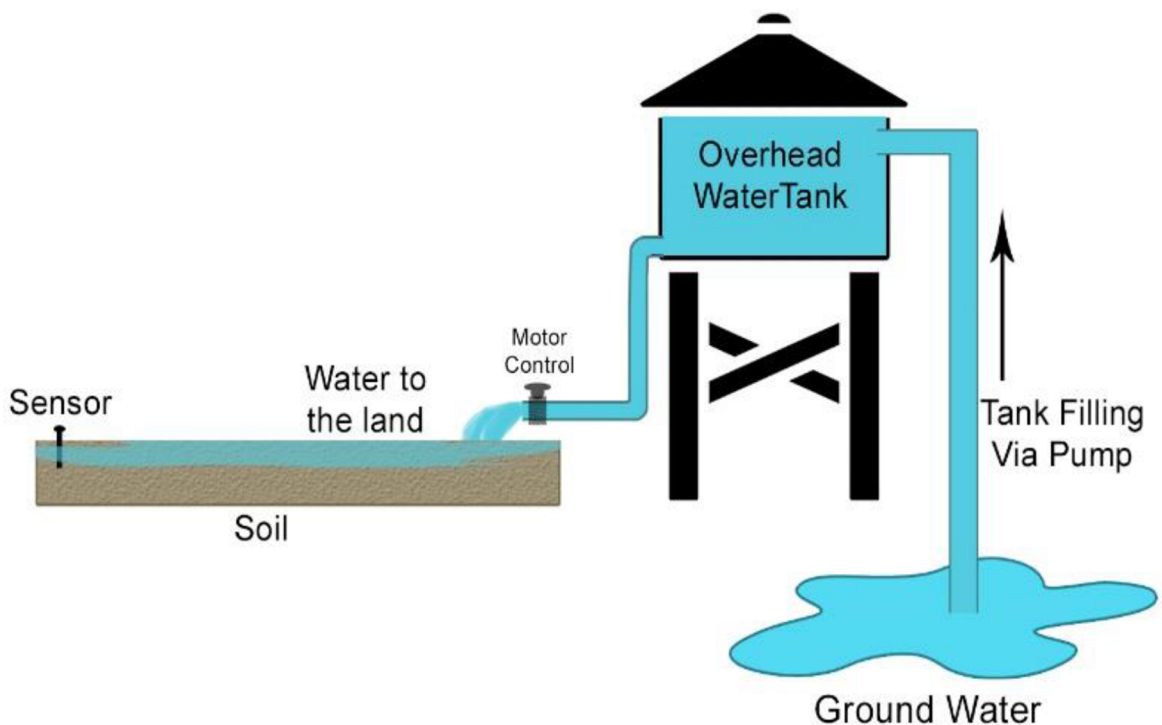


Figure 4.2.2 Field Implementation



### 4.3 Algorithm Construction

The algorithm of the whole system has several parts. We made the process of programming in such way that one part of the program may not hamper the other part. The dependent parts are compartmentalized so that the system runs properly.

#### 4.3.1 Algorithm

Initialize variables startComp← false.

Building fuzzy rule set.

Setting up External Interrupt 0

**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.

```

### 4.3.2 Algorithm Summary

We built our program based on C++/C language; the whole program can be divided into several parts according to work flow:

- i. Declare and initialize the variables
- ii. Building fuzzy rule set

```

// Building FuzzyRule.....1
FuzzyRuleAntecedent* mostVerylow = new FuzzyRuleAntecedent();
mostVerylow->joinSingle(verylow);
FuzzyRuleConsequent* firstRule = new FuzzyRuleConsequent();
firstRule->addOutput(first);
FuzzyRule* fuzzyRule1 = new FuzzyRule(1, mostVerylow, firstRule);
fuzzy->addFuzzyRule(fuzzyRule1);

```

Here, we multiply the function *FuzzyRuleAntecedent* with a rule name *mostVeryLow* (very low moisture level) to build a new rule. Then *verylow* variable is passed through *joinSingle()* to the rule to execute. It combines the single parameter to the rule.

Similarly, *FuzzyRuleConsequent\* firstRule = new FuzzyRuleConsequent()* creates another rule for getting the corresponding output according to previously set rule.

### iii. Fuzzyfication

*Fuzzy object* - This object incorporates all the Fuzzy System, through it, we can control the Fuzzy Sets, Linguistic Rules, inputs and outputs.

*FuzzyInput object* - This object bundles all segments Fuzzy Sets that has a place with the same domain.

*FuzzyOutput object* - This object works similar to FuzzyInput, it groups all output Fuzzy Sets of a same domain.

*FuzzySet object* - This is one of the principle objects of Fuzzy Library, with each set is possible to construct the system. The membership functions are set based on points A, B, C and D, they are passed by parameter in its constructor *FuzzySet(float a, float b, float c, float d)* examples:

Table 4.3.2.(a) Fuzzification Inputs

Sl.	Input	Linguistic fuzzifier output	Region 1	Region 2	Region 3	Region 4
1	Moisture level	Very low	0	5	10	15
2		Low	10	20	25	30
3		Mid	25	35	40	45
4		Accurate	40	55	60	65
5		Exceed	55	75	80	85
6		Over- flowed	75	95	95	100

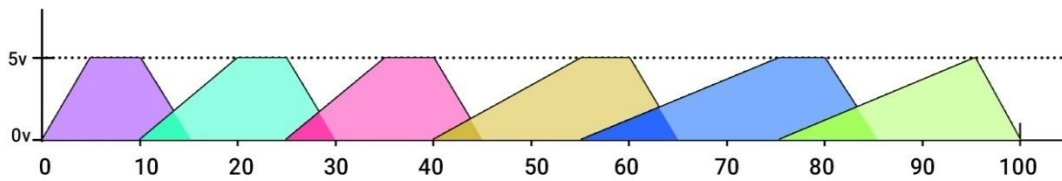


Figure 4.3.2 FuzzySet Input Graph

iv. Defuzzification

Table 4.3.2.(b) Defuzzified Outputs

	IF	THEN
Rule	Moisture level	Motor operation
1	Very low	On [Full]
2	Low	On [Full]
3	Mid	On [Half]
4	Accurate	On [Low]
5	Exceed	Off
6	Overflowed	Off

v. Rotate motor according to output

# CHAPTER 5

## Result and Discussion

To observe the result of our model, we have to compare it with real field according to water usage. After comparing the amount of water usage, we can come up with decision how much our model reduces water misuse.

Wastage of water in irrigation is mainly caused by the use of traditional techniques which are based on timers. Though farmers have estimated calculation how much water the land needs to cultivate their desired crop by years of experience, some system loss still happens and wastage of water and electricity occurs. To calculate the loss of water it is important to know how much water a particular size of land needs to produce a particular crop. The amount of water depends upon many factors like geographic location, season or month of cultivation, crop type, stage of growth of the plant etc.

As we are focusing Bangladesh and Rice is the top most cultivated plant in Bangladesh, our subject plant is rice and the subjected area is Mymensingh district. There are 4 types of rice according to irrigation: Lowland irrigated, Deep water or floating rice, Coastal wetland and Upland rice. In our country, deepwater rice occupied 21% of the total rice amount [16]. Generally, the flood water comes from rainfall or other reasons uses for their irrigation. So, they are not our concerning part. Rest of the 79% of rice requires our system to reduce misusing of water.

Basic formula for the calculation of crop water requirements according to [17] is:

$$ET_{crop} = kc \times Et_0 \quad (1)$$

where:

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

kc = the "crop factor" [17]

Table 5. Crop Factor Values

Sl.	Crop	Kc (initial)	Kc(medium)	Kc(end)	Max Crop Height (h)(m)
1	Spring wheat	0.4	1.15	0.25	1
2	Corn	0.8	1.15	0.15	1.5
3	Suger cane	0.4	1.25	0.75	3
4	Rlce	1.05	1.2	0.9	1

Now, kc of rice in middle growth is =1.2 (average among different kinds of them) [15].

$ET_0$  = the "reference crop evapotranspiration" in mm per unit of day

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad (2) \quad [17]$$

where

$ET_0$ , reference evapotranspiration [mm day<sup>-1</sup>],

$R_n$  net radiation at the crop surface [MJ m<sup>-2</sup> day<sup>-1</sup>],

G soil heat flux density [MJ m<sup>-2</sup> day<sup>-1</sup>],

$T$  air temperature at 2 m height [ $^{\circ}\text{C}$ ],  
 $u_2$  wind speed at 2 m height [ $\text{m s}^{-1}$ ],  
 $e_s$  saturation vapour pressure [ $\text{kPa}$ ],  
 $e_a$  actual vapour pressure [ $\text{kPa}$ ],  
 $e_s - e_a$  saturation vapour pressure deficit [ $\text{kPa}$ ],  
 $D$  slope vapour pressure curve [ $\text{kPa } ^{\circ}\text{C}^{-1}$ ],  
 $g$  psychrometric constant [ $\text{kPa } ^{\circ}\text{C}^{-1}$ ].

$ET_0$  varies place to place. According to a research from Bangladesh Agricultural University the  $ET_0$  value of Mymensingh District of April is 5.5 [18].

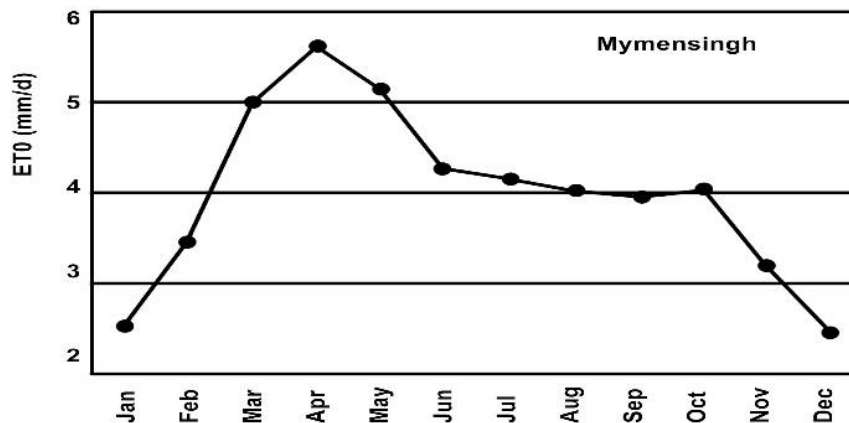


Figure 5. Monthly Reference Crop Evapotranspiration Rate (mm/d)

$$ET_{\text{crop}} (\text{for rice}) = 5.5 \times 1.2 = 6.6 \text{ mm}$$

So in a  $100\text{m}^2$  area of land requires:

$$10 \times 10 \times 0.0066 = 0.66 \text{ m}^3 = 660 \text{ liter/per day}$$

**Misusage reduction from proposed model:**

We have run some tests on a seed bed by our system. We first used regular irrigation process as per the moisture level which we measured by our assumption and fingertip sensation. After long time trial and error irrigation we have got 12% less water usage to maintain certain level of moisture. According to the calculation and our result of trial and error method there is a chance of misuse of 79.2 liters of water per day which can be avoided by our system.



## **CHAPTER 6**

### **Conclusion and Future Work**

Since the beginning of irrigation water was distributed to lands in random manner. It was taken for granted that water is just another stuff that we can use as we please, but this precious natural resource also needs to be used in proper way so that no wastage may occur as well as our irrigation remains satisfied. Watering the agricultural fields may seem to be easy but it is not efficient. In this paper, an automated irrigation model is proposed and successfully implemented by fuzzy algorithm where electric circuit is very simple. Cost-effectiveness and low power consumption is the highest priority at the time of designing and implementation. As the model is fully autonomous, it will help a single farmer to keep multiple field under surveillance easily. The system ensures always the required amount of water for specific crop, so no crop will get under or over irrigation. As a result, they will grow with good health and farmers will get better production. As the structural model is simple, so the total system implementations in real life use will be affordable for farmers. So, they will be financially benefitted and agricultural sector of our country will be stronger. In future we will work to accommodate weather update in our system which will change the irrigation time based on the rain probability. We are also working on giving a web interface to the system so that farmers or researchers as well as system admins can monitor and maintain the system from distance. For further extension of the system it is also possible to include multiple parameter such as temperature, wind speed and evaporation rate in the system.

## Appendix

1. **Traditional Method:** Traditional method is the method farmers are currently using. Mainly they depend on estimation to decide whether
2. **Preset Values:** The desired values from moisture sensor for which the motor will turn on or off.
3. **Low State:** A given percentage. If the moisture level gets below of this percentage then the motor will turn on.
4. **High State:** Another given percentage. If the moisture level gets over this percentage then the motor will turn off.
5. **Uniformly:** Water will be distributed equally in the field so that every section is perfectly moist.
6. **Critical point:** The minimum level of soil moisture below which the crops will die.
7. **Surveillance:** Monitor water flow in several fields at the same time.

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