DEVELOPMENT OF THE PRE SEEDING DECISION SUPPPORT SYSTEM BASED ON IOT IN AGRICULTURE

A THESIS

Submitted by

Kazi Saymatul Jannat

2013-2-60-018

Md. Shariful Islam

2013-2-60-027

Supervised By

Dr. Ahmed Wasif Reza

Associate professor

Department of Computer Science and Engineering

East West University

A Project Submitted in Partial Fulfillment of the Requirements for the Degree of Bachelors of Science in Computer Science and Engineering

to the

Department of Computer Science and Engineering

East West University

Dhaka, Bangladesh

ABSTRACT

Agriculture plays economically vital role of Bangladesh. Most important challenge in agriculture is to find out the specific soil for the specific grain. The pH of soil varies in very few inches. Farmers of our country are not trained enough to find out it. So they need to take help from the soil department of our country but which is very lengthy process. The Internet of Things is one of the technological advances which can provide a solution to this problem. IOT is a revolutionary technology which aims to extend internet to large number of distributed devices by defining standard, interoperable communication protocols. This paper brings up with this solution by IOT for removing the difficulties of farmers in our country. This paper will help the farmers to find out all possible grains for the specific soil. It will give them a very fast process which will definitely save their time. This project is highlighted the features including pH sensor, mobile app, frontend, hardware and backend analysis system. The pH sensor transfers the data via Bluetooth to mobile or other devices including Bluetooth connection such as laptop. After collecting all necessary information the system is capable of giving the list of all possible crops with required amount of fertilizers for each individual crop for specific land as well as crops distribution lists.

Keywords: IOT, Agriculture, pH sensor, Mobile app

DECLARATION

This thesis has been submitted to the department of Computer Science and Engineering, East West University in the partial fulfillment of the requirement for the degree of Bachelor of Science in Computer Science and Engineering by us under the supervision of Dr. Ahmed Wasif Reza, Associate Professor Department of CSE at East West University under the course 'CSE 497'. We also declare that this thesis has not been submitted elsewhere for the requirement of any degree or any other purposes. This thesis complies with the regulations of this University and meets the accepted standards with respect to originality and quality. We hereby release this thesis to the public. We also authorize the University or other individuals to make copies of this thesis as needed for scholarly research.

Kazi Saymatul Jannat
ID: 2013-2-60-018
Department of Computer Science and Engineering
East West University

Md. Shariful Islam
ID: 2013-2-60-027
Department of Computer Science and Engineering
East West University

LETER OF ACCEPTANCE

The thesis entitled "Development of the Pre Seeding Decision Support System Based on IOT in Agriculture" submitted by Kazi Saymatul Jannat, ID 2013-2-60-018 & MD. Shariful Islam, ID 2013-2-60-027 to the department of Computer Science & Engineering, East West University, Dhaka 1212, Bangladesh is accepted as satisfactory for partial fulfillments for the degree of Bachelor of Science in Computer Science & Engineering in August2017.

____

Dr. Ahmed Wasif Reza **Supervisor**

Associate Professor

Department of Computer Science and Engineering

East West University

____

Dr. Mozammel Huq Azad Khan

Professor and Chairperson **Chairperson**

Department of Computer Science and Engineering

East West Universit

ACKNOWLEDGEMENT

First of all, we are grateful to the Almighty Allah for giving us the strength to complete this research. We would like to give our heart and soul gratitude and also immense thanks to our research supervisor **Dr. Ahmed Wasif Reza** associate professor department of Computer Science and Engineering of East West University for showing his deep interest, continuous inspiration, guidance and also his encouragement at each and every steps of our work which has led our thesis a fruitful one.

We also would like to give thanks to all of our honorable faculty members, Department of CSE, East West University. We are also grateful to all of our primary and secondary school teachers who are our first teachers in our life and initiator of our basic knowledge.

We are also thankful to our parents and siblings for their continuous support throughout writing this thesis. And we are thankful to all my friends and colleagues. At last, we are again thankful to our creator for everything.

TABLE OF CONTENTS

CHAPTER NO & TITLE **PAGE NO**

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

In Bangladesh the most important sector of economy is agriculture and it remains the largest employer in the country by far. It helps to meet the basic needs of human and their civilization by providing food, clothing, shelters, medicine and recreation. Agriculture provides food, fiber, fuel, furniture, raw materials, a free fare and fresh environment, plenteous nourishment for driving out starvation, favors companionship by wiping out battles. Tasteful rural generation brings peace, success, harmony, health and riches to people of a country by heading out doubt, conflict and political agitation. It helps to elevate the community consisting of different castes and clauses, thus it leads to a better social, cultural, political and economical life. Agricultural development is multi-directional having galloping speed and quick spread concerning time and space. After green revolution, farmers started utilizing enhanced social practices and rural contributions to escalated editing frameworks with worker concentrated projects to improve the generation potential per unit land, time and information. It provided suitable environment to all these improved genotypes to foster and manifest their yield potential in newer areas and seasons. Agriculture consists of growing plants and rearing animals in order to yield produce and thus it helps to maintain a biological equilibrium in nature. Still in Bangladesh almost more than 70% of the people are directly or indirectly employed in this sector. The total area is about 14.76 million hectares and net cultivable area is about 8.52 Million hectares. Development in agricultural sector is very essential for the advancement of economic condition of the nation. It is true that the farmers of our country still utilize the conventional techniques for cultivating which is not good for the better production. In this case IOT has come to make the cultivation easier than before.

1.1 RESEARCH BACKGROUND

1.1.1 THE CONCEPT OF IOT

In 1999, the concept of the Internet of Things first became popular, through the Auto-ID Center at MIT and related market-analysis publications. The concept of the Internet of Things (IOT) sounds extremely dynamic yet basically implies a gathering of arranged physical devices inserted with hardware. IOT is the system of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment. The IOT refers to the connection of devices to the Internet. The major objective of IOT is to create a smart environment (smart buildings, smart health, smart transport, etc.) using enabling technologies such as sensors, embedded devices, communication protocols. Physical devices such as microcontrollers, microprocessors, actuators, and sensors cannot directly communicate with the Internet but they do so by using an IOT gateway. Now it is generally considered as a network or system, which interfaces everything with the web by radio frequency identification (RFID), sensors, global positioning systems, laser scanners and other information sensing devices. Cars, kitchen appliances, and even heart monitors can all be connected through the IOT. And as the Internet of Things grows in the next few years, more devices will join that list. At present, the architecture of the Internet of things is divided into three layers:

Application layer:

Intelligent Home, Intelligent Medical, Intelligent City, Intelligent Transportation, Intelligent Green, Intelligent Justice, Intelligent Agriculture, Intelligent Logistics.

Network layer (cloud computing platform):

Internet, Mobile Communication Network, Satellite Communications Network, Cable Television Network, Information Center, Network Management Center.

The sensing layer:

RFID Reader, Sensor Network, Access Network, RFID Label, Sensor, Intelligent terminal.

1.1.2 ABOUT IOT IN AGRICULTURE

There has been much research and various attempts to apply IOT technology to agricultural areas. The Internet of Things (IOT) has already brought revolutionary changes in agriculture. In this sector there are so many challenges like high cost of investment, lands limitation, lack of awareness by farmers on better farming methods, imbalanced use of fertilizers , lack of quality seeds , low production and productivity, dividing the country into zoned on the basis of different agricultural crops etc. IOT helps farmers to deal with all these numerous challenges which they face. It is expected that by using IOT in this sector the industry must find out the solution for various problems like increasing water shortages, shortage of lands, difficult to manage costs etc. This new innovation has come to address all these issues and helps to increase the quantity, quality, cost effectiveness and sustainability of agricultural production.

1.1.3 ADVANTAGES OF IOT IN AGRICULTURE

Advantages of IOT applications in agriculture are given below:

1. Improvement in the use efficiency of inputs (Soil, Water, Fertilizers, Pesticides, etc.)
2. Reduced cost of production
3. Increased profitability
4. Sustainability
5. Food safety
6. Protection of the environment.

1.3 PROBLEM STATEMENTS

In our country, location identification is done by manually which is backdated. Co-ordinate collection and finding out the location according to the co-ordinates from a hardcopy map are including in this method. Another problem is still crops and fertilizer recommendation are done manually by following a book which is referred from Soil Resource Development Institution (SRDI).This existing method has some limitations such as it recommends only those crops which are generally cultivating on that region. Another one is it provides the amount of fertilizer which is taken from a previously tested solution that was done around the land. It is not possible to cultivate crops like rice, wheat, jute etc in a small sized land because of all these crops are profitable only for large sized land. Still in our country pH value is measured by using litmus which is time consuming.

1.4 OBJECTIVES

1. To develop a system that will help the farmers to easily find out cultivable crops for their land.

For developing our system we have to divide our full process into two parts. Such as:

Hardware: For data limitation, we cannot use other sensors like humidity, temperature, soil moisture. So we have to use a pH sensor for demonstrating hardware successfully. After collecting data through pH sensor we have to send the value to a smart device via Bluetooth.

Software: In this part, we will develop a fully functioned data analysis system which will receive inputs from sensor as well as user. For giving input to the system we will have to create a web page frontend which will be connected to the system. For making it easier we will develop a smart device app too.

2. To analysis data from the hardware, field as well as SRDI and provides all possible efficient information.

.

Our system will have the capabilities of taking inputs from the sensor as well as user. After that the system will transmit all those data to the data analysis system and then it will give outputs such as information about location, soil and suggest all possible crops for that location and it will also recommend fertilizers and crop distribution lists according to crops.

1.5 CONTRIBUTION

- We have introduced a system that has the capability to find out all possible crops for a specific land and our system also provides fertilizer recommendation for all those crops as well as crop distribution lists.
- We have also integrated IOT with our system that will help to digitalize our agricultural field.
- We have setup hardware with pH sensor.
- We have designed a real life mobile application and also a web page.

1.6 ORGANIZATION

The following is an overview of the contents of the chapter that presented in this research.

- **Chapter 2:** Chapter 2 provides a detailed literature review on IOT in agriculture. The overall soil scenario of our country is highlighted here. In this chapter several recent works is discussed.

- **Chapter 3:** Chapter 3 presents the full structure and design of the work. It also shows the flow graph of the work and also describes the full method of the work. Besides, this chapter also shows the hardware setup.

- **Chapter 4:** Chapter 4 is the chapter that gives the ultimate result of the research by analysis all the data receiving from the user and the hardware.

- **Chapter 5:** Chapter 5 is the conclusion chapter that describes about the summary of the full work. This chapter summarizes all the findings that obtained through the analysis and also describes some details about the future scope of the work. It also provides recommendation for more research.

CHAPTER 2

2.1 INTRODUCTION

A literature review arranges and assesses the exploration accessible on a specific topic or issue that one is looking into and expounding on. It is a piece of rambling composition, not a list of describing or condensing one piece of literature after another. Researchers have researched more for the development of agriculture sector. They even proposed so many different models with one or multiple technologies for the agriculture sector. This chapter provides an overview to the study on IOT in agriculture and also it discusses about the importance of pre seeding decision support system. Apart from these, this review discusses in detail about the soil scenario of our country. In addition to these, this chapter also provides a summary.

2.2 MAP UNIT INFORMATION

Development of agricultural land depends on the availability of climate, geology, soil, land and groundwater and subsistence water. Considering this, a single area of land and soil has been identified as development area in Gazipur Sadar Upazila. Based on the basis of geography, soil quality and development possibilities, the total expansion of total eleven land development units identified in Gazipur Sadar Upazila is shown in the map. Map unit information is given in figure 2.1.

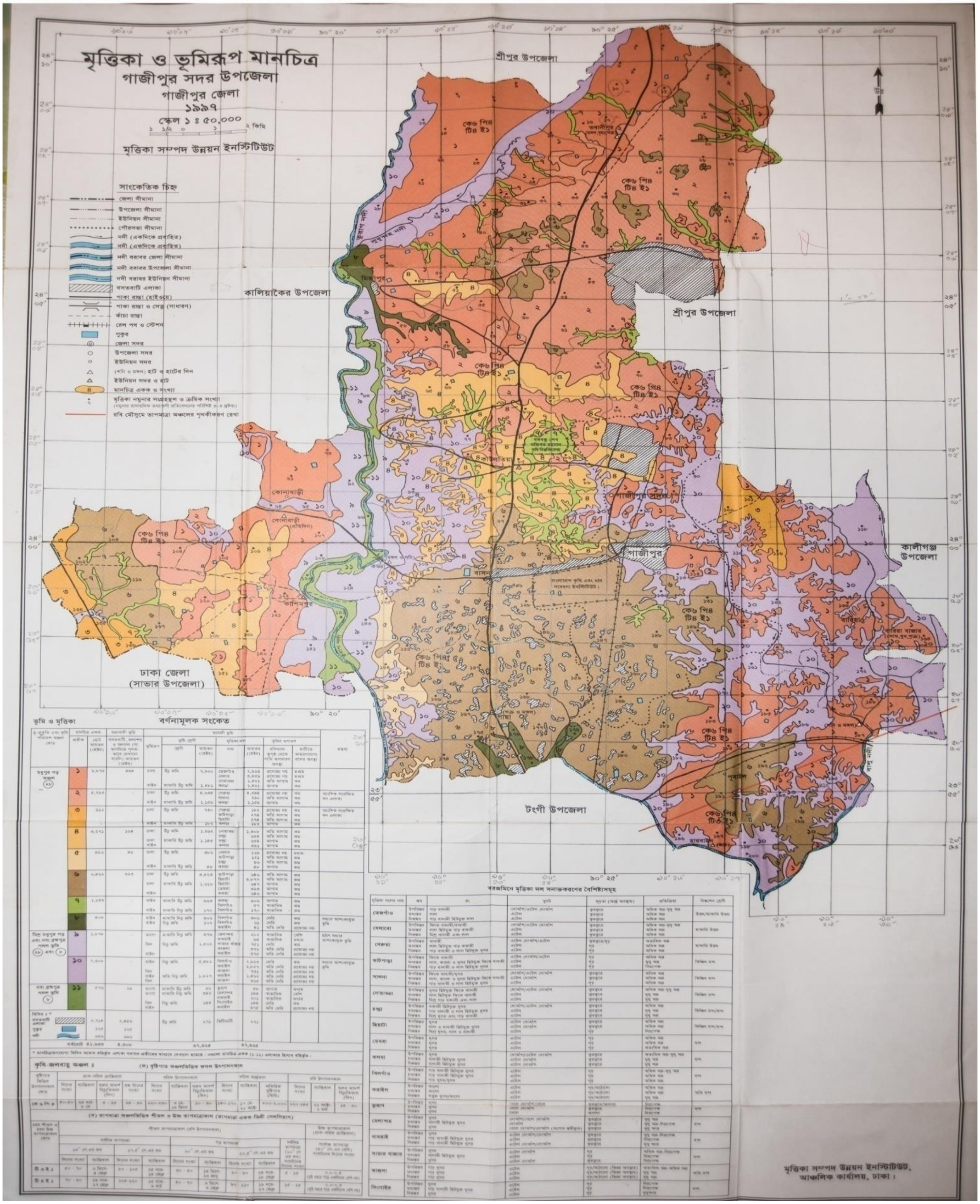


Figure 2.1: Mapping units of Gazipur Sadar Upazilla

Map unit -1:

The total volume of the area is about 9,875 hectors, almost 23.72% of the district. The area is located in Mirjapur (3,269 ha), Pubail (1,475 ha), Baria (1,465 ha), Konabari (1,082 ha), Gazipur powrosova (928 ha), Kaolotia (926 ha) and Kashimpur (731 ha) union.

Map unit -2:

The total volume of the area is about 5,793 hectors, almost 13.92% of the district. The area is located in Mirjapur (2,907 ha), Konabari (95 ha), Gazipur powrosova (212 ha), Kaolotia (2,161 ha) and Kashimpur (418 ha) union.

Map unit -3:

The total volume of the area is about 912 hectors, almost 2.19% of the district. The area is located in Baria (325 ha) and Kashimpur (587 ha) union.

Map unit -4:

The total volume of the area is about 3,271 hectors, almost 7.86% of the district. The area is located in Mirjapur (81 ha), Bason (356 ha), Konabari (200 ha), Gazipur powrosova (206 ha), Kaolotia (1,601 ha) and Kashimpur (827 ha) union.

Map unit -5:

The total volume of the area is about 482 hectors, almost 1.15% of the district. The area is located in Gacha (338) and Bason (144 ha) union.

Map unit -6:

The total volume of the area is about 6,462 hectors, almost 15.52% of the district. The area is located in Mirjapur (334 ha), Pubail (1462 ha), Gacha (1365 ha), Bason (1166 ha), Gazipur powrosova (1236 ha), Kaolotia and Kashimpur (736 ha) union.

Map unit -7:

The total volume of the area is about 1,133 hectors, almost 2.72% of the district. The area is located in Mirjapur (240 ha), Gazipur powrosova (65 ha), Kaolotia (625 ha) and Kashimpur (203 ha) union.

Map unit -8:

The total volume of the area is about 408 hectors, almost .98% of the district. The area is located in Mirjapur (115 ha), Pubail (31 ha), Gacha (199 ha) and Kaolotia (63 ha) union.

Map unit -9:

The total volume of the area is about 1,872 hectors, almost 4.51% of the district. The area is located in Basan (537 ha), Kaolotia (512 ha), Konabari (500 ha), Kashimpur (310 ha) and Gacha (19 ha) union.

Map unit -10:

The total volume of the area is about 7,308 hectors, almost 17.55% of the district. The area is located in Mirjapur (1115 ha), Pubail (1506 ha), Bason (461 ha), Baria (2265 ha), Konabari (144 ha), Gazipur powrosova (807 ha), Kaolotia (560 ha), Gacha (265 ha) and Kashimpur (185 ha) union.

Map unit -11:

The total volume of the area is about 576 hectors, almost 1.39% of the district. The area is located in Bason (163 ha), Kaolotia (152 ha), Konabari (119 ha), Kashimpur (111 ha) and Mirzapur (31 ha) union.

2.3 MOUZA

Mouza is the lowest single-area revenue collection. During the Cadastral survey, each police station was divided into one by one and it was surveyed by identifying each unit with its serial no. Each unit of the Thana area is called mouza. A mouza is recited with one or a few villages or neighborhoods. Mouza boundary of Gazipu Sadar Upazilla is given in Figure 2.2.

Figure 2.2: Mouza boundary of Gazipur Sadar Upazilla

2.4 SOIL GROUP

In Gazipur Sadar Upazilla total 18 group of soil is identified. Soil group identification features are determined on the basis of results obtained in the laboratory and the results of the chemical analysis laboratory. The identity of different Soil Groups is given below:

Tejgaon: In Madhupur gor anchal, good or medium-sized sub-cylindrical clay soil, on wide plain high land. The soil is deeply formed. After the rain, the water moves away from the surface. In the dry season, the amount of nutrient of plants on the soil is medium. In this land, water cannot be stuck.

Belab: In Madhupur gor anchal, medium-good-sized drained clay soil, on wide plain high land. After the rains, the water moves away from the surface. In the dry season, the amount of nutrient of plants on the soil is low. In this land, water cannot be stuck.

Noadda: In Madhupur gor anchal, some poorly drained soils, on wide plain high land. The soil is deeply formed. During Rabikhondo, the water moves away too early. In the dry season, the amount of nutrient of plants on the soil is medium.

Gerua: In Madhupur gor anchal, medium-good-sized drained clay soil, on narrow plain high land. Land nature is rough or slightly high-low. The soil is shallowly formed. In this soil group the impermissible rigid ground level of clay soil is located 30cm to 90cm deep. At this level, the roots of trees are interrupted. Immediately after the rain, the water moves away from the surface. In the dry season, the amount of nutrient of plants on the soil is low.

Salna: In Madhupur gor anchal, bad drained clay soil, on narrow plain high land. Land nature is rough or slightly high-low. The soil is shallowly formed. The impermissible rigid ground level of clay soil is located 30cm to 90cm deep. At this level, the roots of trees are interrupted. During rabikhanda, the water moves away from the surface very early. In the dry season, the amount of nutrient of plants on the soil is low.

Vatpara: In Madhupur gor anchal, bad drained clay soil, on narrow plain high land. Land nature is rough or slightly high-low. The soil is shallowly formed. The impermissible rigid ground level of clay soil is located 25cm to 50cm deep. During rabikhanda, the water moves away from the surface very early. In the dry season, the amount of nutrient of plants on the soil is low.

Ciata: In Madhupur gor anchal, bad drained clay soil on narrow plain high land. The soil is shallowly formed. The impermissible rigid ground level of clay soil is located 60cm to 90cm deep. During rabikhanda, the water moves away very early from the high land surface and early from the medium high land. In the dry season, the amount of nutrient of plants on the soil is low.

Chandra: In Madhupur gor anchal, slightly bad drained clay soil on plain high land and bad drained clay soil on medium high land. The soil is deeply formed. During rabikhanda, the water moves away early from the surface. In the dry season, the amount of nutrient of plants on the soil is low.

Demra: In Madhupur gor anchal, slightly bad drained clay soil on high land. The soil is deeply formed. During rabikhanda, the water moves away very early from the surface. In the dry season, the amount of nutrient of plants on the soil is low.

Kolma: In Madhupur gor anchal, bad drained sub-cylindrical clay soil on narrow baid medium high land. The soil is deeply formed. During rabikhanda, the water moves away early from the surface. In the dry season, the amount of nutrient of plants on the soil is low.

Khilgaon: In Madhupur gor anchal, bad drained impermeable soil on wide and deep baid medium high, medium low and low land. The soil is deeply formed. During rabikhanda, the water moves away from the high land surface at normal times and lately from low land surface. In the dry season, the amount of nutrient of plants on the soil is low.

Korail: In Madhupur gor anchal, very bad drained impermeable soil on deeply flooded wide baid on medium high, medium low and low land. During rabikhanda, the water moves away very lately from low land surface. In the end of dry season, soil remains wet.

Kajla: In mixed Madhupur gor and Brahmaputra sediment ground, bad and very bad drained soil on low and very low land. During rabikhanda, the water moves away very lately from surface. Soil remains wet almost in the end of dry season.

Molandoh: In Nabba Brahmaputra sediment ground, bad drained sub-cylindrical soil on medium low land. During rabikhanda, the water moves away from medium low land surface at normal times. In the dry season, the amount of nutrient of plants on the soil is high.

Dhamrai: Inland of Nabba Brahmaputra sediment ground, bad drained soil on medium low land. During rabikhanda, the water moves away from surface at normal times. In the dry season, the amount of nutrient of plants on the soil is low.

Savar bazaar: In Nabba Brahmaputra sediment bil, bad drained rigid soil on low land. During rabikhanda, the water moves away lately from surface. In the dry season, the amount of nutrient of plants on the soil is low.

Turag: Inland of Nabba Brahmaputra sediment ground, bad drained soil on medium high land. During rabikhanda, the water moves away early from surface. In the dry season, the amount of nutrient of plants on the soil is medium.

Singair: In Nabba Brahmaputra sediment bil area, bad drained soil on medium low land. During rabikhanda, the water moves away lately from surface. In the dry season, the amount of nutrient of plants on the soil is low.

2.5 SOIL SCENARIOS IN BANGLADESH

2.5.1 PLANT NUTRIENTS

For surviving and growing, plants require nutrients. The major source of these nutrients is soil. There are more than 90 elements. But 16 elements are most essential. These elements are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, zinc, copper, molybdenum, boron and chlorine. But for a group of plants there are another four elements such as viz. silicon, sodium, cobalt and vanadium which might be beneficial. Except carbon, hydrogen and oxygen, all the 13 elements are called mineral nutrients which are come from the soil and taken up by the plants. Plants take nutrients from the air, the soil, and the water. Carbon, hydrogen and oxygen are obtained from air and water. There are two sorts of nutrients: 1) macronutrients and 2) micronutrients.

1) Macronutrients:

These nutrients are required relatively in larger quantities (usually above 0.1 % on dry weight basis).

• Primary Macronutrients

- Nitrogen (N)
- Phosphorus (P)
- Potassium (K)

• Secondary Macronutrients

- Sulfur (S)
- Calcium (Ca)
- Magnesium (Mg)
-

2) Micronutrients:

These nutrients are required in smaller quantities.

- Chlorine (Cl)
- Iron (Fe)
- Boron (B)
- Manganese (Mn)
- Zinc (Zn)
- Copper (Cu)
- Molybdenum (Mo)

Other elements are sometimes identified as micronutrients, but they are not essential. Selenium (Se), Silicon (Si), Sodium (Na), Strontium (Sr), Tungsten (W), Vanadium (V), Bromine (Br), Cobalt (Co), Fluorine (F), Iodine (I), Nickel (Ni), Rubidium (Rb).

Table 2.1: Plant nutrients and their sources

Macronutrients			**Micronutrients**
Mostly from air and water	From Soil		From Soil
Carbon (C)	Nitrogen (N)	Sulfur (S)	Iron (Fe)
Hydrogen (H)	Phosphorus (P)	Calcium(Ca)	Manganese (Mn)
Oxygen (O)	Potassium (K)	Magnesium(Mg)	Copper (Cu)
			Zinc (Zn)
			Boron (B)
			Molybdenum (Mo)
			Chlorine (Cl)

The three main nutrients are nitrogen (N), phosphorus (P) and potassium (K). Together they make up the trio which is known as NPK. In this paper we have worked with all these three major elements of soil nutrient. The role of these nutrients play in plant growth is complex. This paper provides only a brief outline.

Nitrogen (N): The key element for plant growth is Nitrogen which is constituent of proteins, nucleic acids, chlorophyll and hormones. Nitrogen is very essential for chlorophyll which allows plants to carry out photosynthesis.

Phosphorus (P): It is key element in energy fixation. Encourages root growth and the ripening process. Phosphorus also promotes blooming, and is essential in DNA. Because of phosphorus, solar energy transformation is also largely possible.

Potassium (K): Regulates flow of water and sugar in the plant, regulates internal acidity, enzyme activator and encourages ripening.

2.5.2 SOIL pH

The most important factor of nutrient availability in soils is soil pH. Generally, availability of macronutrients and Mo increases as soil pH increases and reverse is true for micronutrients except Mo. Again, P availability is low in acid as well as calcareous soils. In most cases, pH 6-7 is optimum for adequate availability of nutrients in soils. Classification of soils according to pH values is given in Table 2.4.7.

2.5.3 LAND TYPES

Traditionally, the Bangladeshi peasants have been classifying the land based on the depth of the rainstorm of our agricultural land from the early age. For example: The high land which is not usually flooded during rainy season. In these lands, fruit trees like sugarcane, banana etc. is cultivated. Likewise, the medium land is usually slightly flooded and in the rainy season Aus, T.Aman and jute are cultivated in these lands. Medium low land is somewhat deeply flooded and usually in the rainy season, Bona Aman is cultivated in these lands. However, in some places Aus is cultivated as mixed crop with it. Low land is deeply flooded and Bona Aman is the main crop in these lands. But in almost all dry seasons, native boro is cultivated in the waterlogged land without irrigation.

Depending on the depth of the flood, five scientific classifications of land and their definitions are defined below:

High land: The land which is not flooded during rainy season. This type of land is divided into two parts such as: 1) good drainage high land where even after heavy rains, the land cannot be stuck water for more than two days and 2) slightly bad drainage high land where water can be stuck usually during rainy season and T.Aman is possible here.

Medium high land: The land which is flooded continuously for more than two weeks to a maximum of 90 cm in the normal flood during rainy season. Medium high land is divided into two parts such as: 1) very little flooded medium high land where Uffshi T.Aman is possible and 2) little flooded medium high land which is considered to be very flooded for Uffshi T.Aman.

Medium low land: The land that is flooded continuously for a few months till the depth of 90 cm to 180cm (approximately 3 to 6 feet) cm in the normal flood during rainy season.

Low land: The land that is flooded continuously for a few months till the depth of 180cm to 275 (approximately 6 to 9 feet) cm in the normal flood during rainy season.

Very low land: The land that is flooded continuously for a few months till the depth of 275 cm (9 feet) in the rainy season.

2.5.4 SOIL TEXTURE

The proportional rate of sandstone, poly particle and mud particle ratio in the soil is considered as soil texture. Soil texture is very important for the cultivation. Although the soil scientists have divided the soil into twelve parts but considering their characteristics in particle field, they are divided into total five texture classes by this report. Such as:

Sandy: In this soil texture the ratio of the sandstone is above 90%. The ratio of the poly particle is below 30% and the ratio of the mud particle is below 15%. Sandy and loam sandy are included in this soil texture.

Sandy loam: In this soil texture the ratio of the sandstone is within 43 to 85%. The ratio of the poly particle is below 50% and the ratio of the mud particle is below 20%. Sandy loam and fine sandy loam are included in this soil texture.

Loam: In this soil texture the ratio of the sandstone is below 52%. The ratio of the poly particle is above 28% and the ratio of the mud particle is below 27%. Very fine sandy loam, loam, poly loam and poly are included in this soil texture.

Clay loam: In this soil texture the ratio of the sandstone is below 80%. The ratio of the poly particle is below 73% and the ratio of the mud particle is within 20 to 40%. Poly clay loam, clay loam and sandy clay loam are included in this soil texture.

Clay: In this soil texture the ratio of the sandstone is below 65%. The ratio of the poly particle is below 60% and the ratio of the mud particle is above 35%. Poly clay and sandy clay are included in this soil texture.

2.5.5 WATER REMOVAL CONDITION FROM THE SURFACE DURING RABIKHANDA

In the rainy season, submerged or wet land is removed at different times in different areas after the rainy season. As a result, Rabi crops are cultivated in different lands at different times. Land is divided into five parts on the basis of when it is possible to cultivate in the Rabikhanda such as:

Too Early: Water is removed from the land surface in the month of Ashin.

Advance: After the month of ashin but within the month of kartik water is removed from the land surface.

Normal: After the month of kartik but within the month of agrohayon water is removed from the land surface.

Late: After the month of agrohayon but within the second week of the month of powsh water is removed from the land surface.

Too late: After the second week of the month of powsh water is removed from the land surface.

2.5.6 SOIL CONSISTENCE

The amount of cultivation required for the cultivation of crops depends on the consistency of the soil. Non consistent land like making sandy land is easy and energy is less costly. But energy is more costly for making clay land.

Classification of soil consistency of dry, humid and wet soils is given below:

- **SOIL CONSISTENCY IN DRY CONDITION:**

In dry conditions, the consistency of the soil can be divided into three groups. For example:
Loose: Soil particles remain separated, or they get separated as soon as touched. Example: Sandy soil.

Crumbly: The ability to resist soil wheel is very low. It is very easily broken by the pressure of two fingers. Examples: Sandy loam and loam soil.

Rigid: The ability of soil to resist the pressure of wheel is very high. It is not very easy to be broken by the pressure of two fingers. Examples: clay loam and clay soil.

- **SOIL CONSISTENCY IN HUMID CONDITION:**

In humid conditions, the consistency of the soil can be divided into three groups. For example:
Loose: Soil particles remain separated, or they get separated as soon as touched. Example: Sandy soil.

Crumbly: The ability to resist soil wheel is very low. It is very easily broken by the pressure of two fingers. Examples: Sandy loam and loam soil.

Rigid: The ability of soil to resist the pressure of wheel is very high. It is not very easy to be broken by the pressure of two fingers. Examples: clay loam and clay soil.

- **SOIL CONSISTENCY IN WET CONDITION:**

In wet conditions, the consistency of the soil can be divided into three groups. For example:

Not glue: After giving pressure on soil by two fingers, in fact the soil does not stick to any finger. Example: Sandy soil.

Little glue: After giving pressure on soil by two fingers, the soil sticks to finger but it is easy to leave. Example: Sandy loam and loam soil.

Glue: The soil sticks to both fingers but it is not easy to leave. Example: Clay loam and clay soil.

2.5.7 SOIL REACTION

Soil reaction is more important than other indicators of crop production. Good production of any crop depends on the level of specific reaction of soil. Most of the crops grow better within the soil reaction of 5.5 to 7.3.

Depending on the relative amount of soil acidity or alkalinity, the reaction of the soil can be divided into seven parts which is shown in Table 2.2.

Table 2.2: Reaction class with pH

Reaction class	**pH**
Very strongly Acidity	Below 4.5
Strongly Acidity	4.5-5.5
Slightly Acidity	5.6-6.5
Neutral	6.6-7.3
Slightly Alkalinity	7.4-8.4
Strongly Alkalinity	8.5-9.0
Very strongly A lkalinity	Above 9.0

2.5.8 DRAINAGE CONDITION

Being drained from a land to natural or special conditions is called the drainage condition. The class of drainage condition is given below:

Good: Immediately water moves away from the land but not so fast. Good drainage land preserves the water required for the plant after the rain or irrigation.

Moderate: Water being drained from the land slight slowly. As a result the soil is wet for a short time. In this case, there is usually a slow entry layer, or groundwater in the rainy season for some time stays in the depth of 1 to 2 meters depth of the surface.

Slightly Bad: Water being drained from the land badly or slowly. Generally, this land stays wet due to the rainfall in the rainy season. But in the normal condition, the water does not stand for fifteen days continuously. In the rainy season, the water of the surface stays in the depth of 1 meter at least for some time.

Bad: The land is under water for 15 days to 7/8 months of the year and water being drained from the land slowly. After the rainy season in many cases the land is sometimes wet or submerged.

Very Bad: This land is under water for more than seven months of the year and the land is almost wet all year round.

2.6 RELETED WORK

The researchers are still trying their best for doing betterment in the agriculture field. They have already been proposed so many ideas about this sector. Some of the work related to our thesis is given below:

The paper [1] used an automation and IOT technologies for making smart agriculture. In this paper the authors used a smart remote controlled robot for performing weeding, spraying, moisture sensing, bird and animal scaring, keeping vigilance and all other tasks. Their system also provides smart irrigation and intelligent decision making based on accurate real time field data. They have also made a smart warehouse management. They used Wi-Fi or ZigBee modules, camera and actuators with micro-controller and raspberry pi for all operations. Actually this paper has given a solution to field activities, irrigation problems, and storage problems by using a remote controlled robot, smart irrigation system and a smart warehouse management system.

The main aim of the paper [2] was to monitor and control the climate of the farm with less human mediation. The level of production can be increased through this smart system. This system has given a smart solution for agriculture and solved farmers' issues efficiently.

The MEGA initiative for defining the reference architecture for water management based on integrating IOT was proposed in [3]. This initiative was taken for achieving a scalable and feasible industrial system. Authors of this paper provided architecture for sub-system interaction and a detailed description of the physical scenario.

In paper [4], it suggested IOT based sensor network for agriculture use which is consisted of soil moisture sensor, soil temperature sensor, and ph sensor for soil. In this paper all the sensors are connected by wireless sensor network xbee and there is a control room. Farmer can access all the data of a website on his smart phone and tablet. It is a kind of system which can also control water and fertilizers requirements and it can also provide atomized irrigation and fertilizer usage in real time to farmer which is very useful.

An idea of combining the latest technology into the agricultural field to turn the traditional methods of irrigation to modern methods was proposed in [5]. This was proposed for making easy production, and economical cropping.

In [6], authors have proposed a system by using IOT where they can have a control over the irrigation and monitoring of the agricultural field. The system connects physical sensing devices and also the irrigation control mechanism with the cloud.

The Automated Intelligent Wireless Irrigation System of the paper [7] provided a real time feedback control system using LITE mote which monitors and controls all the activities of irrigation system efficiently. It is also able to avoid the overflow of water by monitoring the water tank. This system has the ability to determine the soil moisture and necessity of water to crop and through this system the limitations of wired sensor networks can be overcome.

A system which integrates the control of all the deployed systems in a single system was proposed in [8]. This system can help the farmer by giving all the updates of the field.

Authors of paper [9] have given the solution for reducing the transportation cost and also given the prediction of the prices by analyzing the past data and present conditions of the market. They have also given the solution to reduce the medium between the farmers and the end consumers by using IOT.

In [10], authors have described an approach where they have combined IOT and image processing. By using this approach they can determine the environmental factor or man-made factor which is particularly impeding the development of the plant. The system is handled under MATLAB software by the help of histogram analysis to o touch base at definitive outcomes.

The authors of [11] have described a technology to improve the operation efficiency of the supply chain of agricultural products and promote the development of agriculture.

Authors of [12] focused on the study on IOT and the application of cloud computing in agriculture and forestry. This system can enable data sharing, remote data storage, interactions with farmers, agriculture expert consultation and peasant household management. Their idea made a combination of the two techniques and analyzed the feasibility, applications and future prospect of the combination.

2.7 SUMMARY

As agriculture has a great impact on economy so developing countries are developing much more on this sector. In many countries like China, Japan, India has already developed so many things on agricultural sector. They have already proposed IOT based solution and also implemented IOT base solution for different sectors in this field. But until now Bangladesh has been lagging behind by applying old methods. As so far we know there have not been yet worked on the pre seeding part of agriculture so for this we have tried to do something for the betterment (Integrated IOT) in this sector.

CHAPTER 3

3.1 STRUCTURE / DESING

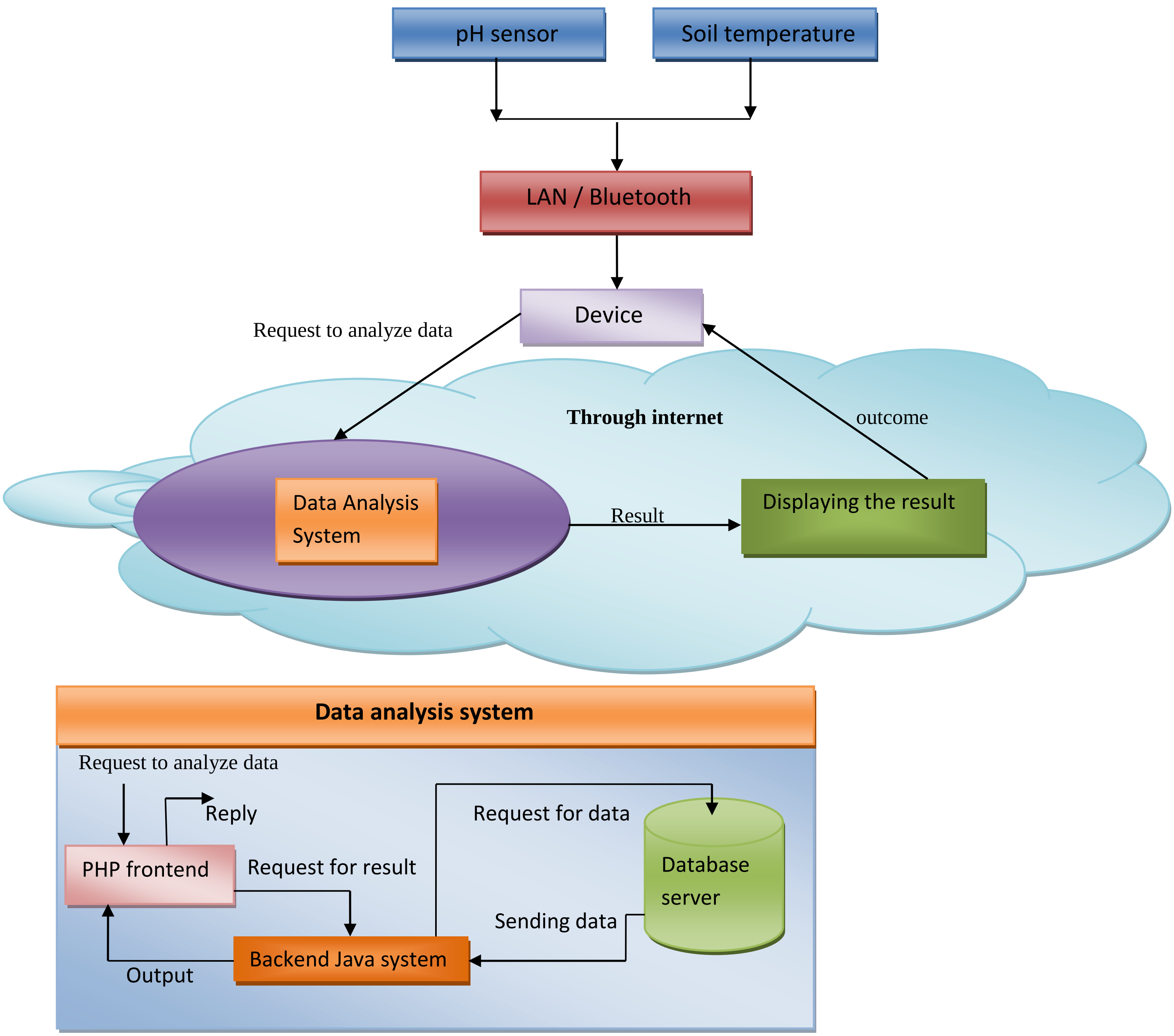


Figure 3.1: System structure

3.1.1 FLOW OF SYSTEM

In the Figure 3.2 it describes the whole process of the system. Where there has a hardware section that takes inputs from pH sensor and transmits it to smart device via Bluetooth connection. After taking input from hardware, user will give some necessary inputs manually through smart device using internet. After taking all inputs, system will initialize all its parameters. Later on all this information will be transmitted to the data analysis system which is connected with a database server. After getting all inputs and related data from database server, the data analysis system will start its process. During the process the system will generate all possible desired outputs on the basis of some conditions, calculations and comparisons. And all those outputs will be sent back to the smart device using internet.

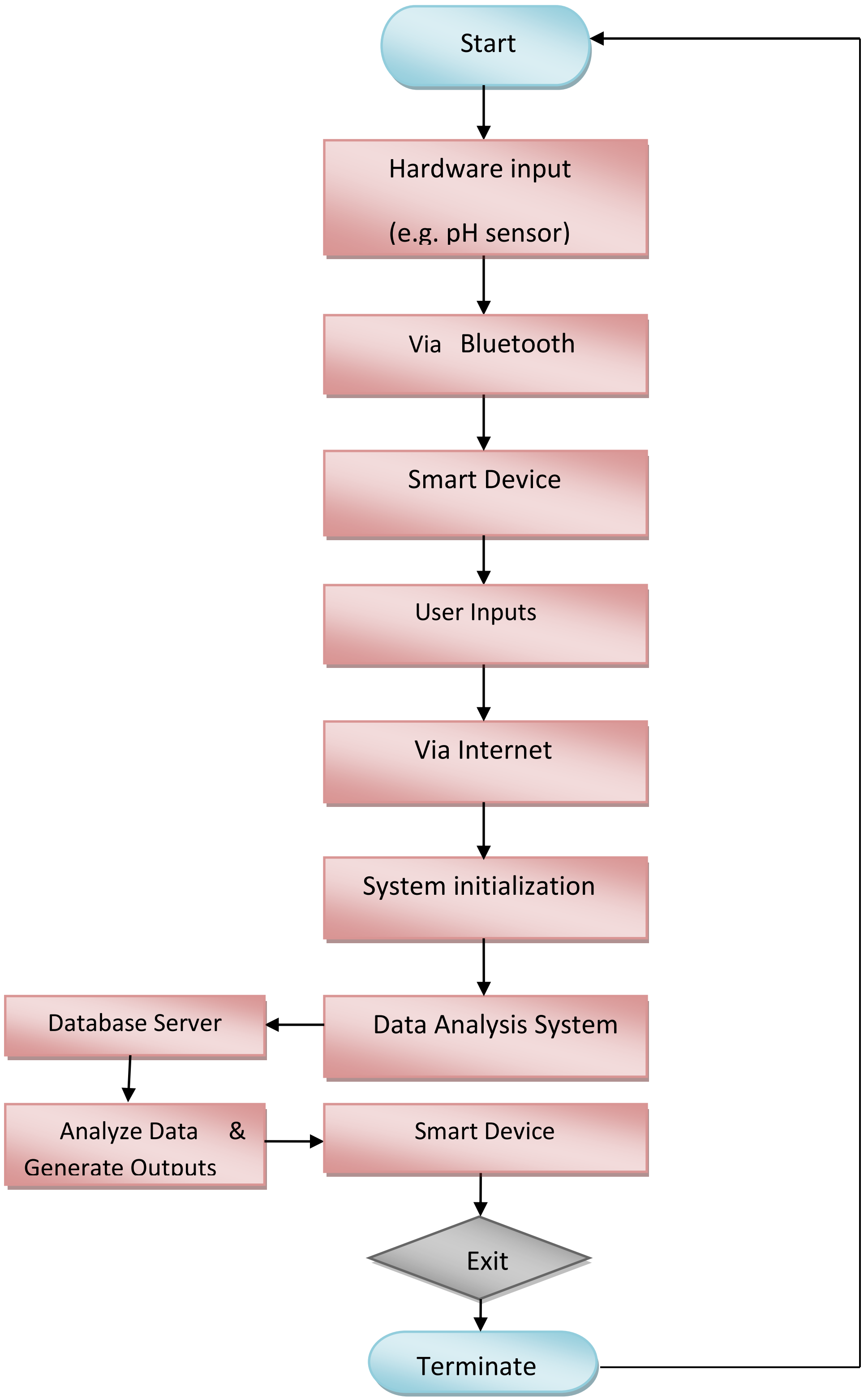


Figure 3.2: Flow of system

3.1.2 Flow of algorithm

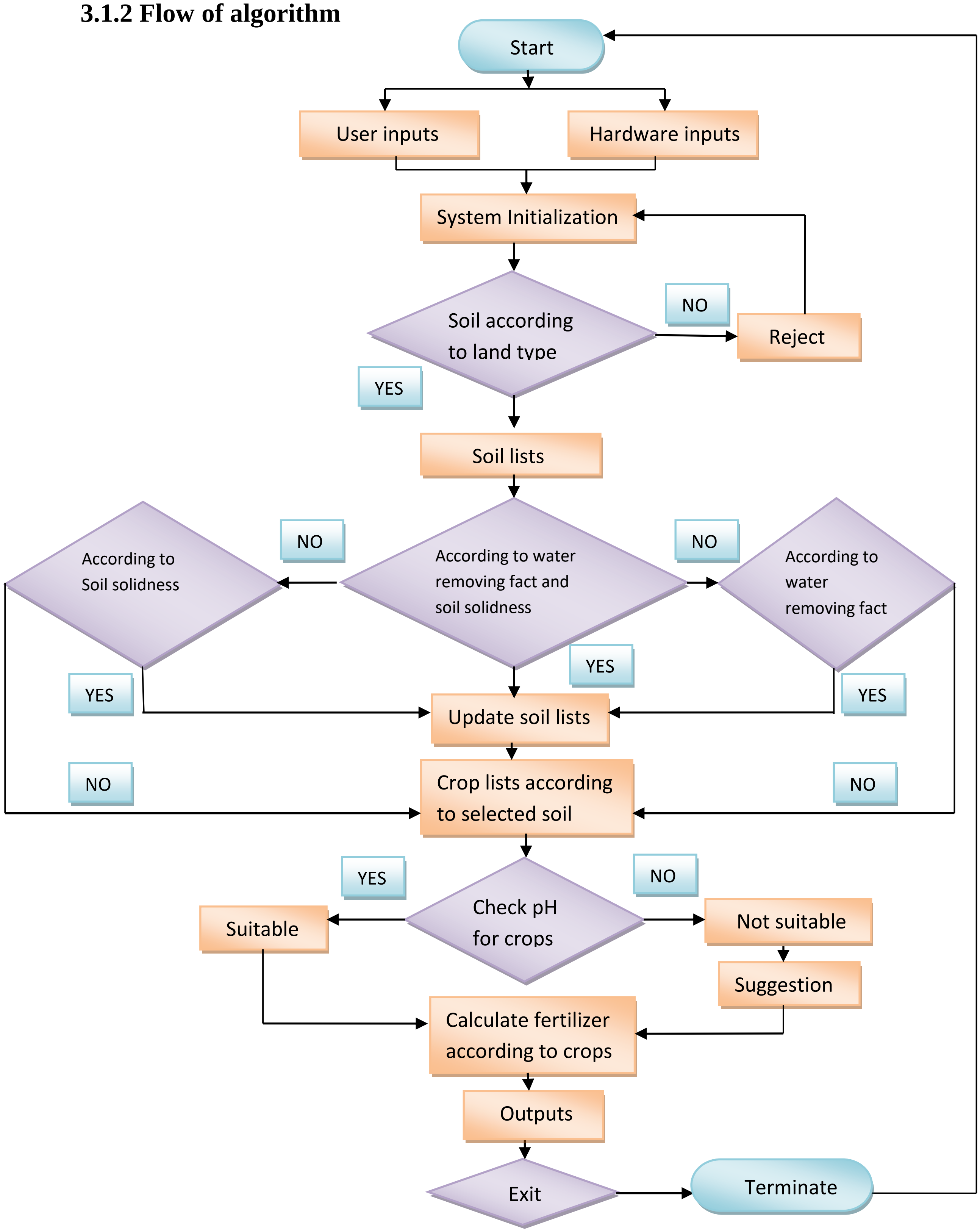


Figure 3.3: Flow of algorithm

3.2 METHOD

At the beginning of the process the system will be initialized by taking inputs from hardware such as pH sensor and some user inputs such as location information, soil information, and some related questions through a smart device application. After that all those information will be transferred to data analysis system by using internet. The data analysis system is developed on java and a PHP platform and connected with database server. After receiving all data, the analysis system will start its processing.

- The initial step of processing is to identify the location. After initializing, the system will request to the database server for all possible mapping units that are presented on that Mouza.

- The next step is to identify the soil. At the beginning of this process the system will fetch all soils according to selected mapping units. After that system will filter soils according to land type information given by user. Later on, the system will try to select those soils which are fulfilling two conditions such as water removal condition from the surface and soil consistency at the same time. If the system cannot find any related soil with above conditions then it will look for single condition to fulfill which is either water removal condition from the surface or soil consistency and if one of these is accepted, then the system will collects soils from database server. And if none of these have been selected then the system will continue with those soils which have been selected according to land type.

- After selecting soil series the system will gather all possible crops information according to irrigation type such as crop name, suitable land type for cultivating and calculate fertilizers according to crop and recommend it. The system is also capable of showing the crop distribution lists. And at the same time the system will measure whether the pH value is suitable with the crop or not. This system will also capable of giving suggestions on basis of pH value.

- After processing all desired data the system will store them into a file and will return them to the smart device using internet for further displaying to user. After that the user will take decision which crop he/she wants to cultivate.

3.2.1 FERTILIZER CALCULATION

Step-1: Consult the Appendix-1A to see the position of given soil test value within the range of the interpretation class.

Step-2: Consult the Table 6 under wheat to see the range of fertilizer nutrient recommended for the same soil test value interpretation class.

Step-3: Compute the exact fertilizer nutrient required for making the recommendation following the formula given below:

$$Fr = U_f - Ci / Cs \times (St - Ls)$$

Where

Fr = Fertilizer nutrient required for given soil test value

Uf = Upper limit of the recommended fertilizer nutrient for the respective STVI class

Ci = Units of class intervals used for fertilizer nutrient recommendation

Cs = Units of class intervals used for STVI class

St = Soil test value

Ls = Lower limit of the soil test value within STVI class

3.3 HARDWARE DESIGN

For the demonstration of our system we need the following hardware:

- Arduino Uno R3
- Analog pH sensor
- Arduino Bluetooth Module (JY-MCU)
- Bread board
- Wire
- Smart device

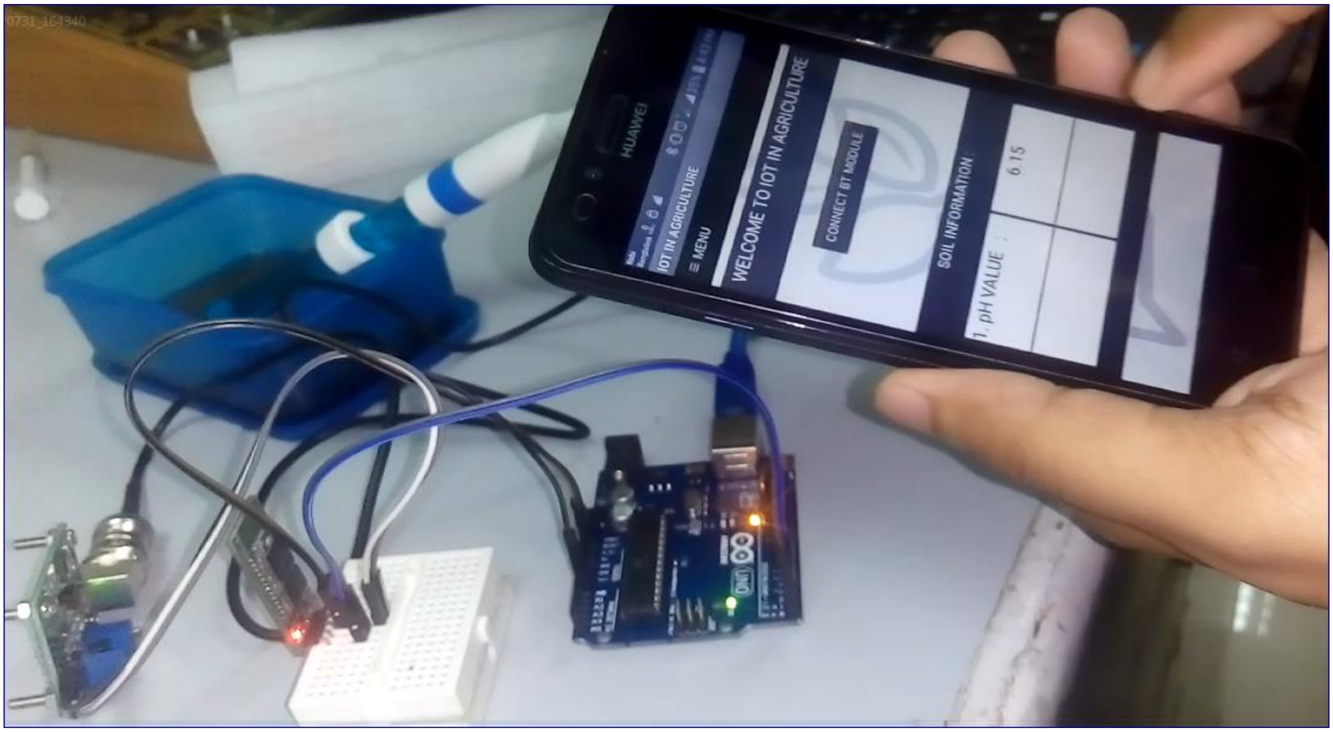


Figure 3.4: Experimental setup

3.3.1 CIRCUIT DESIGN

In figure 3.5 the Analog pH sensor is connected with Arduino Uno R3 at the Power pin 5v, GND and Analog input pin A0. And there has an Arduino Bluetooth Module (JY-MCU) connected with Arduino at Digital pin TXD and RXD. Here, RXD pin of Bluetooth module is connected with TXD pin of Arduino and TXD pin of Bluetooth module is connected with RXD pin of Arduino. After receiving the value from pH sensor by Arduino, it will transmit the value to the smart device using Bluetooth module.

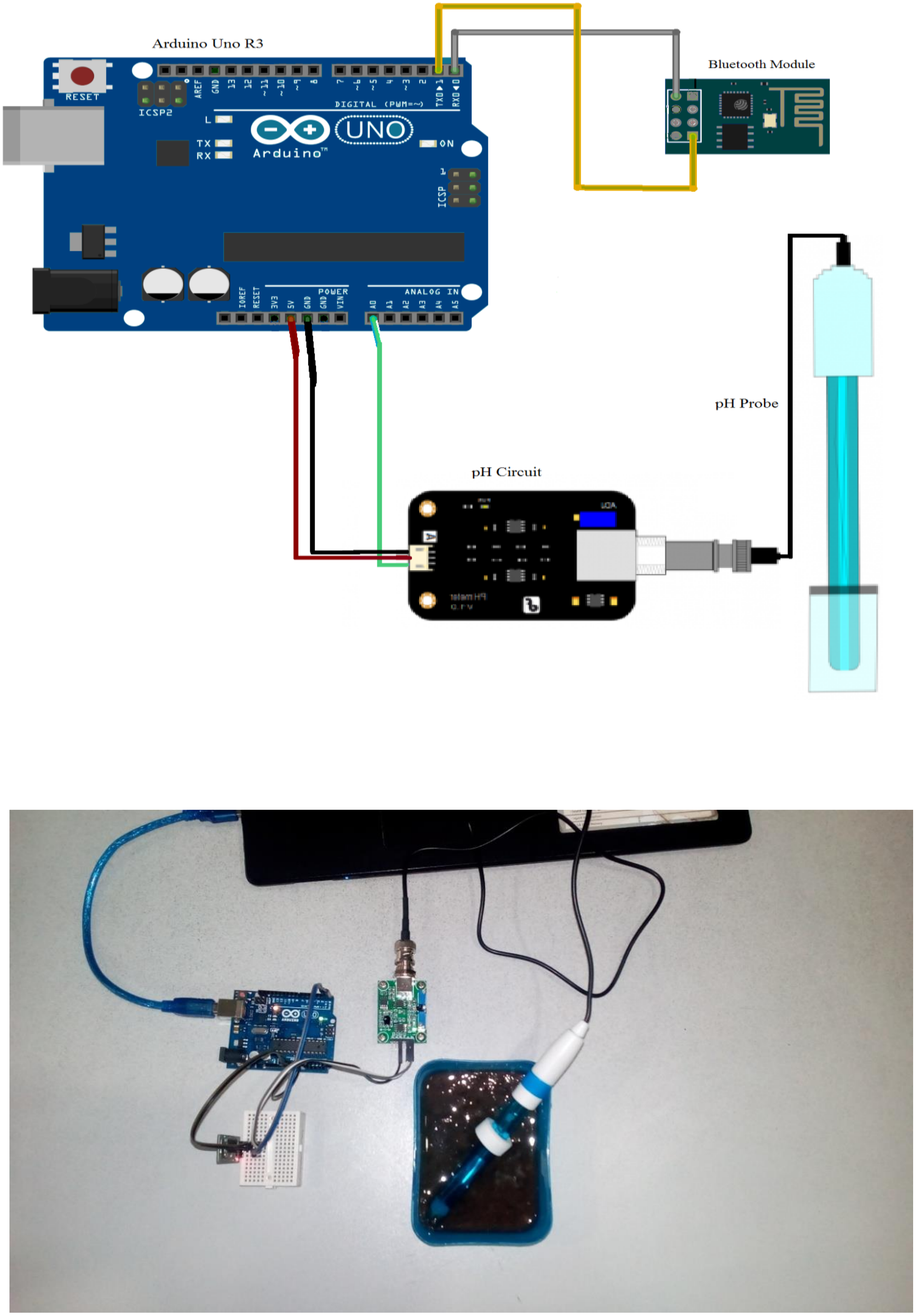


Figure 3.5: Hardware setup

3.4 SUMMARY

All above our system will take inputs from the user as well as hardware through a smart device. After that the bunch of data will be transmitted to the data analysis system through internet. Then the system will initialize all its parameters. At the beginning of the process the system will collect all possible mapping units according to given location. Then the system will collect all soil series and filter them according some condition such as land type, water removal condition from the surface and soil consistency. After getting nearly specified soil series the system will gather all possible crop lists and calculate fertilizers for crops and also recommends the crop distribution lists. The system can also measure whether the ph value is suitable or not and give suggestions.

CHAPTER 4
RESULT AND ANALYSIS

4.1 INTRODUCTION

The main objective of our research was to implement the modern technologies in agriculture field. Usage of IOT concept makes the whole process of the system easy. In this chapter we have discussed about the result that found through the analysis of the data.

4.2 RESULT AND ANALYSIS

To get the proper outputs, the user must give answers of all the required questions. For filling up some input fields the system requires some specific information from the user which is generally known such as:

- The land type on the basis of what becomes the scenario of the land during the rainy season, whether it goes under water or not and if it goes under water then how much it goes.
- Another one is that is the soil consistency of the land measuring by pressing two fingers on the soil.
- And next one that is the water removal condition of the land measuring by when it is possible to cultivate in the Rabikhanda.

Here we take some experimental tests result and analysis it.

RESULT AND ANALYSIS NO 1:

First, we selected a union Kaolatia of Gazipur Sadar Upazilla. For this union we had to select a mouza and we selected Araisho prashad. We selected medium high land and crumbly soil with an advanced water removing fact. We gave the inputs of NPK with the values of N=0.1, P=18, and K=0.15 manually because of some limitations and pH value got from pH sensor with the value of 6.5. After filling up the form we submitted it.

Figure 4.1: Araisho Proshad with mouza boundary

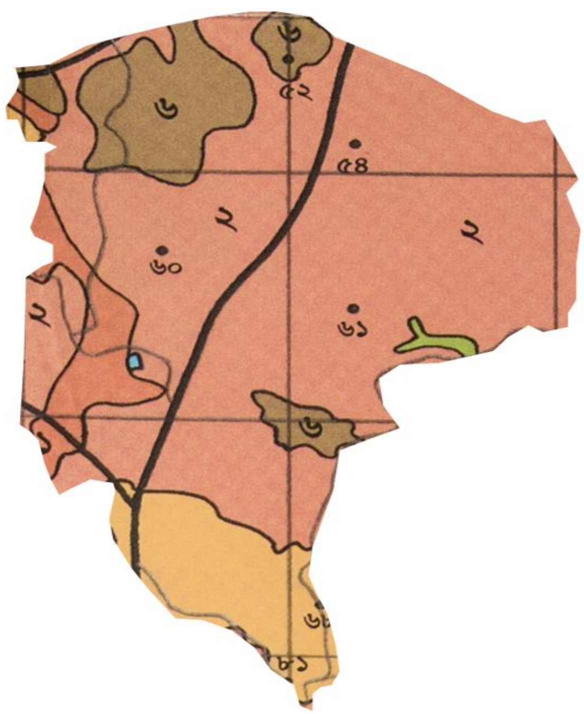


Figure 4.2: Araisho Proshad with mapping units

After submitting the form, according to union (Kaolotia) and mouza (Araisho proshad) we get all possible mapping units that are map-2, map-4 and map-6. All possible soils according to mapping units are given in Table 4.1.

Table 4.1: All possible soils according to mapping units

Map Units	Land Types	Soil Series	
		High land	Medium high land
Map no -2	High land, medium high land	Gerua, salna	Kolma
Map no -4	High land, medium high land	Noadd, chandra	Chandra, kolma
Map no -6	High land, medium high land	Vatpara, ciata	Ciata, demra, kolma

As our selected land type was medium high land so the system can filter soils with respect to land type. Now all filtered soils are given in Table 4.2.

Table 4.2: Soil with respect to land type

Map Units	Land Types	Soil Series
Map no -2	Medium high land	Kolma
Map no -4	Medium high land	Chandra, kolma
Map no -6	Medium high land	Ciata, demra, kolma

After selecting soils according land type all soils with their water removal condition from the surface and soil consistency are given in Table 4.3.

Table 4.3: All soils with water removal condition from the surface and soil consistency

Soil Series	Water removal condition from the surface	Soil Solidness
Kolma	Advance	Crumbly
Chandra	Advance	Crumbly
Ciata	Advance	Crumbly
Demra	Advance	Rigid

Now applying two conditions given by user, filtered soils are given bellow:

Conditions:

- Water removal condition from the surface: Advance
- Soil consistency: Crumbly

Table 4.4: Filtered soils

Soil Series	Water removal condition from the surface	Soil Solidness
Kolma	Advance	Crumbly
Chandra	Advance	Crumbly
Ciata	Advance	Crumbly

Now these are the nearly possible soils for the land as they hold nearly the same characteristics. That’s why crops lists for these soils are same.

Now suggested crop lists with recommended fertilizers and some other information according to all soils are given Table 4.5.

According to irrigation type: Without irrigation

Table 4.5: Kharif 1 crops

Crop name	pH status	Suitable land	Fertilizer		
			N	P	K
Bona aus	ph value is neutral(6.8) and it is suitable for crop	Wetland	94.565 kg Urea/ha	20.033 kg TSP/ha	48.032 kg KCI/ha

Table 4.6: Kharif 2 crops

Crop name	pH status	Suitable land	Fertilizer		
			N	P	K
T. aman	ph value is neutral(6.8) and it is suitable for crop	Wetland	145.000kg Urea/ha	25.042 kg TSP/ha	72.048 kg KCL/ha

Table 4.7: Crops distribution lists

Serial no	Crops distribution lists
1.	Fallow-bona aus-T.aman

According to irrigation type: With irrigation

Table 4.8: Rabi crops

Crop name	**pH status**	**Suitable land**	**Fertilizer**		
			N	**P**	**K**
Wheat	ph value is neutral(6.8) and it is suitable for crop	Upland	252.174 kg Urea/ha	88.073 kg TSP/ha	126.600 kg KCI/ha
Mustard (ufshi)	ph value is neutral(6.8) and it is suitable for crop	Upland	245.870 kg Urea/ha	88.067 kg TSP/ha	89.089 kg KCI/ha
Boro (ufshi)	ph value is neutral(6.8) and it is suitable for crop	Upland	283.696 kg Urea/ha	50.083 kg TSP/ha	112.075 kg KCI/ha

Table 4.9: Kharif 1 crops

Crop name	pH status	Suitable land	Fertilizer		
			N	P	K
T. aus	ph value is neutral(6.8) and it is suitable for crop	Wetland	145.000kg Urea/ha	25.042 kg TSP/ha	72.048 kg KCI/ha

Table 4.10: Kharif 2 crops

Crop name	pH status	Suitable land	Fertilizer		
			N	P	K
T. aman (ufshi)	ph value is neutral(6.8) and it is suitable for crop	wetland	189.130 kg Urea/ha	30.050 kg TSP/ha	72.048 kg KCI/ha

Table 4.11: Crops distribution lists

Serial no	crops distribution lists
1.	Robi crops-bona aus-T.aman(ufshi)
2.	Mustard-boro-T.aman
3.	Boro-fallow-T.aman
4.	Fallow-T.aus(ufshi)-T.aman(ufshi,local)
5.	Boro(ufshi)-T.aman(ufshi,local)

Now all lands of that location are generally using for the following crop lists:

Table 4.12: Generally cultivating crops according to inputs

Crop no	**Crop name**
1.	Boro
2.	T.aman

Above all information we can come to a decision that our system is capable of suggesting all possible crops with fertilizer recommendation and with some other necessary information like suitable land for cultivating crops, with or without irrigation type, suitable season for cultivating etc. Here our system is also providing crop distribution lists based on irrigation type which is an important factor because there has a sequence for cultivating crops one after another. If anyone breaks the sequence of crop distribution lists then a problem may arise which may reduce the productivity of crops.

On the other hand pH status of the soil is slightly acidic and maximum crops are suitable for this value. And if it is needed to increase the soil pH or lower the soil pH then there has a suggestion tab on navigation bar which will be helpful for the users.

RESULT AND ANALYSIS NO 2:

First, we selected a union mirzapur of Gazipur Sadar Upazilla. For this union we had to select a mouza and we selected bokran manipur. We selected high land and crumbly soil with an immediate water removing fact. We gave the inputs of NPK with the values of N=0.25, P=15, and K=0.34 manually because of some limitations and pH value got from pH sensor with the value of 7.2. After filling up the form we submitted it.

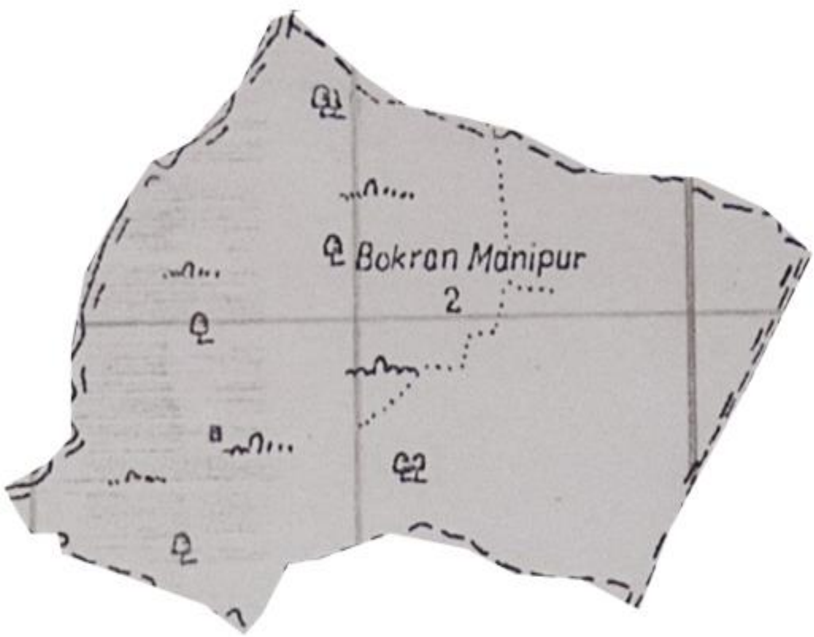


Figure 4.3: Bokran Manipur with mouza boundary

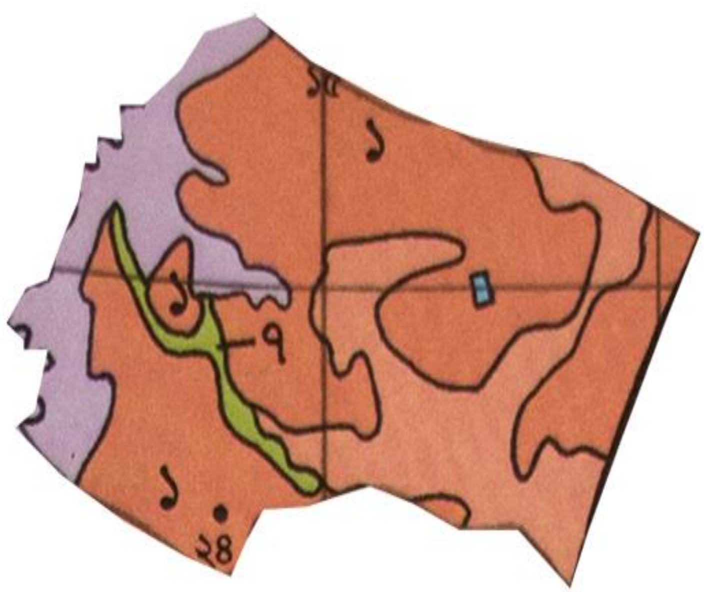


Figure 4.4: Bokran Manipur with mapping units

After submitting the form, according to union (Mirzapur) and mouza (Bokran Manipur) we get all possible mapping units that are map-1, map-2, map-7 and map-10. All possible soils according to mapping units are given in Table 4.13.

Table 4.13: All possible soils according to mapping units

Map Units	Land Types	Soil Series				
		High land	**Medium high land**	**Medium low land**	**Low land**	**Very low land**
Map no-1	High land, medium high land	Tejgaon, Belab, Noadda	Kolma	_	_	_
Map no-2	High land, medium high land	Gerua, Salna	Kolma	_	_	_
Map no-7	Medium high land, medium low land	_	Kolma, Khilgaon	Khilgaon	_	_
Map no-10	Low land, very low land	_	_	_	Khilgaon, korail, kajla	Korail, kajla

As our selected land type was high land so the system can filter soils with respect to land type. Now all filtered soils are given in Table 4.14.

Table 4.14: Soil with respect to land type

Map Units	Land Types	Soil Series
Map no -1	High land	Tejgaon, Belab, Noadda
Map no -2	High land	Gerua, Salna

After selecting soils according land type all soils with their water removal condition from the surface and soil consistency are given in Table 4.15.

Table 4.15: All soils with water removal condition from the surface and soil consistency

Soil Series	Water removal condition from the surface	Soil Solidness
Tejgaon	Immediate	Crumbly
Belab	Immediate	Crumbly
Noadda	Too early	Crumbly
Gerua	Immediate	Crumbly

Now applying two conditions given by user, filtered soils are given bellow:

Conditions:

- Water removal condition from the surface: Advance
- Soil consistency: Crumbly

Table 4.16: Filtered soils

Soil Series	Water removal condition from the surface	Soil Solidness
Tejgaon	Immediate	Crumbly
Belab	Immediate	Crumbly
Gerua	Immediate	Crumbly

Now these are the nearly possible soils for the land as they hold nearly the same characteristics. That's why crops lists for these soils are same.

Now suggested crop lists with recommended fertilizers and some other information according to all soils are given in Table 4.16.

According to irrigation type: Without irrigation

Table 4.17: Rabi crops

Crop name	pH status	Suitable land	Fertilizer		
			N	P	K
Mustard	ph value is neutral(7.2) and it is suitable for crop	Upland	104.565 kg Urea/ha	8.867 Kg TSP/ha	8.867 KCL/ha
Masculine	ph value is neutral(7.2) and it is suitable for crop	Upland	13.406 kg Urea/ha	40.027 Kg TSP/ha	2.333 Kg KCL/ha
Mung bean	ph value is neutral(7.2) and it is suitable for crop	Upland	16.087 kg Urea/ha	100.067 Kg TSP/ha	5.600 Kg KCL/ha

Table 4.18: Kharif 1 crops

Crop name	pH status	Suitable land	Fertilizer		
			N	P	K
Red spinach	ph value is neutral(7.2) and it is suitable for crop	Upland	72.391 kg Urea/ha	60.040 kg TSP/ha	4.667 kg KCI/ha
Chili	ph value is neutral(7.2) and it is suitable for crop	Upland	210.140 kg TSP/ha	15.400 kg KCI/ha	2.391 kg Urea/ha
Kakral	ph value is neutral(7.2) and it is suitable for crop	Upland	53.623 kg Urea/ha	100.067 kg TSP/ha	4.667 kg KCI/ha
Brinjal	ph value is neutral(7.2) and it is suitable for crop	Upland	174.275 kg Urea/ha	140.093 kg TSP/ha	25.200 kg KCI/ha
Lady's finger	ph value is neutral(7.2) and it is suitable for crop	Upland	85.797 kg Urea/ha	110.073 kg TSP/ha	9.800 kg KCI/ha
Ground nut	ph value is neutral(7.2) and it is suitable for crop	Upland	26.812 kg Urea/ha	90.060 kg TSP/ha	7.933 kg KCI/ha
Bona aus	ph value is neutral(7.2) and it is suitable for crop	Upland	40.217 kg Urea/ha	30.033 kg TSP/ha	9.600 kg KCI/ha

Table 4.19: Kharif 2 crops

Crop name	pH status	Suitable land	Fertilizer		
			N	P	K
Red spinach	Ph value is neutral(7.2) and it is suitable for crop	Upland	72.391 kg Urea/ha	60.040 kg TSP/ha	4.667 kg KCI/ha
Masculine	Ph value is neutral(7.2) and it is suitable for crop	Upland	13.406 kg Urea/ha	40.027 kg TSP/ha	2.333 kg KCI/ha
Mung bean	Ph value is neutral(7.2) and it is suitable for crop	Upland	16.087 kg Urea/ha	100.067 kg TSP/ha	5.600 kg KCI/ha

Table 4.20: One year crops

Crop name	pH status	Suitable land	Fertilizer		
			N	P	K
Sugarcane	ph value is neutral(7.2) and it is suitable for crop	Upland	158.188 kg Urea/ha	200.133 kg TSP/ha	25.200 kg KCI/ha
Banana	ph value is neutral(7.2) and it is suitable for crop	Upland	120.652 kg Urea/ha	100.067 kg TSP/ha	20.067 kg KCI/ha
Ginger	ph value is neutral(7.2) and it is suitable for crop	Upland	120.652 kg Urea/ha	170.113 kg TSP/ha	17.733 kg KCI/ha
Pineapple	ph value is neutral(7.2) and it is suitable for crop	Upland	201.087 kg Urea/ha	280.187 kg TSP/ha	35.000 kg KCI/ha
Turmeric	ph value is neutral(7.2) and it is suitable for crop	Upland	88.478 kg Urea/ha	110.073 kg TSP/ha	12.600 kg KCI/ha

Table 4.21: Many year crops

Crop name	pH status	Suitable land	Fertilizer		
			N	P	K
Lemon	ph value is neutral(6.8) and it is suitable for crop	Upland	69.710 kg Urea/ha	50.033 kg TSP/ha	8.867 kg KCI/ha

Table 4.22: Crops distribution lists

Serial no	crops distribution lists
1.	Mustard-kharif vegetables/kharif groundnut
2.	Fallow-aus-masculine
3.	Sugarcane
4.	Banana/ ginger/turmeric
5.	Fallow-T.aus
6.	Mustard-bona aus/corn

According irrigation type: With irrigation

Table 4.23: Rabi crops

Crop name	pH status	Suitable land	Fertilizer		
			N	P	K
Wheat	ph value is neutral(7.2) and it is suitable for crop	Upland	107.246 kg Urea/ha	110.073 kg TSP/ha	12.600 kg KCI/ha
Corn	ph value is neutral(7.2) and it is suitable for crop	Upland	107.246 kg Urea/ha	110.073 kg TSP/ha	13.067 kg KCI/ha
Potato	ph value is neutral(7.2) and it is suitable for crop	Upland	120.652 kg Urea/ha	100.067 kg TSP/ha	18.667 kg KCI/ha
Mustard	ph value is neutral(7.2) and it is suitable for crop	Upland	104.565 kg Urea/ha	100.067 kg TSP/ha	8.867 kg KCI/ha
Sunflower	ph value is neutral(7.2) and it is suitable for crop	Upland	88.478 kg Urea/ha	100.067 kg TSP/ha	8.400 kg KCI/ha
Cabbage	ph value is neutral(7.2) and it is suitable for crop	Upland	174.275 kg Urea/ha	140.093 kg TSP/ha	25.200 kg KCI/ha
Red spinach	ph value is neutral(7.2) and it is suitable for crop	Upland	72.391 kg Urea/ha	60.040 kg TSP/ha	4.667 kg KCI/ha
Chili	ph value is neutral(7.2) and it is suitable for crop	Upland	210.140 kg TSP/ha	15.400 kg KCI/ha	2.391 kg Urea/ha
Lady’s finger	ph value is neutral(7.2) and it is suitable for crop	Upland	85.797 kg Urea/ha	110.073 kg TSP/ha	9.800 kg KCI/ha
Brinjal	ph value is neutral(7.2) and it is suitable for crop	Upland	174.275 kg Urea/ha	140.093 kg TSP/ha	25.200 kg KCI/ha
Cotton	ph value is neutral(7.2) and it is suitable for crop	Upland	99.203 kg Urea/ha	110.073 kg TSP/ha	15.400 kg KCI/ha
Carrot	ph value is neutral(7.2) and it is suitable for crop	Upland	120.652 kg Urea/ha	130.087 kg TSP/ha	14.000 kg KCI/ha
Cauliflower	ph value is neutral(7.2) and it is suitable for crop	Upland	131.377 kg Urea/ha	170.113 kg TSP/ha	18.667 kg KCI/ha
Groundnut	ph value is neutral(7.2) and it is suitable for crop	Upland	26.812 kg Urea/ha	90.060 kg TSP/ha	7.933 kg KCI/ha

Table 4.24: Kharif 1 crops

Crop name	**pH status**	**Suitable land**	**Fertilizer**		
			N	**P**	**K**
Red spinach	ph value is neutral(7.2) and it is suitable for crop	Upland	26.812 kg Urea/ha	90.060 kg TSP/ha	7.933 kg KCI/ha
Corn	ph value is neutral(7.2) and it is suitable for crop	Upland	107.246 kg Urea/ha	110.073 kg TSP/ha	13.067 kg KCI/ha
Chili	ph value is neutral(7.2) and it is suitable for crop	Upland	210.140 kg TSP/ha	15.400 kg KCI/ha	2.391 kg Urea/ha
Karala	ph value is neutral(7.2) and it is suitable for crop	Upland	53.623 kg Urea/ha	100.067 kg TSP/ha	4.667 kg KCI/ha
Brinjal	ph value is neutral(7.2) and it is suitable for crop	Upland	174.275 kg Urea/ha	140.093 kg TSP/ha	25.200 kg KCI/ha
Lady’s finger	ph value is neutral(7.2) and it is suitable for crop	Upland	85.797 kg Urea/ha	110.073 kg TSP/ha	9.800 kg KCI/ha

Table 4.25: One year crops

Crop name	pH status	Suitable land	Fertilizer		
			N	P	K
Sugarcane	ph value is neutral(7.2) and it is suitable for crop	Upland	158.188 kg Urea/ha	200.133 kg TSP/ha	25.200 kg KCI/ha
Banana	ph value is neutral(7.2) and it is suitable for crop	Upland	120.652 kg Urea/ha	100.067 kg TSP/ha	20.067 kg KCI/ha
Pineapple	ph value is neutral(7.2) and it is suitable for crop	Upland	201.087 kg Urea/ha	280.187 kg TSP/ha	35.000 kg KCI/ha

Table 4.26: Many year crops

Crop name	pH status	Suitable land	Fertilizer		
			N	P	K
Lemon	ph value is neutral(6.8) a nd it is suitable for crop	Upland	69.710 kg Urea/ha	50.033 kg TSP/ha	8.867 kg KCI/ha
Betel	ph value is neutral(6.8) a nd it is suitable for crop	Upland	53.623 kg Urea/ha	150.100 kg TSP/ha	7.000 kg KCI/ha

Table 4.27: Crops distribution lists

Serial no	crops distribution lists
1.	Sugarcane
2.	Rabi vegetables/rabi groundnut kharif vegetables
3.	Rabi-crops /bona aus
4.	Banana/pineaple
5.	Betel/lemon

Now all lands of that location are generally using for the following crop lists:

Table 4.28: Generally cultivating crops according to inputs

Crop no	Crop name
1.	Boro
2.	T.aman
3.	Ginger
4.	Turmeric
5.	Pineapple
6.	Banana
7.	Rabi vegetables
8.	Kharif vegetables

Above all information we can come to a decision that our system is capable of suggesting all possible crops with fertilizer recommendation and with some other necessary information like suitable land for cultivating crops, with or without irrigation type, suitable season for cultivating etc. Here, our system is also providing crop distribution lists based on irrigation type which is an important factor because there is a sequence for cultivating crops one after another. If anyone breaks the sequence of crop distribution lists then a problem will arise which may reduce the productivity of crops.

On the other hand, pH status of the soil is neutral and maximum crops are suitable for this value. And if it is needed to increase the soil pH or lower the soil pH then there has a suggestion tab on navigation bar which will be helpful for the users.

CHAPTER 5
CONCLUSIONS AND FUTURE SCOPE

5.1 CONCLUSIONS

Agriculture is one of the most important sectors for the growth of economy in developing country like Bangladesh. This sector becomes an important part in human life, so technological advances must be utilized so as to stay aware of the necessities of the human populace.

All observations and experimental tests prove that the system gives a complete solution for finding out suitable crops for a specific land. Implementation of such a system including with IOT technology into the agricultural field turns the traditional methods of finding suitable crops for specific land to modern methods which helps the farmers taking a good decision before seeding. This concept of modernization of agriculture is efficient, affordable and operable.

5.2 SCOPE FOR FUTURE WORK

The purpose of every research is to open a new way that in future it can explore more for any needs. So our research is not different from it. There are so many possible scopes for this research to explore more. As we have so many limitations that's the reason we couldn't even use some expensive sensors like NPK, soil moisture and soil humidity because lacking of organized data. But by using these sensors it will turn into a new way which will definitely reduce the work. If we use NPK sensor, we don't need to input the value of NPK manually. Again we can also use the soil moisture, soil humidity sensors for more specifying our work.

This research can also be explored by using a GPS tracker for tracking location which will help to find out specific location.

In future we have also a plan to implement the monitoring system so that every work regarding this research can be monitored perfectly. And proper take care will be taken.

An automated system can also be implemented which will reduce the work of the farmers. Through monitoring system we can be informed about the present situations of the crops. If crops are destructed by the attack of the insects then we can use proper insecticides for the insects through an automated process.

This research can also help people in future by providing crops at low rate but best quality and will reduce the transportation cost.

It is hope that this research will bring a huge change in the area of agriculture which will help in the development of agriculture.

APPENDICES

Appendix-1: Interpretation of soil test values based on critical limits

A: Loamy to Clayey Soils of Upland Crops

Nutrient element*	Very Low	Low	Medium	Optimum	High	Very high
N (%)	< 0.09	0.091-0.18	0.181-0.27	0.271-0.36	0.361-0.45	>0.45
P (µg/g soil) (Olsen method)	< 7.5	7.51-15.0	15.1-22.5	22.51-30	30.1-37.5	>37.5
P (µg/g) (Bray & Kurtz method)	< 5.25	5.25-10.5	10.51-15.75	15.76-21.0	21.1-26.25	>26.25
S (µg/g) soil	< 7.5	7.51-15.0	15.1-22.5	22.51-30	30.1-37.5	>37.5
K (meq/100g)	< 0.09	0.091-0.18	0.181-0.27	0.271-0.36	0.361-0.45	>0.45
Ca (meq/100g)	< 1.5	1.51-3.0	3.1-4.5	4.51-6.0	6.1-7.5	>7.5
Mg (meq/100g)	< 0.375	0.376-0.75	0.751-1.125	1.126-1.5	1.51-1.875	>1.875
Cu (µg/g)	< 0.15	0.151-0.3	0.31-0.45	0.451-0.6	0.61-0.75	>0.75
Zn (µg/g)	< 0.45	0.451-0.9	0.91-1.35	1.351-1.8	1.81-2.25	>2.25
Fe (µg/g)	< 3.0	3.1-6.0	6.1-9.0	9.1-12.0	12.1-15.0	>15.0
Mn (µ/g)	< 0.75	0.756-1.5	1.51-2.25	2.256-3.0	3.1-3.75	>3.75
B (µg/g)	< 0.15	0.151-0.3	0.31-0.45	0.451-0.6	0.61-0.75	>0.75
Mo (µg/g)	< 0.075	0.076-0.15	0.151-0.225	0.226-0.30	0.31-0.375	>0.375

B: Sandy Soils for Upland Crops

Nutrient element*	Very Low	Low	Medium	Optimum	High	Very high
N (%)	< 0.075	0.076-0.15	0.151-0.226	0.227-0.30	0.31-0.375	>0.375
P (µg/g soil) (Olsen method)	< 6.0	6.1-12.0	12.1-18.0	18.1-24.0	24.1-30.0	>30.0
P (µg/g) (Bray & Kurtz method)	< 5.25	5.25-10.5	10.51-15.75	15.76-21.0	21.1-26.25	>26.25
S (µg/g) soil	< 6.0	6.1-12.0	12.1-18.0	18.1-24.0	24.1-30.0	>30.0
K (meq/100g)	< 0.06	0.061-0.12	0.121-0.18	0.181-0.24	0.241-0.3	>0.3
Ca (meq/100g)	< 1.5	1.51-3.0	3.1-4.5	4.51-6.0	6.1-7.5	>7.5
Mg (meq/100g)	< 0.375	0.376-0.75	0.751-1.125	1.126-1.5	1.51-1.875	>1.875
Cu (µg/g)	< 0.15	0.151-0.3	0.31-0.45	0.451-0.6	0.61-0.75	>0.75
Zn (µg/g)	< 0.375	0.376-0.75	0.751-1.125	1.126-1.5	1.51-1.875	>1.875
Fe (µg/g)	< 2.25	2.26-4.5	4.51-6.75	6.76-9.0	9.1-11.25	>11.25
Mn (µ/g)	< 0.75	0.756-1.5	1.51-2.25	2.256-3.0	3.1-3.75	>3.75
B (µg/g)	< 0.12	0.121-0.24	0.241-0.36	0.361-0.48	0.481-0.6	>0.6
Mo (µg/g)	< 0.045	0.046-0.09	0.091-0.135	0.136-0.18	0.181-0.225	>0.225

C: Loamy to Clayey Soils of Wetland Rice Crops

Nutrient element*	Very Low	Low	Medium	Optimum	High	Very high
N (%)	< 0.09	0.091-0.18	0.181-0.27	0.271-0.36	0.361-0.45	>0.45
P (µg/g soil) (Olsen method)	< 6.0	6.1-12.0	12.1-18.0	18.1-24.0	24.1-30.0	>30.0
P (µg/g) (Bray & Kurtz method)	< 3.75	3.76-7.5	7.6-11.25	11.26-15.0	15.1-18.75	>18.75
S (µg/g) soil	< 9.0	9.1-18.0	18.1-27.0	27.1-36.0	36.1-45.0	>45.0
K(meq/100g)	< 0.075	0.076-0.15	0.151-0.225	0.226-0.30	0.31-0.375	>0.375
Ca (meq/100g)	< 1.5	1.51-3.0	3.1-4.5	4.51-6.0	6.1-7.5	>7.5
Mg (meq/100g)	< 0.375	0.376-0.75	0.751-1.125	1.126-1.5	1.51-1.875	>1.875
Cu (µg/g)	< 0.15	0.151-0.3	0.31-0.45	0.451-0.6	0.61-0.75	>0.75
Zn (µg/g)	< 0.45	0.451-0.9	0.91-1.35	1.351-1.8	1.81-2.25	>2.25
Fe (µg/g)	< 3.0	3.1-6.0	6.1-9.0	9.1-12.0	12.1-15.0	>15.0
Mn (µ/g)	< 0.75	0.756-1.5	1.51-2.25	2.256-3.0	3.1-3.75	>3.75
B (µg/g)	< 0.15	0.151-0.3	0.31-0.45	0.451-0.6	0.61-0.75	>0.75
Mo (µg/g)	< 0.075	0.076-0.15	0.151-0.225	0.226-0.30	0.31-0.375	>0.375

Appendix- 2: Specific fertilizer recommendation for crops

Table 1: Boro (ufshi)

- High yield (5.4-6.6 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	23 (0-45)	5 (0-10)	14 (0-28)
Medium	68 (46-90)	16 (11-20)	43 (29-56)
Low	113 (91-135)	26 (21-30)	71 (57-84)
Very low	158 (136-180)	36 (31-40)	99 (85-112)

Table 2: Boro (Local improved varieties)

- High yield (3.1-3.9 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	12 (0-23)	3 (0-5)	9 (0-18)
Medium	35 (24-46)	8 (6-10)	28 (19-36)
Low	58 (47-69)	13 (11-15)	46 (37-54)
Very low	81 (70-92)	18 (16-20)	64 (55-72)

Table 3: T.Aus/T.Aman (ufshi)

- High yield (4.0-5.0 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	15 (0-30)	3 (0-6)	9 (0-18)
Medium	46 (31-60)	10 (7-12)	28 (19-36)
Low	76 (61-90)	16 (13-18)	46 (37-54)
Very low	106 (91-120)	22 (19-24)	64 (55-72)

Table 4: T.Aman (Local improved varieties)

- High yield (3.1-3.9 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	12 (0-23)	3 (0-5)	9 (0-18)
Medium	35 (24-46)	8 (6-10)	28 (19-36)
Low	58 (47-69)	13 (11-15)	46 (37-54)
Very low	81 (70-92)	18 (16-20)	64 (55-72)

Table 5: Bona Aus (Local improved varieties)

- High yield (3.0-4.0 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	8 (0-15)	2 (0-4)	6 (0-12)
Medium	23 (16-30)	7 (5-8)	19 (13-24)
Low	38 (31-45)	10 (9-12)	31 (25-36)
Very low	53 (46-60)	15 (13-16)	43 (37-48)

Table 6: Wheat (Kanchan, okbor, agrani, prativa, sowgat)

- High yield (4.0-5.0 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	20 (0-40)	6 (0-11)	14 (0-27)
Medium	60 (41-80)	17 (12-22)	41 (28-54)
Low	100 (81-120)	28 (23-33)	68 (55-81)
Very low	140 (121-160)	39 (34-44)	95 (82-108)

Table 7: Corn (Sadaf, swan-1, swan-2, white, spectrum and canned corn)

- ➢ High yield (5.8-7.2 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	20 (0-40)	6 (0-11)	14 (0-28)
Medium	60 (41-80)	17 (12-22)	41 (29-56)
Low	100 (81-120)	28 (23-33)	68 (57-84)
Very low	140 (121-160)	39 (34-44)	95 (85-112)

Table 8: Jute (Domestic D-154, CVE-3, CDL-1, CC-45 atom jute)

- ➢ High yield (3.1-3.9 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	10 (0-20)	3 (0-6)	9 (0-18)
Medium	31 (21-40)	10 (7-12)	28 (19-36)
Low	51 (41-60)	16 (13-18)	46 (37-54)
Very low	71 (61-80)	39 (19-24)	64 (55-72)

Table 9: Jute (Tosa- and 9897, Falguni jute)

- High yield (4.0-5.0 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	18 (0-35)	4 (0-7)	14 (0-27)
Medium	53 (36-70)	11 (8-14)	41 (28-54)
Low	88 (71-105)	18 (15-21)	68 (55-81)
Very low	123 (106-140)	25 (22-28)	95 (82-108)

Table 10: Cotton

- High yield (2.2-2.8 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	19 (0-37)	6 (0-11)	17 (0-33)
Medium	56 (38-74)	17 (12-22)	50 (34-66)
Low	93 (75-111)	28 (23-33)	83 (67-99)
Very low	130 (112-148)	39 (34-44)	116 (100-132)

Table 11: Lentil

- High yield (1.3-1.7 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	3 (0-6)	5 (0-9)	6 (0-11)
Medium	10 (7-12)	14 (10-18)	17 (12-22)
Low	16 (13-18)	23 (19-27)	28 (23-33)
Very low	22 (19-24)	32 (28-36)	39 (34-44)

Table 12: Masculine (Barimas, barimas-2, barimas-3)

- High yield (0.9-1.1 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	3 (0-5)	2 (0-4)	3 (0-5)
Medium	10 (6-10)	14 (5-8)	18 (6-10)
Low	16 (11-15)	23 (9-12)	13 (11-15)
Very low	22 (16-20)	32 (13-16)	18 (16-20)

Table 13: Mustard (SS-75, sofol, agrani, bari mustard-6, bari mustard-7, bari mustard-8)

- High yield (1.6-2.0 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	20 (0-39)	5 (0-10)	10 (0-19)
Medium	59 (40-78)	16 (11-20)	29 (20-38)
Low	98 (79-117)	26 (21-30)	48 (39-57)
Very low	137 (118-156)	36 (31-40)	67 (58-76)

Table 14: Mustard (Rai-5, dowlot)

- High yield (1.2-1.4 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	16 (0-32)	5 (0-9)	11 (0-22)
Medium	49 (33-64)	14 (10-18)	34 (23-44)
Low	81 (65-96)	23 (19-27)	56 (45-66)
Very low	113 (97-128)	32 (28-36)	73 (67-88)

Table 15: Mustard (Tori-7)

- High yield (1.0-1.3 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	16 (0-31)	5 (0-9)	8 (0-16)
Medium	47 (32-62)	14 (10-18)	25 (17-32)
Low	78 (63-93)	23 (19-27)	41 (33-48)
Very low	109 (94-124)	32 (28-36)	57 (49-64)

Table 16: Groundnut (Zigzag nut, basanti nut)

- High yield (2.9-3.5 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	7 (0-13)	6 (0-11)	11 (0-22)
Medium	20 (14-26)	17 (12-22)	34 (23-44)
Low	33 (27-39)	28 (23-33)	56 (45-64)
Very low	46 (40-52)	39 (34-44)	78 (67-88)

Table 17: Groundnuts (Maizchar, Dhaka-1)

- High yield (2.0-2.4 ton/hectors)

Fertility of the land	**Fertilizer recommendation(kg/ha)**		
	N	P	K
Moderate	5 (0-10)	5 (0-9)	9 (0-17)
Medium	16 (11-20)	14 (10-18)	26 (18-34)
Low	26 (21-30)	23 (19-27)	43 (35-51)
Very low	36 (31-40)	32 (28-36)	60 (52-68)

Table 18: Sunflower (Kirani)

- High yield (1.1-1.3 ton/hectors)

Fertility of the land	**Fertilizer recommendation(kg/ha)**		
	N	P	K
Moderate	17 (0-33)	5 (0-10)	9 (0-18)
Medium	50 (34-66)	16 (11-20)	28 (19-36)
Low	83 (67-99)	26 (21-30)	46 (37-54)
Very low	116 (100-132)	36 (31-40)	64 (52-72)

Table 19: Potato (Cardinal, Diamond, Petronis, Sulta, Dhira, Ailsha chamak, Granola, Cliopetra, Binela)

- High yield (29-35 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	23 (0-45)	5 (0-10)	20 (0-40)
Medium	68 (46-90)	16 (11-20)	61 (61-80)
Low	113 (91-135)	26 (21-30)	101 (81-120)
Very low	158 (136-180)	36 (31-40)	141 (121-160)

Table 20: Cabbage (KK cruse/ Atlas 70, Provati)

- High yield (90-110 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	33 (0-65)	7 (0-14)	27 (0-54)
Medium	98 (66-130)	22 (15-28)	82 (55-108)
Low	163 (131-195)	36 (29-42)	136 (109-162)
Very low	228 (196-260)	50 (43-56)	190 (163-216)

Table 21: Cauliflower

- High yield (36-44 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Good	25 (0-49)	9 (0-17)	20 (0-40)
Medium	74 (50-98)	26 (18-34)	61 (41-80)
Low	123 (99-147)	43 (35-51)	101 (81-120)
Very low	172 (148-196)	60 (52-68)	181 (121-260)

Table 22: Masculine (Barimash, Barimash-2, Barimash-3)

- High yield (0.9-1.1 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	3 (0-5)	2 (0-4)	3 (0-5)
Medium	8 (6-10)	7 (5-8)	8 (6-10)
Low	13 (11-15)	11 (9-12)	13 (11-15)
Very low	18 (16-20)	15 (13-16)	181 (16-20)

Table 23: Radish (Tasakisan, Maino arli, Miamiji)

- High yield (72-88 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	29 (0-57)	9 (0-17)	3 (0-38)
Medium	86 (58-114)	26 (18-34)	58 (39-76)
Low	143 (115-171)	43 (35-51)	96 (77-114)
Very low	200 (172-228)	60 (52-68)	134 (115-152)

Table 24: Lady's finger

- High yield (8-10 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	16 (0-32)	6 (0-11)	11 (0-21)
Medium	49 (33-64)	17 (12-22)	32 (22-42)
Low	81 (65-96)	28 (23-33)	53 (43-63)
Very low	113 (97-128)	39 (34-44)	74 (64-84)

Table 25: Teasel Gourd /Kakral

- High yield (16-20 ton/hectors)

Fertility of the land	**Fertilizer recommendation(kg/ha)**		
	N	P	K
Moderate	8 (0-15)	2 (0-3)	7 (0-14)
Medium	23 (16-30)	5 (4-6)	22 (15-28)
Low	38 (31-45)	8 (7-9)	36 (29-42)
Very low	53 (46-60)	11 (10-12)	50 (43-56)

Table 26: Carrots

- High yield (18-22 ton/hectors)

Fertility of the land	**Fertilizer recommendation(kg/ha)**		
	N	P	K
Moderate	23 (0-45)	7 (0-13)	15 (0-30)
Medium	68 (46-90)	20 (14-26)	46 (31-60)
Low	113 (91-135)	33 (27-39)	76 (61-90)
Very low	158 (136-180)	46 (40-52)	106 (91-120)

Table 27: Brinjal (Uttara, Tarapuri F-1, Shuktara-1, Sofola-1)

- High yield (59-72 ton/hectors)

Fertility of the land	**Fertilizer recommendation(kg/ha)**		
	N	P	K
Moderate	33 (0-65)	7 (0-14)	27 (0-54)
Medium	98 (66-130)	22 (15-28)	82 (55-108)
Low	163 (131-195)	36 (29-42)	136 (109-162)
Very low	224 (196-260)	50 (43-56)	190 (163-216)

Table 28: Brinjal (Islampuri, Khotkhatia, Dohajari, Singnath)

- High yield (27-33 ton/hectors)

Fertility of the land	**Fertilizer recommendation(kg/ha)**		
	N	P	K
Moderate	13 (0-26)	5 (0-9)	17 (0-34)
Medium	40 (27-52)	14 (10-18)	52 (35-68)
Low	66 (53-78)	23 (19-27)	86 (69-102)
Very low	92 (79-104)	32 (28-36)	120 (103-136)

Table 29: Chili

- High yield (1.8-2.2 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	17 (0-33)	11 (0-21)	17 (0-33)
Medium	50 (33-64)	32 (22-42)	50 (34-66)
Low	83 (67-99)	53 (43-63)	83 (67-99)
Very low	116 (100-132)	74 (64-84)	74 (64-84)

Table 30: Turmeric

- High yield (2.7-3.3 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	17 (0-33)	6 (0-11)	14 (0-27)
Medium	50 (34-66)	17 (12-22)	41 (28-54)
Low	83 (67-99)	28 (23-33)	68 (55-81)
Very low	116 (100-132)	39 (34-44)	95 (82-108)

Table 31: Ginger

- High yield (12-14 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	23 (0-45)	9 (0-17)	19 (0-38)
Medium	68 (46-90)	26 (18-34)	58 (39-76)
Low	113 (91-135)	43 (35-51)	96 (77-114)
Very low	158 (136-180)	60 (52-68)	134 (115-152)

Table 32: Sugarcane

- High yield (90-110 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	30 (0-59)	10 (0-20)	27 (0-54)
Medium	89 (60-118)	31 (21-40)	82 (55-108)
Low	148 (119-177)	51 (41-60)	136 (109-162)
Very low	207 (178-236)	71 (61-80)	190 (163-216)

Table 33: Pineapple (Giant Q, Honey queen, Ghorashal)

- High yield (27-33 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	38 (0-75)	14 (0-28)	38 (0-75)
Medium	113 (76-150)	42 (29-54)	113 (76-150)
Low	188 (151-225)	70 (55-84)	188 (151-225)
Very low	278 (226-320)	99 (85-120)	263 (226-300)

Table 34: Banana

- High yield (22-28 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	23 (0-45)	5 (0-10)	22 (0-43)
Medium	68 (46-90)	16 (11-20)	65 (44-86)
Low	113 (91-135)	26 (21-30)	108 (87-129)
Very low	158 (136-180)	36 (31-40)	161 (130-172)

Table 35: Betel

- High yield (3.5-6.0 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	10 (0-20)	8 (0-15)	8 (0-15)
Medium	31 (21-40)	23 (16-30)	23 (16-30)
Low	51 (41-60)	38 (31-45)	38 (31-45)
Very low	71 (61-80)	53 (46-60)	53 (46-60)

Table 36: Lemon

- Before seeding

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	13 (0-26)	3 (0-5)	10 (0-19)
Medium	40 (27-52)	5 (6-10)	29 (29-38)
Low	66 (53-78)	13 (11-15)	48 (39-57)
Very low	92 (79-104)	18 (16-20)	67 (58-76)

Table 37: Red spinach (BARI Lal sak-1 and other varieties)

- High yield(14 + 1.4 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	14 (0-27)	3 (0-6)	5 (0-10)
Medium	41 (28-54)	10 (7-12)	16 (11-20)
Low	65 (55-81)	16 (13-18)	26 (21-30)
Very low	95 (82-108)	22 (19-24)	36 (31-40)

Table 38: Mungbean / Greengram (BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5, BINA Mung-4, BINA Mung-5 and BAU Mung-1)

- High yield (1.5 + 0.15 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	3 (0-6)	5 (0-10)	6 (0-12)
Medium	10 (7-12)	14 (11-20)	19 (13-24)
Low	16 (13-18)	16 (21-30)	31 (25-36)
Very low	22 (19-24)	36 (31-40)	43 (37-48)

Table 39: Karala/Bitter gourd

- High yield (25 + 2.5 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	10 (0-20)	5 (0-10)	5 (0-10)
Medium	31 (21-40)	14 (11-20)	14 (11-20)
Low	51 (41-60)	16 (21-30)	16 (21-30)
Very low	71 (61-80)	36 (31-40)	36 (31-40)

Table 40: Onion (BARI Piyaj-1, BARI Piyaj-2 and Taherpuri)

- High yield (16.0 + 1.6 ton/hectors)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	15 (0-30)	8 (0-15)	20 (0-40)
Medium	46 (31-60)	23 (16-30)	61 (41-80)
Low	76 (61-90)	16 (31-45)	101 (81-120)
Very low	106 (91-120)	53 (46-60)	141 (121-160)

Table 41: Garlic

- High Yield Goal (Yield: 10.0 + 1.0 t/ha)

Fertility of the land	Fertilizer recommendation(kg/ha)		
	N	P	K
Moderate	15 (0-30)	8 (0-15)	20 (0-40)
Medium	46 (31-60)	23 (16-30)	61 (41-80)
Low	76 (61-90)	16 (31-45)	101 (81-120)
Very low	106 (91-120)	53 (46-60)	141 (121-160)

Appendix-3: Map unit information

Table 1: Map unit-1

General information				Land information							
Geography	**Area**	**Union**		**Non-irrigated land area hector**	**Land fill**	**Cultivator land**		**Soil group**		**Land quality**	
		Name	**Area**			**Land class**	**Area**	**Name**	**Area**	**Water removal condition**	**Plant nutrition**
Madhupur gor anchal	9875	Mirzapur	3,269	498	Chala	High land	7,900	Tejgao	2,963	Immediate	Medium
		Pubail	1,475					Belab	3,465	Immediate	Medium
		Baria	1,465					Noadda	1,481	Too early	Low
		Konabari	1,082		Baid	Medium High land	1,481	Kolma	1,481	Early	Low
		Kaolotia									
		Kashimpur	925								
		Gazipur	731								
		powroshova	92								

Table 2: Map unit-2

General information				Land information							
Geography	**Area**	**Union**		**Non-irrigated land area hector**	**Land fill**	**Cultivator land**		**Soil group**		**Land quality**	
		Name	**Area**			**Land class**	**Area**	**Name**	**Area**	**Water removal condition**	**Plant nutrition**
Madhupur gor anchal	5,729	Mirzapur	2,970	–	Chala	High land	4,634	Gerua	4,344	Immediate Too early	Low
		Koalotia	2,161			Medium		Salna	290	Early	Low
		Kashimpur	418		Baid	High land	1,159	Kolma	1,159		Low
		Gazipur powroshova	212								
		konabari	95								

Table 3: Map unit-3

General information				Land information							
Geography	**Area**	**Union**		**Non-irrigated land area hector**	**Land fill**	**Cultivator land**		**Soil group**		**Land quality**	
		Name	**Area**			**Land class**	**Area**	**Name**	**Area**	**Water removal condition**	**Plant nutrition**
Madhupur gor anchal	912	Kashimpur	587	_	Chala	High land	730	Gerua	182	Immediate	Low
		baria	325					Vat-para	274	Too early Too early	Low
								Ciata	274	Early	Low
					Baid	Medium high land	182	Kolma	182		Low

Table 4: Map unit-4

General information				Land information							
Geography	**Area**	**Union**		**Non-irrigated land area hector**	**Land fill**	**Cultivator land**		**Soil group**		**Land quality**	
		Name	**Area**			**Land class**	**Area**	**Name**	**Area**	**Water removal condition**	**Plant nutrition**
Madhupur gor anchal	3,271	Kaolotia	1,601	164	Chala	High land	1,962	Noadda	1308	Too early	Low
		Kashimpur	827					Chandra	654	Too early	Low
		Basan	356								
		Gazipur powrosova	206		Chala	Medium high land	1,145	Chandra	654	Early	Low
		Konabari									
		Mirzapur	200		Baid			Kolma	491	Early	low
			81								

Table 5: Map unit-5

General information				**Land information**							
Geography	**Area**	**Union**		**Non-irrigated land area hector**	**Land fill**	**Cultivator land**		**Soil group**		**Land quality**	
		Name	**Area**			**Land class**	**Area**	**Name**	**Area**	**Water removal condition**	**Plant nutrition**
Madhupur gor anchal	482	Gacha	338	48	Chala	High land	386	Belab	169	Immediate	Medium
		Basan	144					Vat- para Chandra	121	Too early	Low
								Kolma	96	Too early	Low
					Baid	Medium high land	48		48	Early	Low

Table no 6: Map unit-6

General information				Land information							
Geography	**Area**	**Union**		**Non-irrigated land area hector**	**Land fill**	**Cultivator land**		**Soil group**		**Land quality**	
		Name	**Area**			**Land class**	**Area**	**Name**	**Area**	**Water removal condition**	**Plant nutrition**
Madhupur gor anchal	6,462	Pubail	1,462	323	Chala	High land	4,523	Vat-para		Too early	Low
		Gacha	1,365			Medium		Ciata		Too early	Low
		Gazipur powrosova	1,236		Chala	high land	1,616	Ciata		Early	Low
		Basan	1,166					Demra		Early	Low
		Kashimpur	736		Baid			Kolma		Early	Low
		Mirjapur	334								
		Kaolotia	163								

Table no 7: Map unit-7

General information				Land information							
Geography	Area	Union		Non-irrigated land area hector	Land fill	Cultivator land		Soil group		Land quality	
		Name	Area			Land class	Area	Name	Area	Water removal condition	Plant nutrition
Madhupur gor anchal	1,133	Kaolotia	625	_	Baid	Medium high land	963	Kolma	906	Early	Low
		Mirjapur	240					Khilgao	57	Normal	Low
		Kashimpur	203		Baid	Medium low land	170	Khilgao	170	Normal	Low
		Gazipur powrosova	65								

Table no 8: Map unit-8

General information				Land information							
Geography	Area	Union		Non-irrigated land area hector	Land fill	Cultivator land		Soil group		Land quality	
		Name	Area			Land class	Area	Name	Area	Water removal condition	Plant nutrition
Madhupur gor anchal	408	Gacha	199	_	Baid	Medium low land	306	Khilgao	306	Late	Low
		Mirjapur	115		Baid	Low land	102	Khilgao	61	Late	Low
		Kaolotia	63					Korail	41	Too late	Low
		Pubail	31								

Table no 9: Map unit-9

General information				Land information							
Geography	Area	Union		Non-irrigated land area hector	Land fill	Cultivator land		Soil group		Land quality	
		Name	Area			Land class	Area	Name	Area	Water removal condition	Plant nutrition
Mixed Madhupur gor and nabbo Brahmaputra polol vumi	1,878	Basan	537	_	Danga	Medium high land	376	Molandoh	282	Normal	High
		Kaolotia	512			Low land		Dhamrai	94	Normal	Medium
		Konabari	500		Bil		1,502	Savar bazaar	751	Late	Low
		Kashimpur	310					Kajla	376	Late	Low
		Gacha	19		Baid			Korail	375	Too late	Low

Table no 10: Map unit-10

General information				Land information							
Geography	Area	Union		Non-irrigated land area hector	Land fill	Cultivator land		Soil group		Land quality	
		Name	Area			Land class	Area	Name	Area	Water removal condition	Plant nutrition
Mixed Madhupur gor and nabbo Brahmaputra polol vumi	7,308	Baria	2,265	–	Baid	Low land	5,481	Khilgao	2,923	Normal	Low
		Pubail	1,506					Korail	1,827	Too late	Low
		Mirjapur	1,115		Bil			Kajla	731	Too late	Low
		Gazipur powrosova	807								
		Kaolotia	560		Baid	Very low land	1,827	Korail	1,462	Too late	Low
		Basan	461		Bil			Kajla	365	Too late	Low
		Gacha	265								
		Kashimpur	185								
		Konabari	144								

Table no 11: Map unit-11

General information				Land information							
Geography	Area	Union		Non-irrigated land area hector	Land fill	Cultivator land		Soil group		Land quality	
		Name	Area			Land class	Area	Name	Area	Water removal condition	Plant nutrition
Nabbo Brahmaputra polol vumi	576	Basan	163	29	Danga	Medium high land	58	Turag	58	Early	Medium
		Kaolotia	152		Danga	Medium low land	345	Molandoh	144	Early	High
		Konabari	119			Low land		Dhamrai	201	Early	Medium
		Kashimpur	111		Bil		144	singair	144	Late	Low
		Mirjapur	31								

Appendix-4: Crop and possible crop formation according to land and soil characteristics

Soil group and map unit no.	Land characteristics			Soil characteristics			
	Land class	Rough-ness	Water removing condition	Drainage class	Texture (high/middle level)	Soil consistency (high level)	Climatic conditions on the ground
Chandra 4	Medium high land	Plain	Early	Bad	Loam/ clay loam	Crumbly	Low
Ciata 6	Medium high land	Plain	Bad	Bad	Clay loam/ clay loam	Crumbly	Low
Kolma 1,2,3,4,5,6,7	Medium high land	Almost plain	Bad	Bad	Loam/ clay loam	Crumbly	Low

Possible crops distribution (with irrigation)	Suitable crops (with irrigation)			Possible crops distribution (without irrigation)	Suitable crops (without irrigation)			
	Kharif-2	Kharif-1	Rabi		**Kharif-2**	**Kharif -1**	**Rabi**	**Reaction (high level)**
1. fallow-T.aus(ufshi)-T.aman(ufshi, local) 2.boro(ufshi)-T.aman(ufshi,local)	T.aman(ufshi)	T.aus (ufshi)	Boro (ufshi)	Fallow-T.aus-T.aman	T.aman	Bona aus	–	More acidic Light acidic
1. Rabi crop-fallow-T.aus-T.aman 2.boro-fallow-T.aman(ufshi,local)	T.aman(ufshi)	T.aus (ufshi)	Boro (ufshi)	Fallow-bona.aus-T.aman	T.aman	Bona aus	–	More acidic
1. Rabi corp-T.aus-T.aman(ufshi) 2.Mustard-boro-T.aman 3. boro-fallow-	T.aman(ufshi)	T.aman (ufshi)	Wheat, mustard (ufshi) ,Boro (ufshi)	Fallow-bona.aus-T.aman	T.aman	Bona aus	–	Excessive acidic Light acidic

Appendix-5: Location specific and yield goal basis fertilizer recommendation for crops based on soil test values

For example: Crop-Wheat

Table 1: Wheat

Soil analysis	**Soil test value**	**Soil test value interpretation (Appendix- 1A)**	**Range of values used within the interpretation class (Appendix- 1A)**
Texture	Loam	-	-
Total N (%)	0.1	Low	0.091-0.18
Available P (µg/g)	18	Medium	15.1-22.5
Exchangeable K (meq/100g)	0.15	Low	0.091-0.18

Calculation:

N (kg/ha)

= 120 – 40/0.09 x (0.1-0.091)

= 120 – 40/0.09 x (0.009)

= 120 – 40/9 x 0.9

= 120 – 36/9

= 120 – 4

=116 kg N/ha

=116 x 100/46

= 252.24 kg Urea/ha

P (kg/ha)

= 20 – 10/7.5 (18-15.1)

= 20 – 10/7.5 x 2.9

= 20 – 3.9

= 16.1 kg P/ha

=16.1 x 100/20

= 80.5 kg TSP/ha

K (kg/ha)

= 90 – 30/0.09 x (0.15 – 0.091)

= 90 – 30/0.09 x (0.059)

= 90 – (30 x 5.9)/9

= 90 – 19.7

= 70.3 kg k/ha

= 70.3 x 100/50

= 140.6 kg KCI/ha

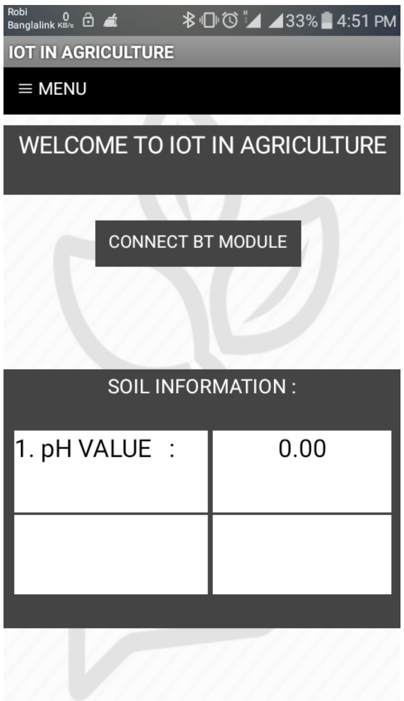
The Final Recommendation:

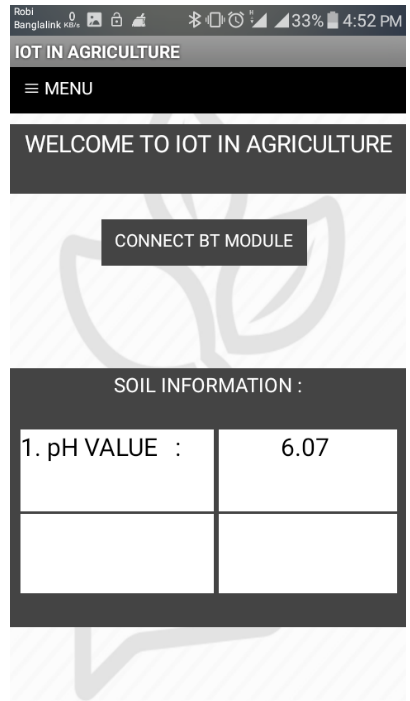
From the above example, the final fertilizer recommendation would be the following:

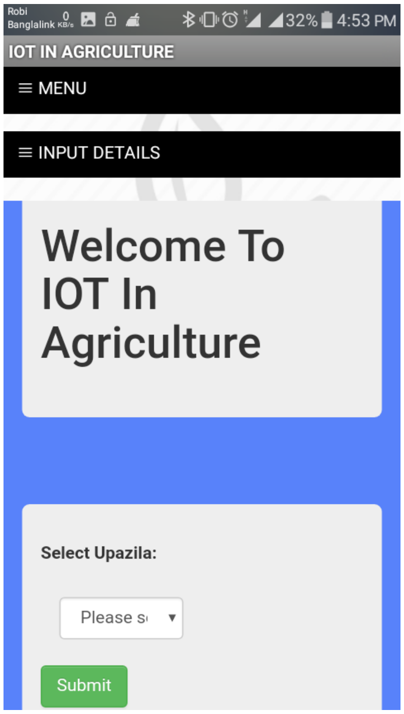
Nutrient (kg/ha)	**Fertilizer (kg/ha)**
N = 116	Urea = 252.2
P = 16.1	TSP = 80.5
K = 70.3	MP = 140.6

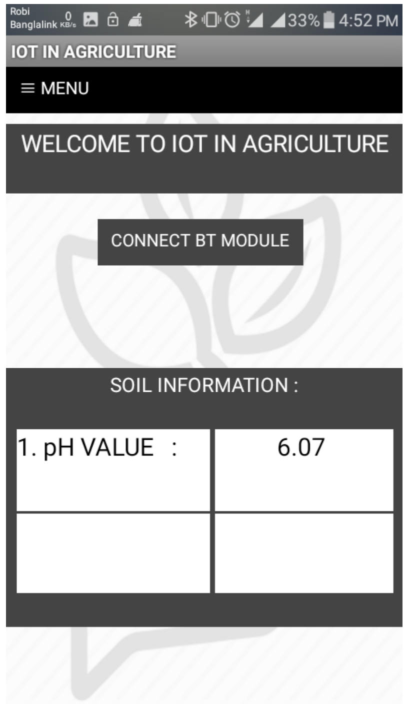
Appendix-6: Screenshots of the system

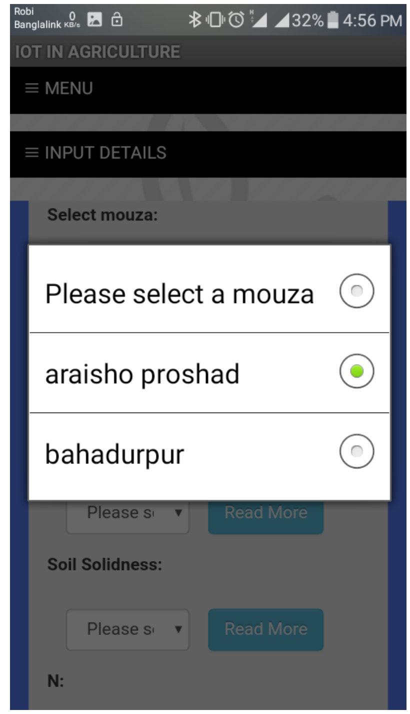
Some screenshots of our system is given below:

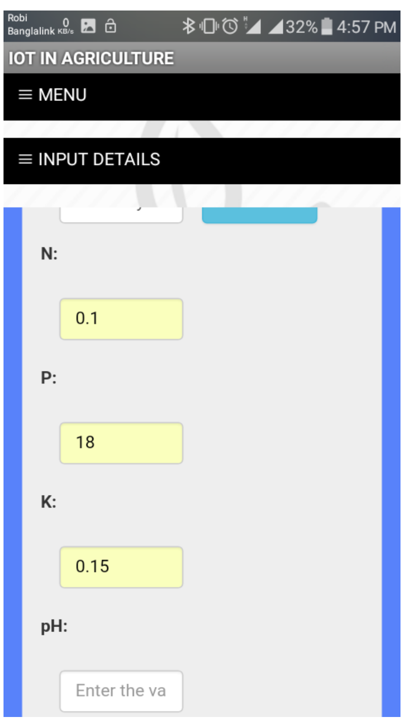


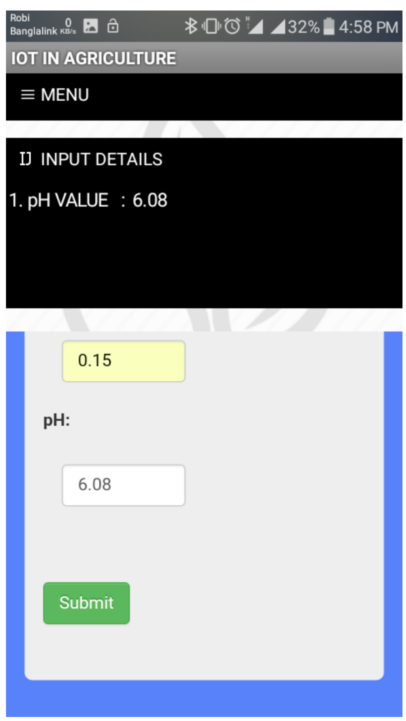


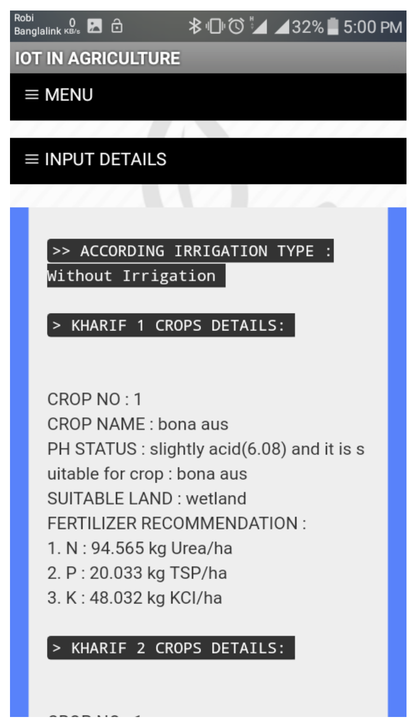

IOT IN AGRICULTURE
MENU
INPUT DETAILS
Welcome To IOT In Agriculture
Select Upazila:
Please s
Submit

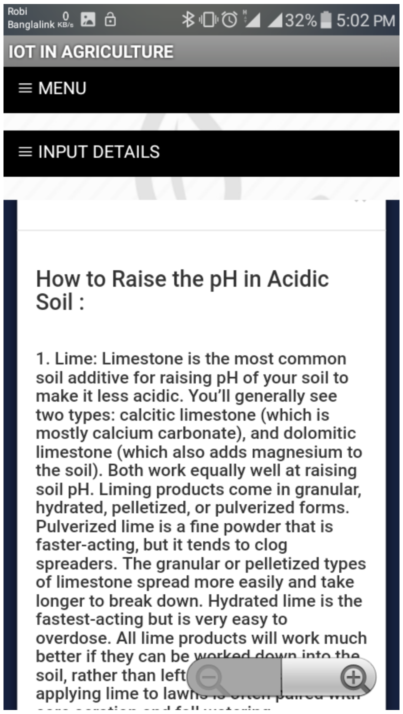

IOT IN AGRICULTURE
MENU
WELCOME TO IOT IN AGRICULTURE
CONNECT BT MODULE
SOIL INFORMATION :
1. pH VALUE :
6.07

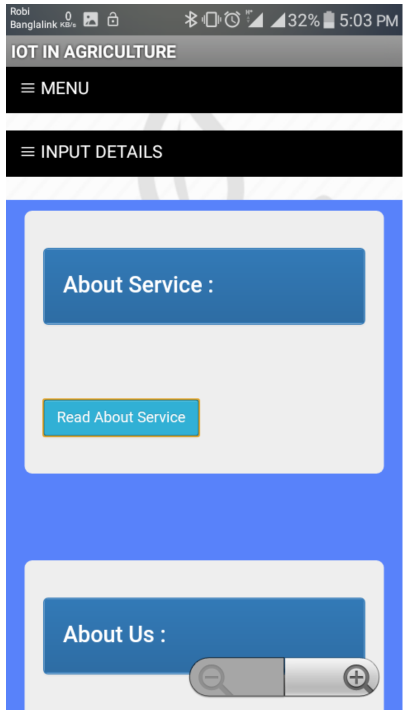

IOT IN AGRICULTURE
MENU
INPUT DETAILS
Select mouza:
Please select a mouza
araisho proshad
bahadurpur
Please s
Read More
Soil Solidness:
Please s
Read More
N:

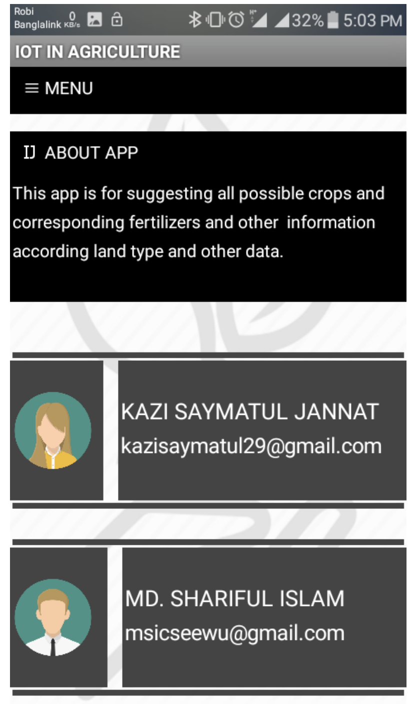

IOT IN AGRICULTURE
MENU
INPUT DETAILS
N:
0.1
P:
18
K:
0.15
pH:
Enter the va


IOT IN AGRICULTURE
MENU
INPUT DETAILS
1. pH VALUE : 6.08
0.15
pH:
6.08
Submit


IOT IN AGRICULTURE
MENU
INPUT DETAILS
>> ACCORDING IRRIGATION TYPE :
Without Irrigation
> KHARIF 1 CROPS DETAILS:
CROP NO : 1
CROP NAME : bona aus
PH STATUS : slightly acid(6.08) and it is s
uitable for crop : bona aus
SUITABLE LAND : wetland
FERTILIZER RECOMMENDATION :
1. N : 94.565 kg Urea/ha
2. P : 20.033 kg TSP/ha
3. K : 48.032 kg KCl/ha
> KHARIF 2 CROPS DETAILS:


Robi Banglalink
32% 5:02 PM
IOT IN AGRICULTURE
≡ MENU
≡ INPUT DETAILS
How to Raise the pH in Acidic Soil :
1. Lime: Limestone is the most common soil additive for raising pH of your soil to make it less acidic. You'll generally see two types: calcitic limestone (which is mostly calcium carbonate), and dolomitic limestone (which also adds magnesium to the soil). Both work equally well at raising soil pH. Liming products come in granular, hydrated, pelletized, or pulverized forms. Pulverized lime is a fine powder that is faster-acting, but it tends to clog spreaders. The granular or pelletized types of limestone spread more easily and take longer to break down. Hydrated lime is the fastest-acting but is very easy to overdose. All lime products will work much better if they can be worked down into the soil, rather than left
applying lime to lawns


Robi Banglalink
32% 5:03 PM
IOT IN AGRICULTURE
≡ MENU
≡ INPUT DETAILS
About Service :
Read About Service
About Us :


Robi Banglalink
32% 5:03 PM
IOT IN AGRICULTURE
≡ MENU
ABOUT APP
This app is for suggesting all possible crops and corresponding fertilizers and other information according land type and other data.
KAZI SAYMATUL JANNAT
kazisaymatul29@gmail.com
MD. SHARIFUL ISLAM
msicseewu@gmail.com

REFERENCES

[1]N. Gondchawar and P. Kawitkar, "IoT based Smart Agriculture", *International Journal of Advanced Research in Computer and Communication Engineering*, vol. 5, no. 6, 2016.

[2]A. Yadav, P. Pandhare, S. Kulkarni, S. Kale and S. Zope, "Design and implementation of Smart Agriculture using Embedded System", *International Journal Of Engineering And Computer Science ISSN: 2319-7242*, vol. 5, no. 12, 2016.

[3]R. Calero, T. Robles, M. Navarro3, R. Alcarria, D. Mart´ın, S. Iglesias and M. L´opez, "An IoT based reference architecture for smart water management processes", *Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications*, vol. 6, no. 1.

[4]S. Israni, H. Meharkure and P. Yelore, "Application of IOT Based System for Advance Agriculture in India", *International Journal of Innovative Research in Computer and Communication Engineering*, vol. 3, no. 11, 2015.

[5]R. Kumar, G. Vaishnavi, P. Rao and D. Marur, "Crop Monitoring using Visual Sensors and IOT", *SSRG International Journal of Electronics and Communication Engineering (SSRG-IJECE)*, vol. 4, no. 4, 2017.

[6]S. Jaishetty and R. Patil, "IOT SENSOR NETWORK BASED APPROACH FOR AGRICULTURAL FIELD MONITORING AND CONTROL", *IJRET: International Journal of Research in Engineering and Technology*, vol. 5, no. 6, 2016.

[7]A. P and D. K R, "Design and Implementation of Wireless Sensor Network for Precision Agriculture", *International Journal of Scientific Engineering and Applied Science (IJSEAS)*, vol. 1, no. 4, 2015.

[8]O. Savale, A. Managave, D. Ambekar and S. Sathe, "Internet of Things in Precision Agriculture using Wireless Sensor Networks", *International Journal Of Advanced Engineering & Innovative Technology (IJAEIT) ISSN: 2348 7208*, 2015.

[9]J. Shenoy and P. Pingle, "IOT in agriculture", in *International Conference on Computing for Sustainable Global Development (INDIACom)*, India, 2016.

[10]A. Kapoor, S. I Bhat, S. Shidnal and A. Mehra, "IMPLEMENTATION OF loT (INTERNET OF THINGS) AND IMAGE PROCESSING IN SMART AGRICULTURE", in *International Conference on Computational Systems and Information Systems for Sustainable Solutions*, India, 2016.

[11]X. Wang and N. Liu, "The application of internet of things in agricultural means of production supply chain management", *Journal of Chemical and Pharmaceutical Research*, vol. 6, no. 7, 2014.

[12]Y. Bo and H. Wang, "The Application of Cloud Computing and the Internet of Things in Agriculture and Forestry", in *International Joint Conference on Service Sciences*, 2011.

[13]A. Vishwanathan, M. Farkade, S. Jha, P. Dubey and Y. Pandit, "IOT Based Irrigation System for Methodical Agricultural Practices", *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol. 5, no. 6, 2016.

[14]M. Miah, *Fertilizer recommendation guide--2005*. Dhaka: Bangladesh Agricultural Research Council, 2005.