Impact of Water Logging in South Western Coastal Zone of Bangladesh: A Case Study

by

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering at the Department of Civil Engineering

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Declaration

This is to certify that the thesis work entitled " *Impact of Water Logging in South Western Coastal Zone of Bangladesh: A Case Study* " has been carried out by *Md. Ajmal Hossain Gazi* in the Department of Civil Engineering, Khulna University of Engineering & Technology, Khulna, Bangladesh. The above thesis work or any part of this work has not been submitted anywhere for the award of any degree or diploma.

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Abstract

An integrated drainage path is an important component for tropical countries. If heavy rainfall occurred with lacking of drainage path, water logging is the consequence of the surroundings. Three southwestern coastal districts of Bangladesh namely Satkhira, Khulna and Jashore are the worst hit areas and experiencing severe prolonged water logging and remain submerged in every year for long periods. Mostly affected Tala upazila has been selected for this study. The Coastal Embankment Project (CEP) disconnected the wetlands from the rivers and disallowed sedimentation inside the wetlands which gradually caused the drainage congestion of the rivers as the sediment deposited on the river bed. In many places the river bed became higher than the wetlands in the surrounding basins.

The aim of this study is to illustrate the impact of water logging, investigate the salinity related variables (Chloride, EC and SAR) and acidic conditions in soil solution (pH and sulfate) related to plant nutrients (Nitrogen, Potassium, and Phosphorus) in soils after prolonged water-logging and propose suggestions for future work.

To obtain this aims necessary information were collected through house hold survey, field visit and key informant interviews. Most of the laboratory investigation of soil and water sample was performed from environmental laboratory, KUET and Soil Resource Development Institute (SRDI), Regional Laboratory, Khulna. Secondary data were also collected for comparing with the experimental results.

The study results that due to prolonged water logging of the study area the agricultural land price are not increased as the residential or commercial land price. Because both types of agricultural land become ideal and the land can't use for cultivation. Presently only 16% of people are alive taking farming as the main occupation and about 60% of people living with day laboring occupation.

The structures of the study area has affected seriously due to prolonged water logging. The brick foundations losses its longevity by corrosive effect of salinity and damping. Water logging causes the damage to roads in the rainy season every year leading to the movement problem and interrupts the journey. The educational institutions of the study

area became flooded for long time and the students can't continue their learning. Crop production also hampered due to prolonged water logging, especially the Amon rice production.

From the laboratory investigation of the soil and water sample the average value of sulfate (SO_4^{-2}) concentration was found within the optimum range 25-200 mg/L. The nitrate (NO_3^-) concentration of the soil sample was lower than the optimum range for all location, water sample result found within the optimum range 0 -10mg/L. Nitrogen content was found less than the optimum limit. Potassium, Calcium and Magnesium content was exceed the optimum limit. Phosphorus content in Kumira and Gopalpur union exist within the limit but in the Tala and Tentulia union excess than the optimum limit. The maximum chloride concentration of soil was found .080g/kg, 0.315g/kg, 0.356g/kg and 0.490g/kg of Tentulia, Tala, Islamkathi and Kumira union respectively. Paddy can grow with maximum soil Cl^- concentration of 1g/kg without any yield loss. Therefore, rice production has not affected by chloride concentration, salinity related variables or plant nutrients of the study area. It is only affected by prolonged water logging. To safe the study area from the water logging the main drainage path of the study area anyhow need to make smooth to carry the upstream rain water.

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Operational Definitions

Ambagan	**:**	Local name of Mango Cultivated Land, Gopalpur Ambagan is mostly affected largest Mango forest due to water logging of the study area.
Aus	**:**	Paddy planted in the month of March-May and harvested in the month of June-August.
Aman	**:**	Paddy planted in the month of May-August and harvested in the month of November-January.
Boro	**:**	Paddy planted in the month of December-February and harvested in the month of April-May.
CS Map	**:**	Cadastral Survey (CS) map prepared for all over Bangladesh based on the survey from 1912 to 1915. People use these maps to find location and actual area of land in the field.
Dengue	**:**	A disease vector, which is dangerous threat to public health that spreads by a special mosquitoes named "Aedes". Dengue breaks out in full-blown during rainy season as stagnant rain water is suitable breeding sites for Aedes mosquitoes.
Drainage System	**:**	Channels, either constructed or natural, passes through surface or underground or both that are usually used to drain out the flood or rain water
Katcha	**:**	A term locally used for earthen infrastructure or structures made with mud, bamboo and thatch.
Canals	**:**	Canals passes through the study area that are created naturally and used as drainage channel to drain out the flood as well as rain water to the surrounded outfall rivers.
Pucka	**:**	The houses made with cement/brick/concrete and shaded by slab
Semi-Pucka	**:**	The houses made with cement/brick/concrete and shaded by CI Sheet.
Water logging	**:**	Flooding in built up areas caused by rainfall, where water remains stagnant for long time due to lack of proper drainage system and creates many adverse impact on daily life.

Nomenclature

BBS	Bangladesh Bureau of Statistics
Beel	Low Land
BIWTA	Bangladesh Inland Water Transport Authority
BTM	Bangladesh Transverse Mercator coordinates system
BWDB	Bangladesh Water Development Board
CEP	Coastal Embankment Project
DMB	Disaster Management Bureau
EC	Electric Conductivity
EPWAPDA	East Pakistan Water and Power Development Board
EEZ	Exclusive Economic Zone
GIS	Geographical Information System
Gher	Shrimp Firms
GoB	Government of Bangladesh
HHS	House Hold Survey
HYV	High Yield Varieties
IS	Indian Standards
JICA	Japan International Cooperation Agency
Katcha	The houses made with mad/soil
km	Kilometer
Kobadak	The main river of the study area
KUET	Khulna University of Engineering and Technology
LGED	Local Government Engineering Department

lpcd	Liter per capita per day
LPG	Liquid Petroleum Gas
m	Meter
mg/L	Milligram per liter
mm	Millimeter
MoFDM	Ministry of Food and Disaster Management
Pucka	The type of structure/houses is made with brick or concrete both of wall and roof slab.
SAR	Sodium Absorption Ratio
Upazila	Sub district
UTM	Universal Transverse Mercator coordinates system

CHAPTER I

Introduction

1.1 General

Bangladesh is one of the most vulnerable countries in the world to disasters and climate change impacts. Different types of natural hazards such as flood, drought, cyclone and storm surge, tidal surges, intrusion of saline water, increase of soil salinity and river water salinity, water-logging, tidal flooding, river bank erosion, tornadoes etc., significantly affect the agriculture production systems and overall economic and social development of the country(Miah, 2010). The coastal zone of Bangladesh has been officially defined as consisting of 19 districts and the Exclusive Economic Zone (EEZ). The coastal zone covers 47,201 square kilometer land area, which is 32 percent of total landmass of the country (Miah and Islam, 2005). The coastal districts of Bangladesh have been demarcated into three adjoining regions, as south-west constituting Satkhira, Khulna and Bagerhat; south-central comprising Jashore, Patuacanali, Noacanali and Barisal, and south-east consisting of Chittagong and Cox's Bazar (BCAS, 2010). The land in these regions is intensively used for agriculture, settlements, forests, shrimp firms (local name Gher), water bodies and fisheries, salt production, industrial, infra-structural developments and tourism. The coastal areas are important ecologically, as well as they provide a number of environmental goods and services to people. They contain critical terrestrial and aquatic habitats, such as the mangrove forests, wetlands and tidal flats (Miah and Islam, 2005). But the vast cultivable area is under great threat of vulnerabilities of the climate change and crop production is rapidly declining due to climate risk factors. Water-logged areas have significantly increased to 147,917.00 hectares (2008-09) from 61,929.00 hectares (1975-76) due to seasonal submergence, tidal surges, drainage congestion, increased roads and embankments, faulty sluice gate, increased shrimp culture under gher areas and heavy clays in the coastal region (Miah, 2010).

Three southwestern coastal districts of Bangladesh namely Satkhira, Khulna and Jashore are the worst hit areas and experiencing severe prolonged water logging and remain submerged for long periods every year, especially during the monsoon season (Hossain, 2010, Oxfam, 2011 and UNDP, 2011). The combined effect of higher sea water levels, subsidence, siltation of estuary branches, higher riverbed levels and reduced sedimentation in flood protected areas will impede drainage and gradually increase water logging problems (Ali, 1996). According to Disaster Management Bureau (DMB) of the Ministry of Food and Disaster Management (MoFDM) estimation about 20,0000 people of about 41,000 families were affected in the year 2009 and more than 80,0000 people were affected in the year 2011 by monsoon flood in Satkhira district. It was the worst affected district and its most affected upazila Tala is selected as the study area for the present research.

1.2 Background of the Study

Bangladesh is located on the extensive floodplains of the Ganges and Brahmaputra. Therefore, flooding is a natural part of the life of its inhabitants (Tawhid, 2004). Thus water logging in Bangladesh is not a new problem but the frequency and intensity of this problem is increasing day by day. Flooding due to rainfall is also a severe problem for the study area that is inundated for several month mainly due to the drainage congestion. This Tala upazila area has experienced water logging for last couple of years.

The Coastal Embankment Project (CEP), implemented in the 1960s to increase agricultural production, irreversibly changed the region's ecosystem. These interventions disconnected the wetlands from the rivers and disallowed sedimentation inside the wetlands which gradually caused the drainage congestion of the rivers as the sediment deposited on the river bed. In many places the river bed became higher than the wetlands in the surrounding basins. All of the canal opening/sluice gate of the Embankment connecting Kobadak river has been closed by the local people to stay away from the river water as the river water is flowing 5-6 feet higher than that of the surrounding area. This study aims at investigating the causes, impact and also mitigating measure of prolonged water logging in the south-western coastal zone of Bangladesh in particular Tala upazila, Satkhira district hence proposing strategies for its sustainable development.

In the past Kobadak river is the main drainage path for rainy water of the study area but now the Kobadak resulted in a very narrow flow and loses its navigability at most places. In summer the river almost dries up but in the monsoon season (May to October) the water level become higher and water passes crossing the danger level. The river water enter in the locality instead of drained out the rain water. At that time the storm water become stagnant and flooded the study area. As an impact of prolonged water logging various species of plants like jackfruit tree, mango tree, coconut tree, nut tree and many other trees are going to deplete.

1.3 Objectives of the Study

The main focus of the study would be on the factors influencing the water logging problem in Tala upazila. The physical development trend, the rainfall intensity and the storm water drainage system of the study area would be established. The effects on human life, plants, agriculture, economy and the environmental quality of the area due to water logging would be studied. Finally develop some recommendations from the technical, social and ecological point of views as an input for the concerned authorities for better management of storm water. These recommendations are based on the observation, discussion and primary information that have been collected for the study. However, the specific objectives of this study are outlined as below:

a) To investigate the causes of prolonged water-logging in the south-western coastal zone of Bangladesh in Particular Tala upazila, Satkhira District;

b) To study the actual (social and economic) impact of the prolonged water-logging in the area;

c) To investigate the salinity related variables (Chloride, EC and Sodium Adsorption Ratio) and acidic conditions in soil solution (pH and sulfate) related to plant nutrients (Nitrogen, Potassium, and Phosphorus) in soils after prolonged water-logging;

d) To propose suggestions or mitigation measures and develop an approach for solving the water logging problems.

1.4 Scope of the Study

The study area is one of the deserted coastal areas of the country. Majority of the people in coastal areas are involved in crop cultivation and fishing and they remain frequently unemployed due to tidal flooding and other natural disasters resulting food insecurity in the areas (Hossain, 2010). As a result of prolonged water logging the economic condition of the study area is become poor to poorer. On the other hand, the local people did not have any work that they can live on. Many of them forced to change their occupation or leave their origin homestead. This picture is clearly visible in BBS census report 2011. Based on BBS; in the study area there were 307695 people in 2001 and after ten years in 2011 its total population became 311236 (BBS, 2012). The yearly population growth rate of the study area is 0.115%, whereas the overall national growth rate is 1.078%.

To overcome the water logging problem of the study area, it is necessary to find out the inherent causes of this problem considering its associated impacts on the human life. Thus the study focuses to find out the causes addressing its effects of water logging, which will be helpful to take appropriate steps for better management of the problem proposing strategies for its sustainable development.

1.5 Limitations of the Work

The study area is one of the rural areas of Bangladesh and these types of research are not performed in the past. So, some limitations were encountered during the study period to complete research work according to the selected objectives. These limitations are described below:

Generally two types of water logging occurs in the study area one is water logging due to river flooding and another is water logging due to heavy rainfall. But sometimes it was very difficult to differentiate these two types of water logging as they merged each other due to heavy rainfall.

Related study of water logging and drainage system for the study area is not available. As a result, there was no sufficient literature to enrich the analysis of this study by reviewing their study findings.

Source of secondary data is not sufficient to collect related to past drainage system in terms of width, length, depth, capacity, pick flow rate, drainage coefficient etc. and integrated

layout map. Therefore, it was not possible to compare the capacity of present drainage system to drain out the stagnant water with the past, which was needed to enrich the recommendations to reduce the problem.

Detailed elevation data is very necessary to find out the actual depth of water logging and sometimes it was very hard to measure the actual depth of water logging without elevation data. Therefore, in some case it has to depend on photograph rather than numeric data to illustrate the causes and effects of the situation.

During the questionnaire survey, some interviewee did not want to make any comments against the responsible development authorities even they know the lack of efficiency of those authorities, because they think that any negative comments can be harmful for them in near future.

1.6 Statement of the Thesis

This study report is described and arranged in a chronological and comprehensive way for better understanding of topic evaluated the analysis and finding of the study. This report consists of six chapter.

CHAPTER I: This chapter includes the general introduction, background, objective, scope and limitation of the study.

CHAPTER II: This chapter shows the general description of the study area like drainage system, area, population, climate, land use etc.

CHAPTER III: This chapter comprises of a comprehensive literature review on water logging and its impacts.

CHAPTER IV: This chapter includes the elaborate description of the methodology for the survey in selected area, sample collection, testing and analysis.

CHAPTER V: This chapter shows the present status of the study area finding from the house hold survey, the quality of soil and water of the different location of the study area also the comparison of the quality of soil and water samples to the standard quality required for plant life. This chapter also represents necessary suggestions/mitigation measure for the prolonged water logging of the study area.

CHAPTER VI: This chapter contains the conclusion of the study as well as recommendations for the future research.

CHAPTER II

Description of the Study Area

2.1 Geographic Location

The selected study area Tala upazila is situated in south western costal region of Bangladesh. It is located between 22°32' and 22°50' north latitudes and between 89°05' and 89°20' east longitudes. The study area is situated in the Ganges Basin, Kobadak river is the main drainage path of this upazila which is an offshoot branches out from the Bhairab river and flowing south meets with the Shibsa river near Paikgachha in Khulna district. Figure 2.1 shows the location of the study area.

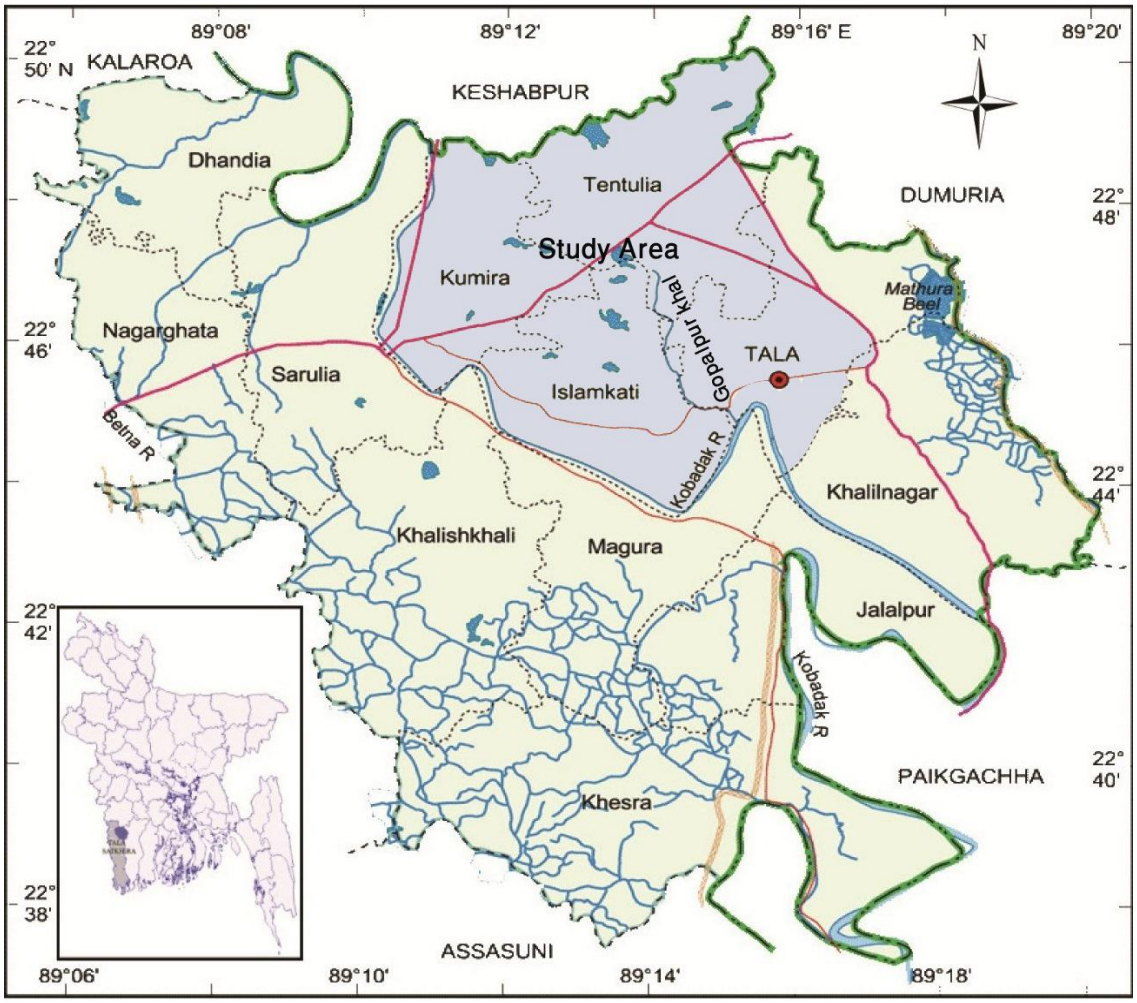


Figure 2.1: Location map of the study area

The upazila bounded on the north by Keshabpur upazila of Jashore district and Kalaroa Upazila of Satkhira district, on the east by Dumuria and Paikgachha upazilias of Khulna district, on the sourth by Assasuni upazila and on the west by Satkhira Sadar upazila (BBS, 2012).

2.2 Area and Population

The selected study area is one of the rural upazila of the country occupies an area of 337.24 sq. km. the total population of the selected upazila is about 299820 (BBS, 2011). Among the total population there are male 152017, female 142383; Muslim 212029, Hindu 79867, Buddhist 2143 and others 361. Most of the people of this area is involved with Agriculture based occupation. Main sources of income agriculture 70.34%, non-agricultural laborer 2.67%, industry 1.30%, commerce 13.17%, transport and communication 3.02%, service 4.21%, construction 0.85%, religious service 0.25%, remittance 0.15% and others 4.04% (BBS, 2011). Table 2.1 shows the area and population of the study area.

Table 2.1 : Area and population of the study area

Sl. No.	Year	Area (sq. km)	Total Households	Total Population	Population Density per sq. km
01	1981	344.14		228000	663
02	1991	344.14	47394	251000	729
03	2001	344.14	65028	294400	855
04	2011	337.24	72465	299820	889

Source: District statistics, BBS, 2011

2.3 Recent Years Water Logging Profile

Water logging problem is the common phenomena of the study area for last decade. During the flooding time the people of the area faces many problems. The following Figures 2.2-2.4 shows some real pictures of the water logging of the study area during year 2012, 2014, and 2016 respectively.

Figure 2.2: Water logging in the study area, 2012

Figure 2.3: Water logging in the study area, 2014

Figure 2.4: Water logging in the study area, 2016

2.4 Climate

Like other area of the tropical country the study area climate is marked by the fairly different six seasonal variations. It is hot and humid during May to October while cool and dries during November to February. The rainy season generally prevails from May to October. Approximately 90 per cent of the annual rainfall occurs during this time and the average annual rainfall is about 1710mm. Heavy rainfalls, sometimes extending up to several days, are common during the monsoon. The total annual rainy days vary from 90 to 130 days. Rainfall is rather scarce during the months from November to February. The lowest temperature during this period may drop down to about 12.5^{0}C. On the other hand, temperature as high as 35.5^{0}C may occurs during the warm months of March and April. Monthly evaporation varies from 80 to 130 mm. The climatic condition of the study area are summarized in the Table 2.2.

Table 2.2 : Climatic condition of the study area

Parameter	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Avg. rainfall (mm)	6.5	20.2	52.3	124.0	283.0	398.0	391.4	328.0	264.0	160.0	25.3	7.4
Rainy days/m	1	2	4	8	14	19	22	22	16	9	2	1
Temperature ^{0}C												
High (extreme)	34.2	36.6	40.6	42.3	40.6	38.4	35.2	35.9	35.3	38.8	33.3	31.2
Low (extreme)	5.6	4.5	10.4	15.6	18.4	20.4	21.7	21.0	22.0	10.4	10.6	6.7
Average	18.8	21.5	26.1	28.7	28.9	28.7	28.7	28.7	28.7	27.4	23.6	19.8
Relative Humidity	70.7	66.0	63.0	71.0	79.0	86.0	87.0	86.0	86.0	81.0	75.0	74.0
Evaporation	104	79	81	77	78	83	87	130	118	106	75	105
Wind velocity (K_{not} = 1.852 m/hr)	2.0	2.0	3.0	5.0	5.0	4.0	4.0	4.0	3.0	2.0	1.0	1.0

Source: Japan International Corporation (JICA), 1991

2.5 Land Use

The study area is one of the deserted coastal areas of the country. The study area consist with different types land use. Majority of the land of the area is used by crop cultivation and

fishing. The land of this area is mostly suitable for cultivating different kinds of crops like paddy, wheat, jute, mustard, potato, gram, onion, lentil, turmeric, vegetables. The study area is well-known for growing different kinds of fruits. Mango, jackfruit, coconut, betel nut, litchi, papaya, plum, guava, banana, blackberry is some of them. Shrimp firms (local name Gher) is also a very important part of this area. Every year our country earn huge amount of foreign money by exporting the "White Gold" named shrimp. About 65.80% landowner have their own agricultural land and another 34.20% landless (Banglapidia, 2015).

2.6 History of Physical and Demographic Development

The study area is one of the rural areas of Bangladesh, Tala Thana was formed in 1913 and it was turned into an upazila in 1989. There are 84.19 km of pucka road, 31.73 km of semi-pucka road and about 621.15 km earthen road in the selected Tala upazila (Banglapidia, 2015).

2.7 Storm Water Drainage System of the Study Area

The study area is situated in rural area of Bangladesh. Therefore the drainage system has developed in natural way. Storm water is accumulated in the nearby low land (Beel), pond and drained out through different natural canals (Canal). Finally the water is discharged to the surrounding rivers through canals is described in below:

2.7.1 Drainage Channels of the study area

There are many inter connected channels in the study area. Some of the channels are Gopalpur Canal, Tala-Atarui Canal, Madhabcanali Canal, Islamkathi Canal and some small Canals are connected to the river. Kabadak river is the main drainage path of the study area. Figure 2.5 shows the drainage channels of the study area.

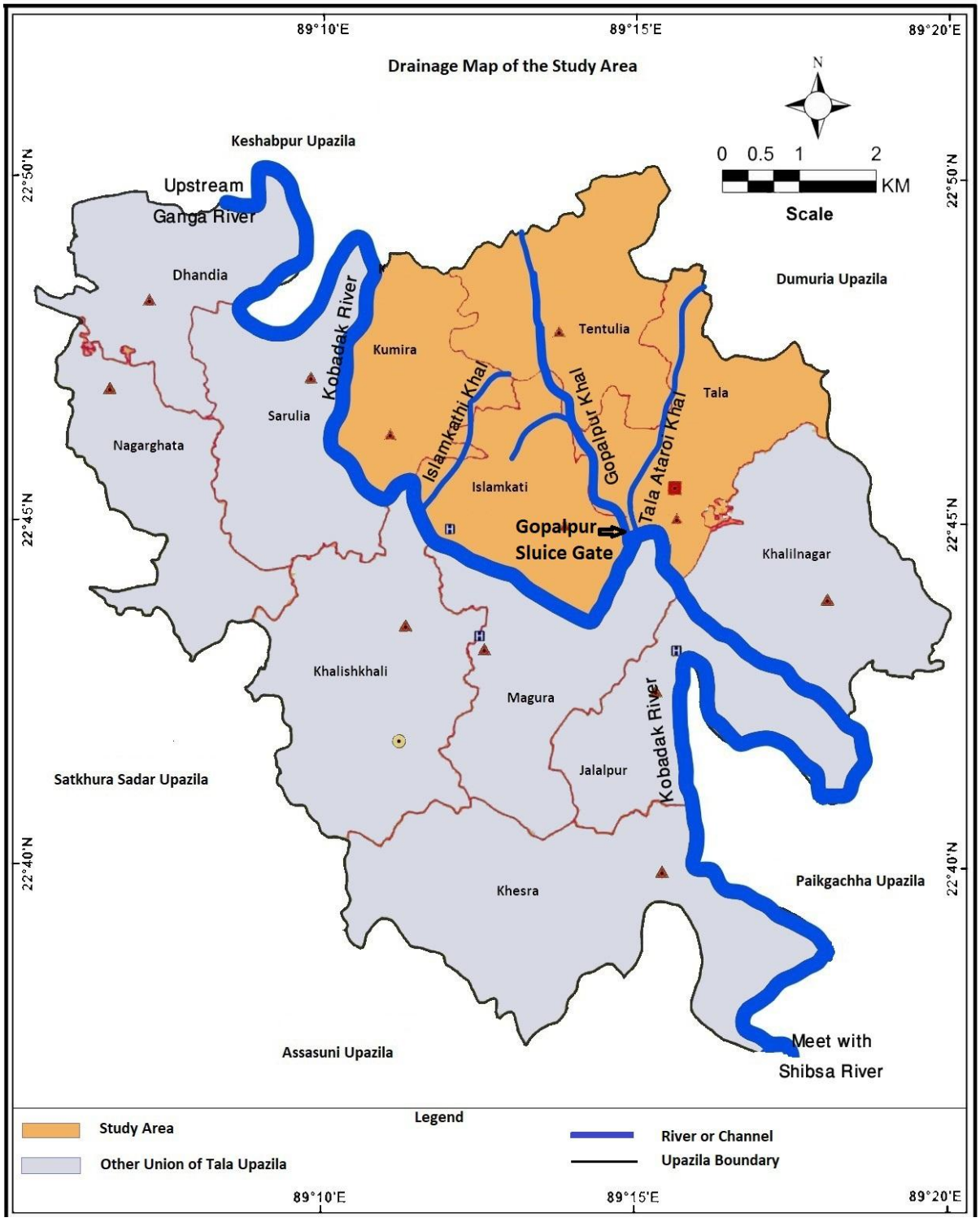


Figure 2.5: Drainage map of the study area

2.7.2 Flood Water Storage Area

The lands of the study area can be divided by three categories as shown in the Table 2.3. The storm water of the high land area comes to the medium land and then it's come to low land area.

Table 2.3 : Land types of the study area

Upazila	High land Area		Medium land Area		Low land Area (Storage Area)		Total land Area	
Tala	acre	Percentage	acre	Percentage	acre	Percentage	acre	Percentage
	2176	4%	11782	23%	37138	73%	51096	100%

Source: District statistics 2011, Satkhira district, BBS, 2011

From the Table 2.3 it is clearly understand that 73% land is belongs to low land category which is mainly used for storage of the rain water of the study area, in the monsoon the medium land 23% also filled by water and after fulfilling these two categories including the channels the water is stagnant in the surrounding high land and resulting waterlogging.

CHAPTER III

Literature Review

3.1 General

This chapter describes the relevant literature related to the subject of research. The chapter of literature review has mainly focused on causes of water logging, impact of water logging and also mitigation measure for water logging. Very few studies have been conducted on water logging and drainage system of the study area. Also no more study been conducted to find out the causes of such problem and its impacts on the human life, agriculture as well as the economy of the study area. Worldwide most of the previous study has been done for the urban areas. Some of the important previous study is described below.

3.2 Causes of Water Logging

Unplanned spatial development activities and growth of habitation due to rapid population growth are causing encroachment on retention areas and natural drainage paths with little or no care of natural drainage system. Excessive rainfall, inadequate drainage sections, conventional drainage system with low capacity and gravity, natural siltation, absence of inlets and outlets, indefinite drainage outlets, lack of proper maintenance of existing drainage system, and over and above disposal of solid waste into the drains and drainage paths are accounted for the prime causes of blockage in drainage system and water logging (Tawhid, 2004).

To find out inherent causes of water logging in Dhaka City, a field survey as a questionnaire survey, informal interviews and open discussion has been conducted with the authorities of different concerned organizations, experts and people living in different parts of Dhaka City.

The total numbers of respondent were 100 and following Table 3.1 shows the summarized opinions about the prime causes for water logging in the Dhaka city.

Table 3.1 : Prime causes for water logging in the Dhaka city.

Sl. No.	**Causes**	**Percentage**
1	Excessive rainfall	74
2	Population growth and unplanned development	95
3	Waste management system	82
4	Encroachment	76
5	Topography	46
6	Capacity and gravity of drainage system	67
7	Drainage management system	83
8	Development works during rainy season	40
9	Storage of construction materials	37
10	Lack of public awareness	60
11	Lack of regulations and its implementation	45

Source: Tawhid, 2004

The Kobadak River has been experiencing huge siltation over a long reach that reduces the drainage. It affects every sphere of life including cultivable lands, employments, culture fish production, grazing land, bio- diversity and live-stocks (Shampa et. al., 2012). Human interventions such as construction of polders, bridges and encroachment into the river for cultivation deteriorated the condition of Kobadak River. The decrease of flushing flow from upstream and substantial reduction of tidal flooding area along the river by constructing polders caused severe siltation over a long stretch of the river.

In their study they have described the Physical Method of Tidal River Management as below:

Tidal river management (TRM) involves taking full advantage of the natural tide movement in rivers. During flood tide, tide is allowed to enter into an embanked low-lying area (tidal basin) where the sediment carried in by flood tide is deposited. During ebb tide, water flows out of the tidal basin with greatly reduced sediment load and eventually erodes the downstream riverbed. The natural movement of flood and ebb tide along the tidal basin and along the downstream river maintains a proper drainage capacity in that river. Figure 3.1 shows the conceptual model of TRM. Before TRM operation the critically silted stretches of the river needs to be de-silted by capital dredging and manual excavations to increase the drainage capacity otherwise TRM will not be effective.

- Tidal prism of the river is calculated.
- Then comparison is made between the existing tidal prism and the required tidal prism to maintain the design cross-section.
- A beel with adequate volume to accommodate the tidal prism is selected.
- Design and construction of link canal.
- Finally connecting the beel to the river through the link canal.

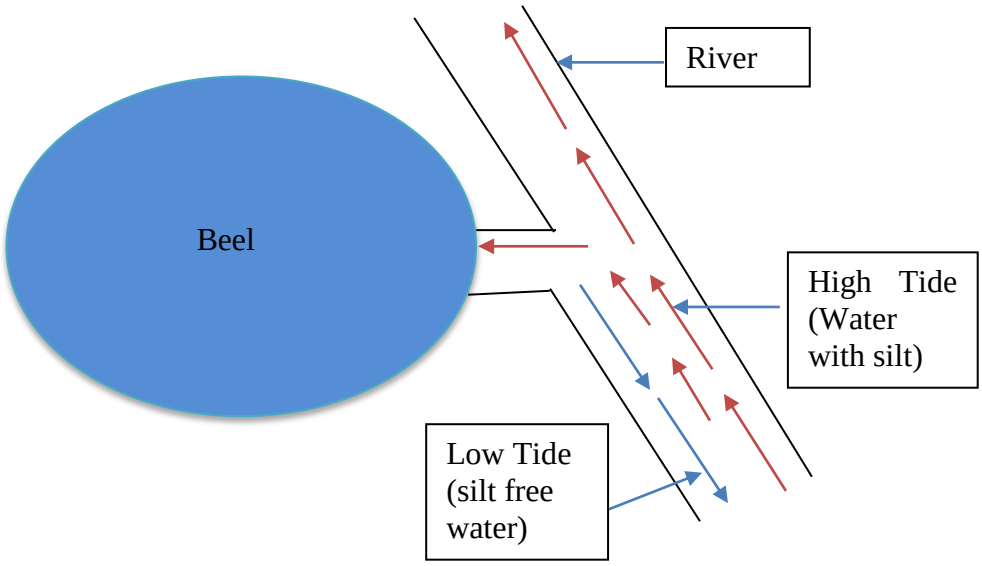


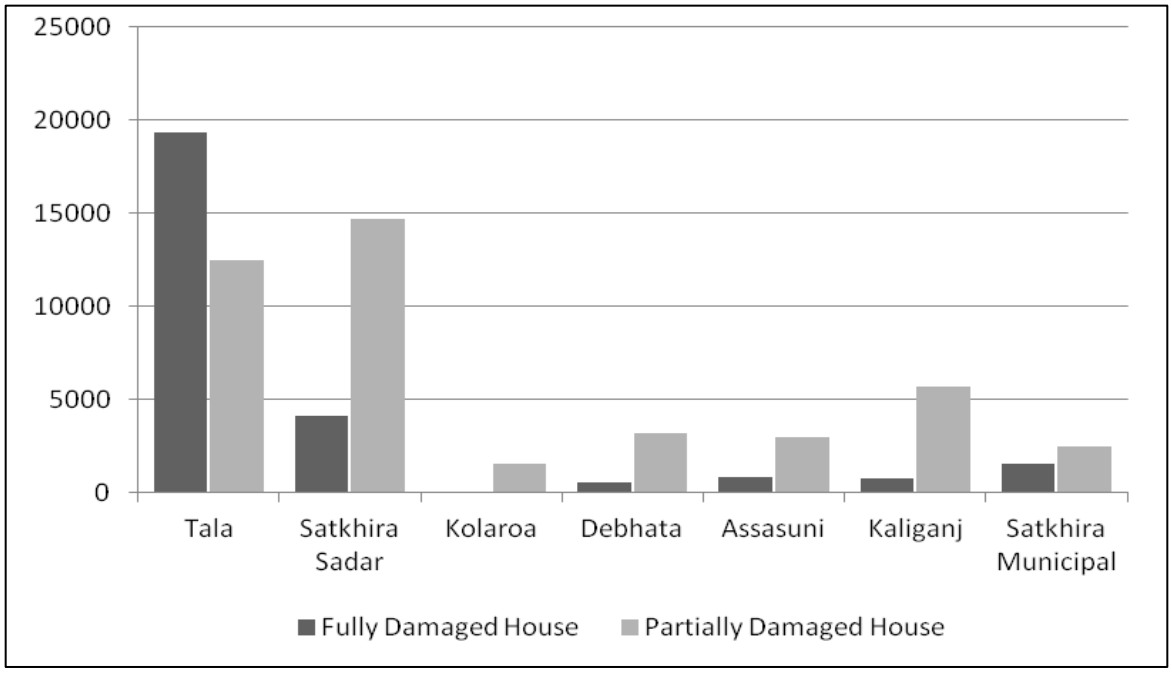
Figure 3.1: Conceptual model of TRM

Source: Shampa and Pramanik, M. I. M., 2012

3.3 Effects of Water Logging

A report was published form UNDP "Water Logging in Satkhira District an Analysis of Gaps between Needs and Response" November 2011. This report investigated cause and effect of waterlogging in southwestern district of Bangladesh. Due to perpetual siltation in the rivers and as a consequence of unplanned development interventions on the river system, long-lasting water-logging in the human settlements is taking place in Satkhira resulting in considerable loss and damage to dwelling houses, standing crops, shrimp farms, roads, educational institutions and so on in Tala, Satkhira Sadar, Kolawara, Debhata, Assasuni, Kaliganj upazilas including the Municipal areas of Satkhira district. It also find out the floods and prolonged water-logging have caused significant displacement presenting humanitarian challenges in safe water supply, sanitation, shelter and food security shown in Figure 3.2.

Figure 3.2: Impact of the water-logging on houses by Upzila of Satkhira District



Source: UNDP, 2011

Most of houses built with mud and other primary natural materials were damaged by the inundation. These houses were built on raised ground (plinth) one or two feet above the flood level. About 27,000 houses were completely destroyed with another 43,000 houses partially damaged. It is also important to note that a considerable part of household economic activities in rural Bangladesh take place in the homestead. This means such income stops once a house becomes affected by disaster.

According to the government, the number of internally displaced households now stands around 70,303. However, this refers only to people who took shelter in schools, mosques and government buildings and does not include the thousands who are taking shelter on roads and those staying with relatives or friends.

Some displaced people may not return to their homes as their houses were badly damaged. This indicates that many of the people presently displaced will remain so until flood waters recede enough for rebuilding on their homes to start and until they are able to get access to materials needed for repairs and rebuilding. People were very uncertain about how long it would be before they could return home, due to: i) the severity of damage to their houses and property and ii) the length of time it would be before they could resume livelihood activities. Women and young girls expressed security concerns to the assessment team.

Sahriar Rahman & Syed Hafizur Rahman, 2011 in their study "Indigenous Coping Capacities due to Water-logging, Drinking Water Scarcity and Sanitation at Kopotaksho Basin, Bangladesh" investigated the causes of water logging of the basin is under the peril of water-logging due to the natural and human interventions and effect of this problem the social life was hampered due to freshwater scarcity, outbreak of waterborne and sanitation problem people were defecated at open place.

Since many tubewells have been submerged by the polluted water, people had to travel longer distance to fetch fresh water for drinking, cooking and other household uses. More than 50% of the respondents in the study area need to ramble about a kilometre to fetch fresh water for drinking and other household uses. Public health situation in the study area has been deteriorating due to unhygienic condition caused by stagnant water. There had been a substantial increase in the incidence of various water borne diseases like cholera, diarrhoea, typhoid due to water-logging. About 35% of the households in the study area had reported diarrhoea problem, 30% cholera and typhoid, 20% skin diseases and 15% other diseases at the waterlogged condition shown in Figure 3.3.

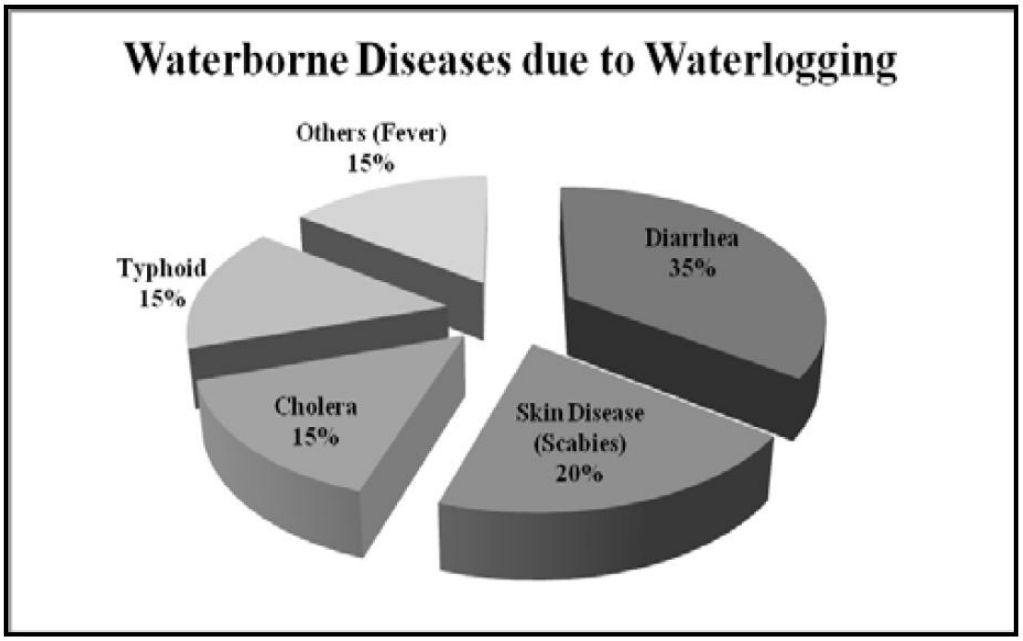


Figure 3.3: Outbreak of Water-borne diseases due to Water-logging.
Source: Sahriar et. al., 2011

According to the local people 78% latrine was inundated during water-logging, 12% partial and only 10% was unaffected at the Kopotaksho river corridor. People were defecated at open place (55% people) and use public latrines (20% people) in the waterlogged situation. Before the water-logging more than 64.17% people used their own latrine but after water-logging it was about 23.33% shown in Figure 3.4.

About 60% of the existing educational institutions were abandoned and many other social institutions (markets, offices, hospitals, mosques, temple, etc) were also damaged due to prolonged water-logging. Unemployment problem, lack of food and drinking water was found the main social problems due to water-logging.

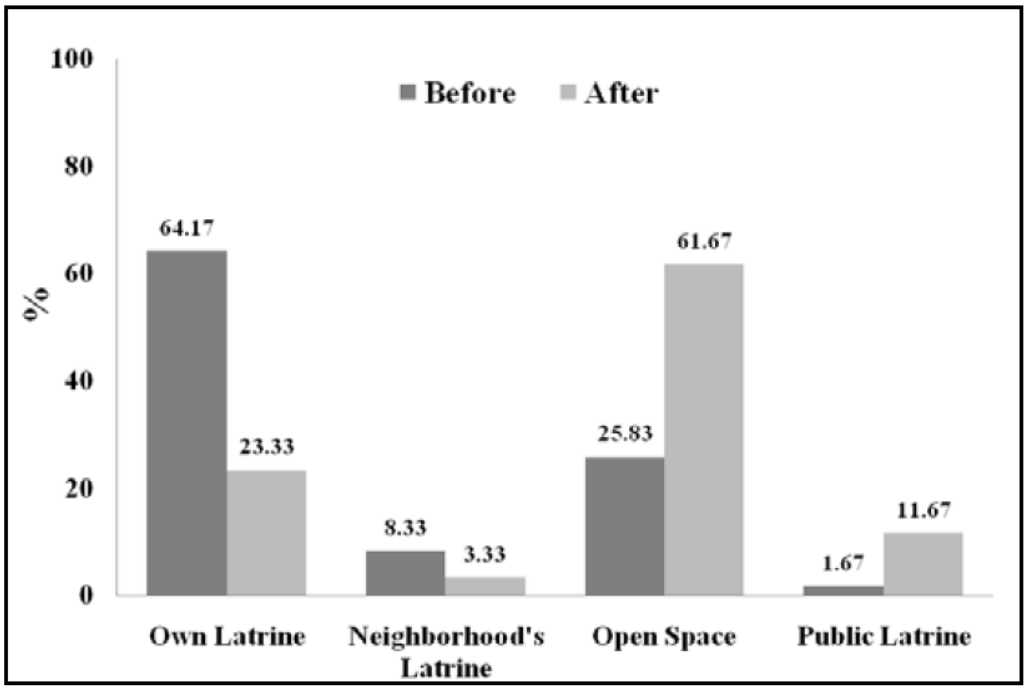
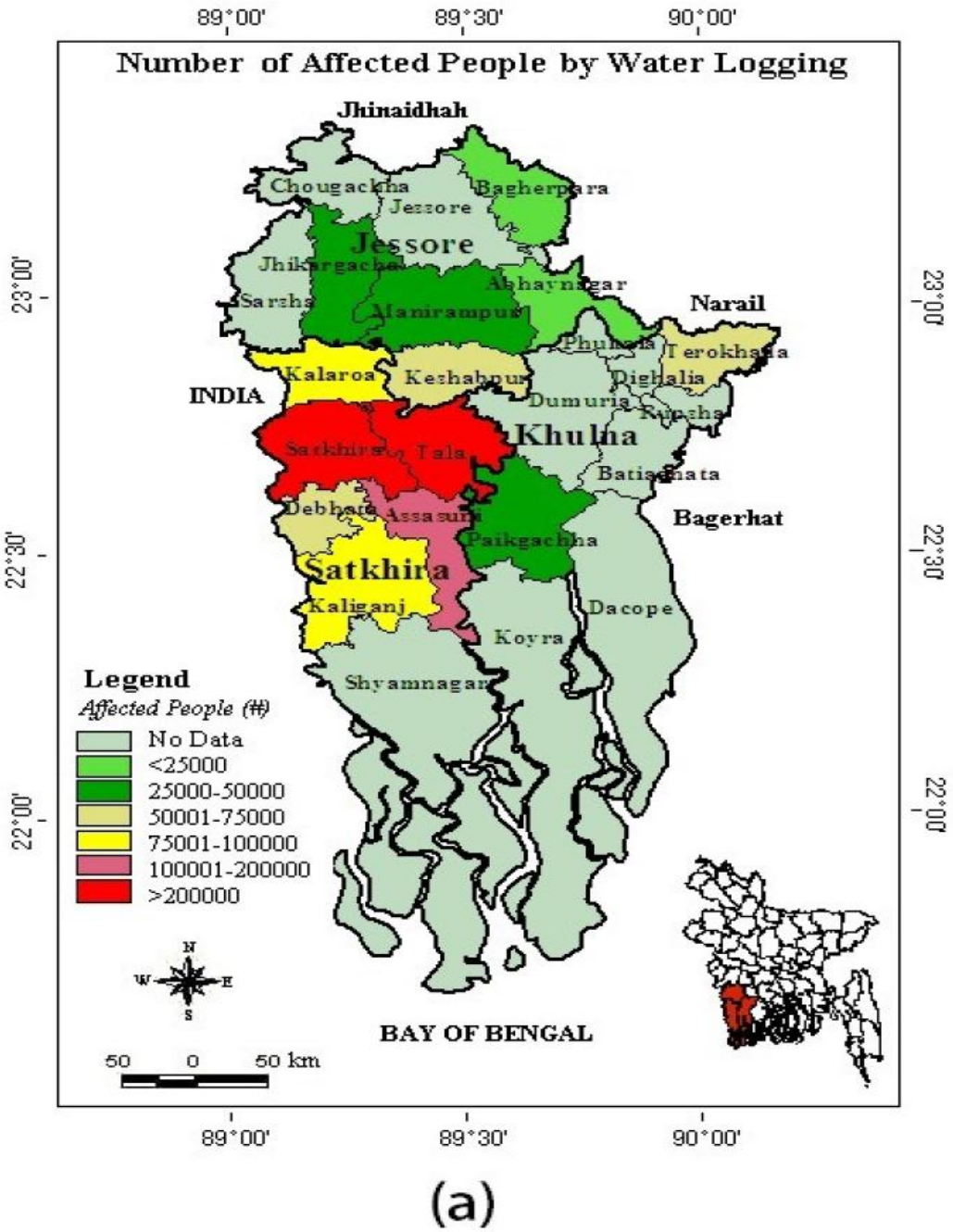


Figure 3.4: Use of different types of latrine under crisis.

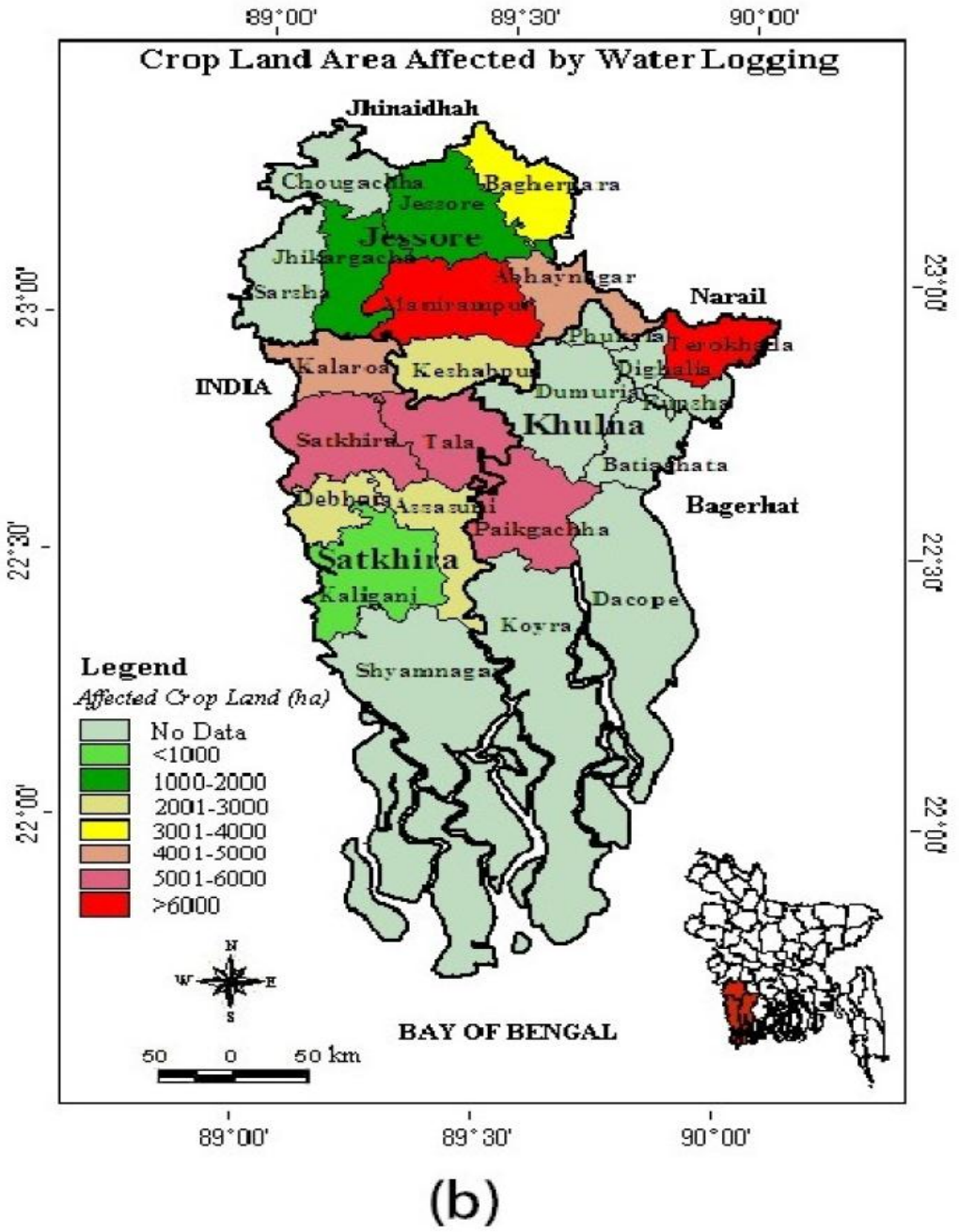
Source: Sahriar. et,al., 2011

Indigenous Coping Practices: Local people of the study area had developed their own coping mechanisms and strategies to sustain their lives and livelihoods against water-logging. Non-Government Organizations (NGOs), Community Based Organizations (CBOs) and Government Organizations (GOs) were found effective combat against water-logging. Local people (about 55%) built their own strategies to combat against water-logging and the significant portion of their coping strategy covers local strategies. Through participatory appraisal, Social supporting NGOs, Government organizations (Department of Public Health) were also found active in supporting water-logging affected people (28% of total affected people).

Md. Abdul Awal, 2014 in his study "Water logging in south-western coastal region of Bangladesh: local adaptation and policy options" describe that the effect of long term waterlogging in human livelihood. Last three decade it's also impact to our economy. In his study he has described the number of people who were affected due to monsoon flooding of 2011 and subsequent water logging in the three south-west districts of Bangladesh shown in Figure 3.5(a & b).



(a)



(b)

Figure 3.5: Maps show the number of affected people (a) and crop land (b) from different sub-district of Jashore, Satkhira and Khulna districts due to monsoon flooding and subsequent water logging in 2011

Source: Awal, M. A, 2014

From the figure 3.5 is observed that much variation was found in the number of affected people for the different sub-districts (upazilas). The higher number of people was affected in

Tala and Sadar upazilas of Satkhira District followed by Asasuni and Kalaroa of the same district. The number of affected people was found lowest in Abhaynagar and Bagherpara upazilas of Jashore District while the other reported upazilas ranked in middle. The water logging during 2011 monsoon was so intense in the recent times when about one million people were affected in the different upazilas of those three districts.

For removing water logging effect, plinth rising and elevating the local habitats and physical infrastructures can be considered as an immediate and short-term measure whereas operation of Tidal River Management (TRM) technology might be considered for long-term or permanent solution for raising the low lands or bells. The dead or silted-up rivers, canals, ponds and irrigation channels can be excavated or re-excavated by operating the major workfare social safety net programs of the government like Food-for-Work (FFW) or Cash-for-Work (CFW) and the excavated soil can be utilized for creating, maintaining or raising the rural roads, polder/embankment and related other infrastructures which are quite crucial for mitigating the flood or water logging problem in the region.

A study named "Vulnerability of Bangladesh to climate change and sea level rise through tropical cyclones and storm surges." done by Ali, 1996 described that combined effect of higher sea water levels, subsidence, siltation of estuary branches, higher riverbed levels and reduced sedimentation in flood protected areas will impede drainage and gradually increase water logging problems.

Miah, 2010 in his study "Assessing Long-term Impacts of Vulnerabilities on Crop Production Due to Climate Change in the Coastal Areas of Bangladesh" investigated the impacts of climate change in the country. Though he found that Bangladesh has made a remarkable progress in the last three decades towards achieving self-sufficiency in food grains due to substantial intensification of cropping, introduction of high yielding crop varieties and expansion of irrigated areas and increased use of chemical fertilizers. But the in the study area faces long-term impact of different climatic risks/vulnerable factors on crop production are described below in Table 3.2.

Table 3.2 Long-term impacts of different climatic risks/vulnerable factors on crop production at Satkhira district

Crop	Climatic risks/vulnerable factors	Severity of vulnerable factors (very severe, severe, moderate or low)*	Crop loss/yield reduction (%)	Remarks
T.Aman	Drought, water-logging Drought,water-logging Drought, water-logging Water-logging River erosion, salinity Drought, flood, erosion Drought	Moderate Moderate Moderate Moderate Moderate Moderate Moderate	20-40 20-40 20-40 20-40 20-40 20-40 20-40	Satkhira(S) : 4,500 ha (drought) Kalaroa : 2,500 ha (drought) Tala : 7,500 ha (erratic rainfall) Debhatta : 500 ha (waterlogging) Shyamnagar : 3,000 ha (erosion) Assasuni :8,200 ha (drought,erosion) Kaliganj : 9,500 ha (drought)
Irrigated crops HYV boro	Saline ground water Unavailability of surface water Salinity Pests and diseases	Severe Severe Moderate Moderate	20-40 ,, ,, ,,	Risk factors causing 20-40% yield reduction in the cultivation HYV boro crop.
T.Aus	Water stagnancy/floods Salinity Submergence Pests and diseases	Moderate Moderate Moderate	20-40 ,, ,,	The mentioned environmental risk factors causing 20-40% yield reduction in the cultivation of HYV T.Aus crop.
HYV T.Aman	Floods/water stagnancy Drought Changed timing of rainfall Pests and diseases	Moderate Moderate Moderate Moderate	20-40 ,, ,, ,,	The mentioned environmental risk factors causing 20-40% yield reduction in the cultivation of HYV T.Aman crop.

* Very severe= > 60% yield loss, Severe= 40-60% yield loss, Moderate=20-40% yield loss and Low=< 20% yield loss.

Source: Miah, 2010

In his study it is also identified that the trends of Crop Production (for example in Satkhira district) due to Climate Change are shown graphically below in Figure 3.6.

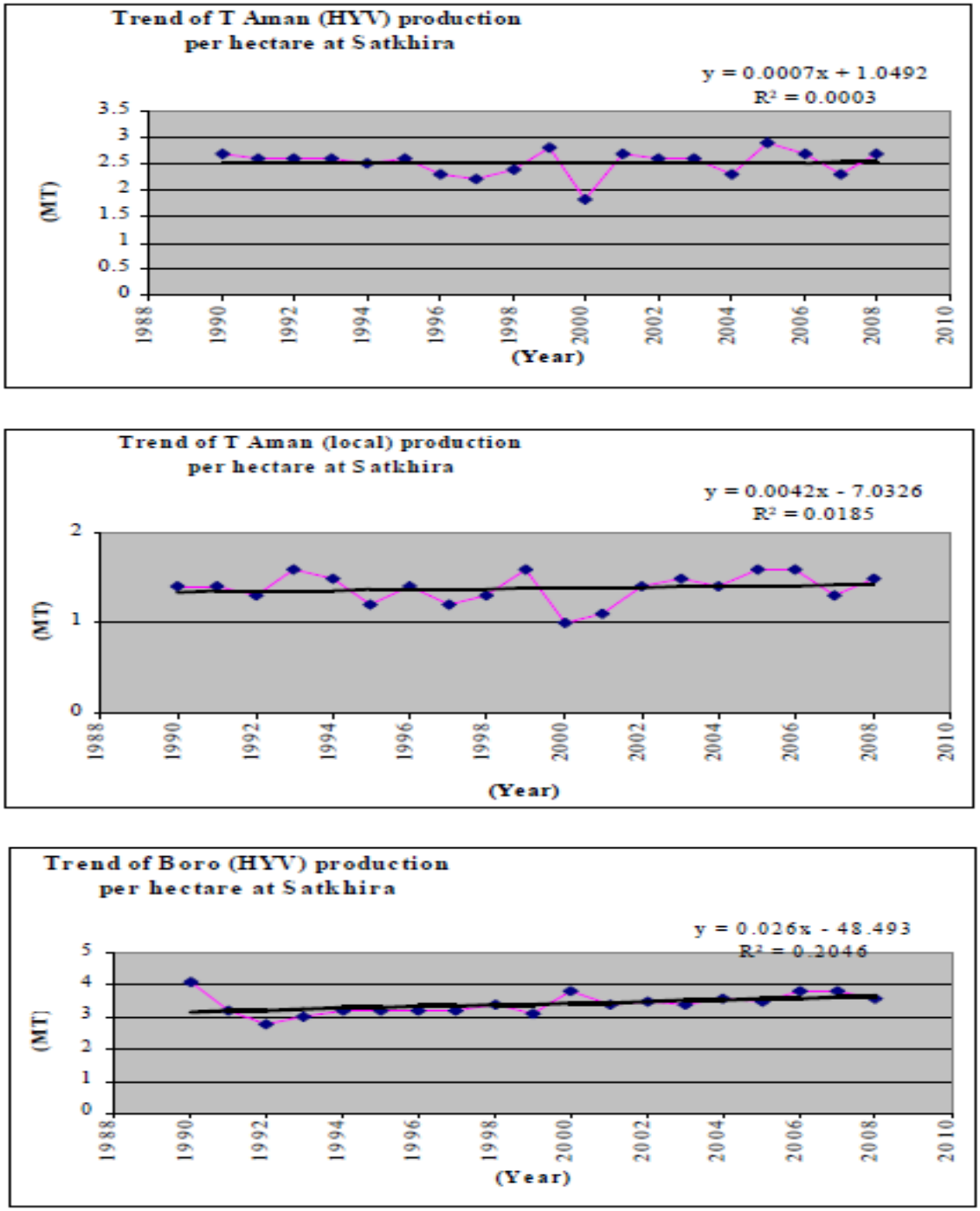


Figure 3.6: Trends of Crop Production due to Climate Change
Source: Miah, 2010

The impacts of Water logging on trees and plants has been studied by many researches most of them influences on Oxygen shortage at the root zone is the main cause for low yield or depleting. It is evident from the literature that flooding causes a marked reduction in photosynthetic capacity of a number of plants. However, plants exhibit certain adaptation under waterlogging stress to maintain photosynthetic capacity (Li et al., 2004). Moreover,

flood induced destruction of chlorophyll has been investigated widely by a number of researchers (Jackson et al., 1991; Huang et al., 1994; Ashraf et al., 2011). This decrease in chlorophyll directly or indirectly affects the photosynthetic capacity of plants under waterlogged conditions (Ashraf et al., 2011).

A project has been taken by "Bangladesh Water Development board (BWDB)" 2011 to 2015 under the MINISTRY OF WATER RESOURCES (MoWR). Name of the project is "Removal of Water Logging of Kobadak River Project (1st Phase)" (কপোতাক্ষ নদের জলাবদ্ধতা দূরীকরণ প্রকল্প (১ম পর্যায়)). Due to sediment deposition the river is turned to a drain. During rainy season when heavy rainfall starts the river can't carry out the rain water. Thus the BWDB take this project to solve this problem. The project have several work like River dredging, connection canal dredging, embankment and many other constructional work. Without any integrated drainage master plan after implementation of this project can't help to solve the water logging problems for the whole study area.

CHAPTER IV

Methodology

4.1 General

The detailed methodologies related to the research work are outlined in this chapter. This chapter is mainly separated into three sections. The first section is acquiring the necessary information's by house hold survey work, secondary data collection, soil and water sample testing, second section is data analysis and third section is given some mitigation measures for prolonged water logging. The chronological activities of the methodology of this study are delineated in Figure 4.1.

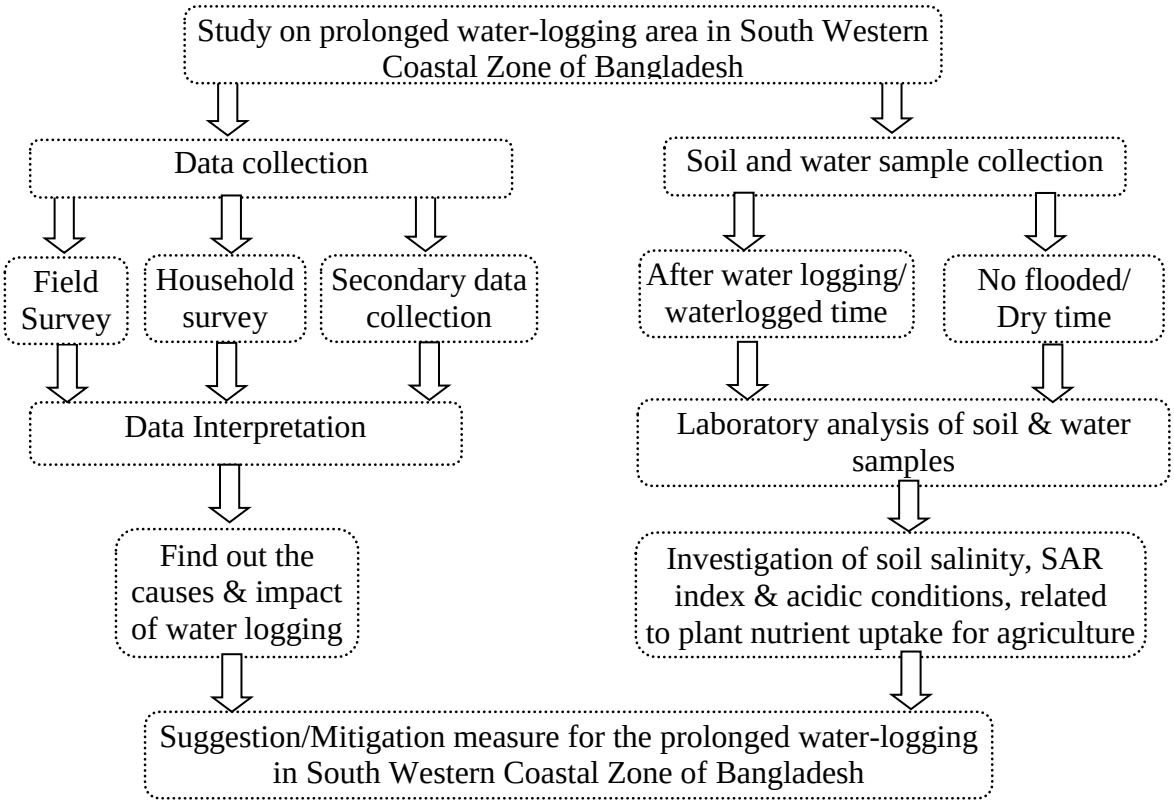


Figure 4.1: Flowchart showing the sequential steps in the research works

4.2 Data Collection

The impact of water logging is differing in urban and rural areas. The study area is situated in rural region of the country and very few study are available in the sector of water logging. The effect of water logging is controlled by different parameters. To fulfill the objective of the study both primary and secondary data has been collected and described in the following section.

4.2.1 Field Survey

Time to time field visiting is of the study area is one of the main technique of data collection process for this study. During site visit different discussion has been conducted with the local people and Key Informant Interviews regarding the causes and effect of water logging. Lots of photographs has been also taken in lieu of various arenas of water logging in the course of field survey.

4.2.2 Household Survey

The objective of the household survey (HHS) is to provide a baseline assessment to develop a better understanding of (i) the demographic and economic profile of households in the study area, education, health and sanitation in the region; (ii) how households respond to water-logging and frequent natural disasters including migration patterns; and, (iii) how household strategies could be strengthened to reduce the impact of water-logging and future environmental changes. The scope of the work included collecting information on: household characteristics, consumption, agriculture, livestock, aquaculture, forestry, nature of climate-induced cyclones, storm surges, water logging and salinity intrusion impacts on households. Total 230nos households has been selected during January, 2015 for the study. The household survey regions were selected by choosing 5% villages from each of the four prolonged water logged unions (Tala, Tentulia, Islamkati and Kumira) of the upazila. Finally minimum 5% households of the selected villages has been taken for survey.

4.2.3 Secondary Data Collection

Time series data/information on water level and sea level rise of different measuring points were collected from local offices of Bangladesh Inland Water Transport Authority (BIWTA), Bangladesh Water Development Board (BWDB) and the SAARC Metrological Research Council (SMRC). Rainfall data also collected from Bangladesh Metrological Department (BMD). Other required data has been collected from the relevant sources.

4.2.4 Soil Sampling

The south western coastal area is well-known for the agricultural product, fruits and shrimp culture. Mango fruit of this area is one of the favorable fruits for whole country even in the outside of the country. Due to prolonged water-logging most of the trees of the study area is going to dead. In this context soil sample has been collected from different water-logged area of the Tala upazila. At each location, soil samples were collected during year 2014-2015 at depths of 0cm and 30cm. The soil samples were collected adopting the PVC pipe coring technique (Towatana et al, 2001). Prior to collecting the samples, these PVC pipes (diameter 7 cm and 1.5 m long) were cut in halves along their length and fastened back together with wires. Thus, after coring, the soil samples in the pipes could be easily recovered by cutting the wires and splitting the pipes apart along the cut. About 250g of soil sample were collected from each depth interval and conserved in air dried plastic bags.

4.2.5 Water Sampling

In the recent years mostly after the flooding different types of trees and plants are going to deplete. In this context water samples were collected during year 2014-2015 from different water-logged area of the selected area. The water samples were collected with the help of water bottle of 500 ml each.

4.2.6 Laboratory Analysis

Firstly, the soil samples were air-dried and passed through a 2 mm stainless steel sieve to remove large particles. Then, the chemical characteristics has been determined after extracting the soil samples with distilled water (1/5, w/v). The different chemical parameters such as chloride (Cl^-), soluble sulfate (SO_4^{-2}), and soluble cations (Ca, Mg, Na, K) has been determined respectively by $AgNO_3$ titration, turbid metric method and atomic adsorption spectrometry method. The pH and EC also measured in the supernatant suspension with distilled water (1/5, w/v) and converted to 25°C using pH-meter and EC-meter, respectively. The plant nutrients related variables (nitrogen and phosphorus) were determined using Spectrophotometer and dry combustion procedure.

4.2.7 Soil salinity and Sodium Adsorption Ratio

Plant salt-tolerance appraisal variables ECe (EC of saturated extract) were determined using standard procedure (Nguyen et al, 2007).

$$ECe = 6.4 * EC_{(1/5)}$$

Two different criteria are currently recognized in the scientific literature as indices of salinity. These are the Sodium Adsorption Ratio (SAR) with a reported threshold of 12 (cmol $kg^{-1})^{0.5}$ and Exchangeable Sodium Percentage (ESP) with a reported threshold of 15% (Summer, 1993; Willy, 2007; Quirk, 2001). These are defined as Eq. (1) and Eq. (2):

$$SAR = \frac{[Na^+]}{\sqrt{\frac{[Ca^{2+}]+[Mg^{2+}]}{2}}} \quad \cdots\cdots\cdots\cdots\cdots\cdots (1)$$

Where, Na^+ and (Ca^{2+} + Mg^{2+}) are sodium and calcium-plus-magnesium concentrations in the soil solution in (meq/L) and SAR expressed in (meq/L) $^{1/2}$

$$ESP(\%) = \frac{Exchangeable \quad Na^+}{CEC} x100 \quad \cdots\cdots\cdots (2)$$

Where, CEC = Cation Exchange Capacity, was calculated from total exchangeable cations expressed in meq/100g soil.

The soluble salts that accumulate in soil consist principally of Na, Ca and Mg as cations, Cl and SO_4 as anions. A soil whose ECe > 4 ds–m (25°C), pH < 8.5 and ESP < 15 is categorized as saline Soil. If the EPS >15% and pH >8.5, the soil is categorized as saline-sodic soil. Crop plants differ in their tolerance to salinity shown in Table 4.1

Table 4.1 : Agronomic classification of soil Salinity based on EC

ECe (ds–m at 25°C)	**Classification**	**Plant Response**
0-2	Non-saline	Salinity effects mostly negligible
2-4	Slightly saline	Yields of very sensitive crops may be restricted
4-8	Saline	Yields of many crops restricted
8-16	Strongly saline	Only tolerant crops yield satisfactory
>16	Extremely saline	Only a few very tolerant crops yield satisfactory

4.2.8 Soil Acidity and Nutrients Uptake by Plants

Soil pH is a convenient measure of soil acidity characterized as pH < 5.5. The supply and availability of nutrient is the environmental factor that influences the plant growth. Nutrients are absorbed by roots, leaves and stems, but the major portion by roots from soil with water. The three mechanisms proposed for contact of the nutrient ions with roots are: i) diffusion, ii) mass flow, and iii) contact exchange or root interception. Soil pH is the most important factor which governs availability of nutrients in soil (shown in Figure 4.2). It can influence the activity of microbes that take part in nutrient transformation and availability. The pH range of 6.5 to 7.5 is the optimum for availability of most of the nutrient elements (Biswas Mukherjee, art: 7.2.2) shown in Figure 4.2.

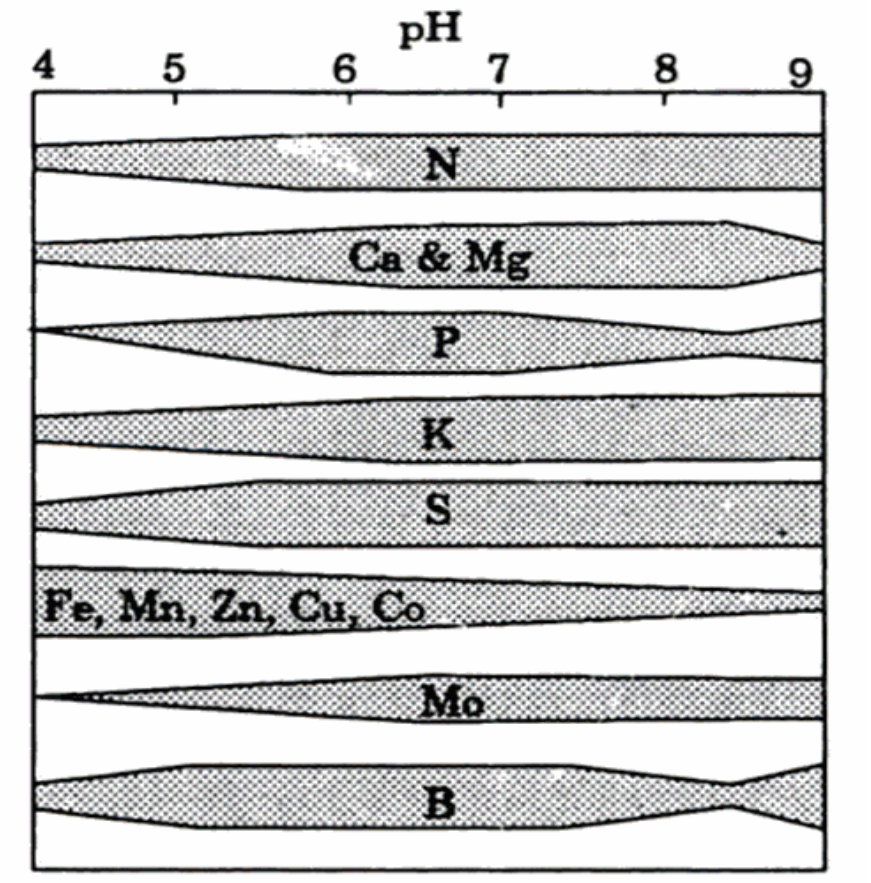


Figure 4.2: Soil pH and availability of plant nutrients
(Source: Biswas Mukherjee, art: 7.2.2)

Necessary plant nutrients like Potassium, Nitrogen, Phosphorus, Calcium and Magnesium of the soil sample has been tested from Bangladesh Soil Research Institute, Khulna. Different methods are being used for different test are describe below:

- **Nitrogen:**

  Procedure Name: Dry Combustion Procedure

  0.5g soil + 10ml Potassium dichromate + 10ml H_2SO_4 + 15ml DW + 10 ml Ortho-phosphori**c** acid + 2-3 ml Diphenylamine indicator

  ⇩

  Ammonium Ferrous Sulfate Titration

- **Phosphorus:**

2.5g soil + 50 ml Sodium bicarbonate 30 minute shaking

⇩ Filtration

5ml filtered solution + 5 ml (0.3mol) H_2SO_4 +1 ml Ammonium molybdate Ascorbic acid Solution + 30 ml DW

⇩

Spectrophotometer (Direct Reading)

- **Potassium**:

Procedure Name: Ammonium Acetate Procedure

2.5g soil + 25 ml (1molar) Ammonium Acetate solution 30 minute shaking

⇩ Filtration

Flame Photo meter (Direct Reading)

- **Calcium and Magnesium**:

2.5g soil + 25 ml (1molar) Ammonium Acetate solution 30 minute shaking

⇩ Filtration

1.0 ml filtered solution + 4.0 ml Lanthanum Chloride + 45 ml DW

⇩

Atomic absorption Spectrophotometer (Direct Reading)

4.2.9 Collection of Maps

The existing land use map and existing drainage layout map has been collected from the relevant literatures and organizations.

4.2.10 Collection of Photographs

Lot of photographs also needed to illustrate the situation of water logging, related obstacles into the smooth drainage and impact of water logging. Some of these photographs have been collected directly from field survey and some other from daily newspapers as well as from internet websites.

4.2.11 Data Analysis and Presentation

All the data both spatial and aspatial collected from different sources has been analyzed separately. The data has been analyzed using computer software. Finally the both types of analyzed data have been integrated and presented as maps, tables, and graphs and putted in the report.

4.3 Suggestion/Mitigation Measure for the Prolonged Water Logging

From the collected information and data analysis the actual impact of the water logging has been identified. Finally some effective mitigation measure or suggestions has been proposed to reduce the impact and for solving the prolonged water logging of the study area.

CHAPTER V

Results and Discussion

5.1 General

The geographic location and geomorphologic condition of Bangladesh have made the country one of the most vulnerable ones to climate change. Extreme flood frequency as well as water logging problem has increased in the recent years of the study area. The river Kobadak is the main component to drain out the rain water from the study area. Different types of technique has been adopted to fulfill the objectives of the study. Particularly the household survey, field survey, laboratory investigation of soil and water samples are being used as the primary sources to search the necessary information regarding this study are delivered below.

5.2 Causes of Water Logging

Water logging of any area can occurred in many ways. To investigate the actual causes of water logging of the study area field survey, Key Informant Interviews (KII) and house hold survey techniques have been implemented as described in the following:

5.2.1 Findings through Field Survey and Key Informant Interviews

Water logging of the study area is the combined consequences of different issues. The following section describes the causes of finding from field survey and Key Informant Interviews (KII).

5.2.1.1 Topography and Elevation of the Study Area

Topographic condition is an important factor for water logging in the study area. The north side of the study area is elevated than south side. The river Kobadak is running from north-western corner to south-eastern corner of the study area and fall down to the Shibsa river then

connected to Bay of Bengal. Following Table 5.1 shows reduced level of the study area with different coordinates systems.

Table 5.1 : Reduced level of some points of the study area.

Sl. No	UTM_ X_m	UTM_ Y_m	Latitude	Longitude	RL (mPWD)	Location
1	730707	2516902	22 44 37.47	89 14 47.68	2.87	Top of RCC Pipe NE Corner of Vill: Gopalpur, P.S: Tala, Dist: Satkhira
2	730866	2517662	22 45 2.09	89 14 53.66	4.77	Top of Wing Wall SE corner of sluice gate at Vill: Gopalpur, P.S:Tala, Dist: Satkhira
3	737264	2511249	22 41 30.504	89 18 34.32	4.19	On NE corner of Railling of culvert on Paikgacha-Tala road at Kopilmuni bazar (north end) Paikgacha, Khulna
4	736944	2512372	22 42 7.158	89 18 23.73	4.39	On NE corner of culvert Railling on Paikgacha-Tala road at Vill: Kashimnagor, U.P: Kopilmoni, P.S: Paikgacha, Khulna
5	736318	2512984	22 42 27.36	89 18 2.136	4.93	On K.M. Post showing 49 K.m. And Paikgacha 17 K.m. Tala, Satkhira
6	734935	2514384	22 43 13.554	89 17 14.454	4.38	On K.M. Post showing Khulna 47 K.m. And Paikgacha 19 K.m. at Vill: Gongarampur, Tala, Satkhira
7	733172	2515516	22 43 51.216	89 16 13.308	3.68	On SE corner on Railling of culvert on Paikgacha-Tala road .Beteen Vill: Gunail, And Horichandrakati, U.P Kali Nagar,Tala,Satkhira
8	732010	2516803	22 44 33.62	89 15 33.29	4.16	On Railing SE corner of culvert on Paikgacha-Tala road at Vill: Mubarakpur, Tala, Satkhira
9	731452	2518935	22 45 43.176	89 15 14.874	3.80	On Railing NW corner of culvert on Tala-Khulna road at Vill: Shahapur, Tala, Satkhira

Source: Bangladesh Water Development Board, Divisional Office Jashore, 2014.

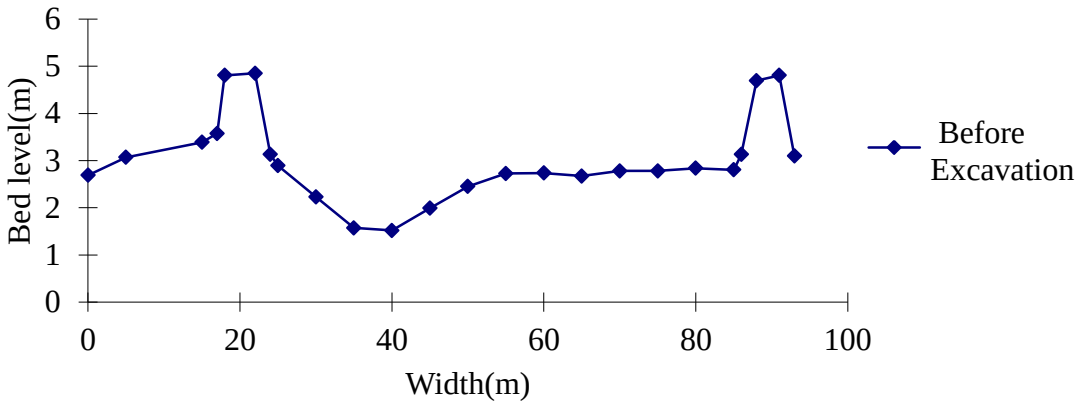


Figure 5.1: Kobadak River bed level before dredging

Source: BWDB, 2014

Table 5.1 shows that most of the TBM location on the top of culvert wing wall or road kilometer post which is elevated than the normal ground. Considering that height maximum value of RL of the TBM is 4.93 m and the minimum level is 2.87 m. On the other hand Figure 5.1 also shows that the river Kobadak has been silted.

5.2.1.2 Excessive Rainfall

As Bangladesh is a tropical country and located on the extensive floodplains of the Ganges and Brahmaputra. The Himalayas stands to the north-east of the country and the Bay of Bengal lies on the south of the country. As a result heavy downpour occurs on the country, especially in the coastal areas of our country. In recent years the study area has been exposed to water logging due to heavy rainfall and drainage congestion. In the monsoon relatively low intensity of rainfall also causes serious water logging problems and inundated for several month mainly due to the drainage congestion of the Kobadak river. The Figure 5.2 shows the monsoon rainfall of the study area within Khulna Division during 1989-2013.

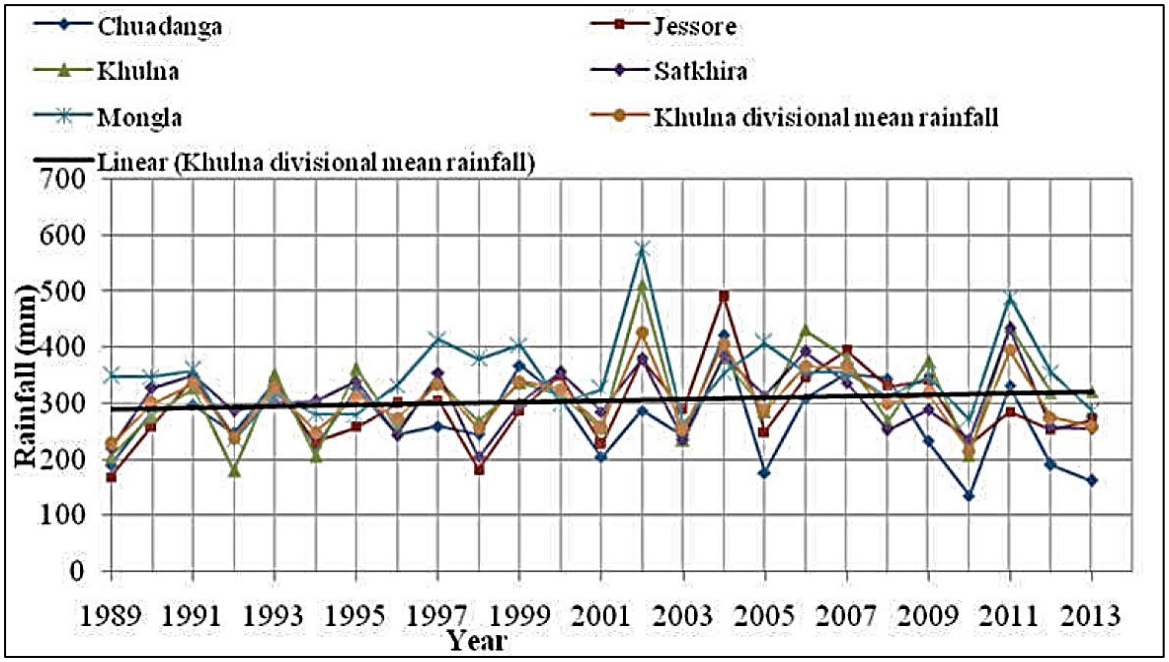


Figure 5.2: Time series of monsoon mean rainfall, during 1989 to 2013.
Source: Bangladesh Meteorological Department, 2017

The graph shown that in the year 1995, 1997, 2000, 2002, 2004, 2006, 2007 and 2011 the monsoon mean rainfall of the Satkhira district was more than the Khulna divisional mean rainfall and create water logging.

5.2.1.3 Obstacle of Natural Drainage System by Vegetation

Low land, natural canal and rivers are the components of the drainage system of the study area. Obstacle of natural drainage system by vegetation is one of main causes for water logging. However drainage system has disappearance in different way.

Rapid population growth and unplanned development, unplanned land filling to develop new residential areas, uncontrolled and haphazard disposal of solid wastes and garbage into the existing drainage system, canals and rivers with unauthorized construction are the summarized general manmade physical and social activities related to the desertion of natural drainage system. The upstream flow of the main river has been blocked due to construction of Farakkha Dam. There is no sufficient flow in the river, therefore the vegetation comes with the rain water and stay on surface. Figure 5.3 shows the vegetation of the drainage systems of the study area. These vegetation create obstacle to the flow through the drainage canals and help to water logging in the surrounding.

Figure 5.3: Vegetation of the river Kobadak

5.2.1.4 Blockage of Drainage Network for Fish Culture

Now a day's maximum wet-land in the coastal regions is engaged on shrimp cultivation. The sluicegates controller and the Gher owners allow to enter the salty water in the study area for fish cultivation. Sometimes the canal and rivers are being used for fish culture and create

drainage problem to the upstream. From the field investigation Figure 5.4 shows the drainage system blockage by fish culture.

Figure 5.4: Blockage of drainage network due to fish culture.

5.2.1.5 Reduction of Capacity and Gravity of Natural Drainage System

In the past there was a lot of natural canals, ponds, ditches in the study area. The rain water from the high land goes to the low land, ponds, ditches, canals and finally fall to the Bay of Bangal though river Kobadak. The reason of long lasting water logging situation in the study area is owing to inadequate drainage capacity. The river Kobadak is the main source of drainage system for the surrounding Kesobpur upazila under Jashore District, Tala Upazila under Satkhira District, Paikghaca upazila under Khulna district. The drainage capacity of river is reduced by many ways like reducing the width, siltation in the river bed illegal occupant, unplanned construction etc.

As per the official record of Bangladesh Water Development Board (BWDB), 2014 the actual width and position of the river Kobadak is shown in the following Table 5.2.

Table 5.2 : Width and position of Kobadak river from km 84.00 to km 154.00 km

Sl. No.	Chainage (km)	Left bank		Right bank		Width	
		Mouja name	Dag no	Mouja name	Dag no	Feet	Meter
1	84.00	Chandra	5	N/A	N/A	232.00	70.71
2	85.50	Chandra	3296	N/A	N/A	230.00	70.10
3	87.50	Barondali	43	N/A	N/A	186.00	56.69
4	88.00	Barondali	1509	N/A	N/A	237.00	72.23
5	89.00	Barondali	1105	N/A	N/A	210.00	64.00
6	90.00	Barondali	13	N/A	N/A	235.00	71.62
7	91.00	Barondali	322	N/A	N/A	245.00	74.67
8	92.00	Barondali	659	N/A	N/A	238.00	72.54
9	93.00	Barondali	1851	N/A	N/A	248.00	75.59
10	94.00	Barondali	94	N/A	N/A	255.00	77.72
11	95.50	Barondali	249	N/A	N/A	288.00	87.78
12	105.00	Sagardari	1721	N/A	N/A	237.00	72.23
13	106.00	Sagardari	1548	N/A	N/A	205.00	62.48
14	111.00	Sagardari	1358	N/A	N/A	288.00	87.78
15	112.00	Sagardari	1292	N/A	N/A	247.00	75.28
16	115.00	Dadpur	11	N/A	N/A	268.00	81.68
17	115.30	Dadpur	14	N/A	N/A	264.00	80.46
18	115.80	Dadpur	287	N/A	N/A	330.00	100.58
19	116.30	Raripara	5	N/A	N/A	231.00	70.41
20	117.30	Raripara	387	N/A	N/A	290.00	88.39
21	118.30	Kumira (s-1)	109	N/A	N/A	330.00	100.58
Sl. No.	Chainage (km)	Left bank		Right bank		Width (Feet)	Width (Meter)

		Mouja name	Dag no	Mouja name	Dag no		
22	119.30	Kumira (s-1)	901	N/A	N/A	300.00	91.44
23	120.30	Kumira (s-2)	1175	N/A	N/A	264.00	80.46
24	120.80	Kumira (s-2)	1629	N/A	N/A	330.00	100.58
25	122.00	Kumira	N/A	Varsha	525	305.00	92.96
26	122.50	Kumira	N/A	Katacanali	43	270.00	82.29
27	123.00	Kumira	N/A	Katacanali	31	320.00	97.53
28	123.50	Kumira	N/A	Katacanali	202	190.00	57.91
29	124.00	N/A	N/A	Katacanali	799	240.00	73.15
30	124.50	N/A	N/A	Katacanali	881	290.00	88.39
31	125.00	N/A	N/A	Katacanali	923	370.00	112.77
32	125.50	N/A	3098	Bolorampur	N/A	248.00	75.59
33	126.00	N/A	3210	Bolorampur	N/A	310.00	94.48
34	126.50	Baokhola	517	Bolorampur	N/A	330.00	100.58
35	127.00	Baokhola	517	Bolorampur	N/A	335.00	102.10
36	127.50	Baokhola	429	Foyla	N/A	372.00	113.38
37	128.00	Paranpur	11	Foyla	N/A	352.00	107.28
38	128.50	Paranpur	111	Magura	N/A	392.00	119.48
39	129.00	Paranpur	176	Magura	N/A	392.00	119.48
40	129.50	Chandpur	45	Magura	N/A	402.00	122.52
41	130.00	Utholi	578	Magura	N/A	330.00	100.58
42	130.50	Utholi	541	Carikhada	N/A	227.00	69.19
43	131.00	Utholi	372	Carikhada	N/A	290.00	88.39
Sl. No.	Chainage (km)	Left bank		Right bank		Width (Feet)	Width (Meter)
		Mouja name	Dag no	Mouja name	Dag no		

44	131.50	Utholi	372	Baruipara	N/A	290.00	88.39
45	132.00	Utholi	564	Baruipara	N/A	268.00	81.68
46	132.50	Gopalpur	596	Cargram	N/A	350.00	106.67
47	133.00	Gopalpur	411	Cargram	N/A	402.00	122.52
48	133.50	Majhiara	1711	Cargram	42	372.00	113.38
49	134.00	Majhiara		Cargram	6	260.00	79.24
50	134.50	Tala	113	Cargram	99	310.00	94.48
51	135.00	Tala	343	Cargram	388	350.00	106.67
52	136.00	Mobarakpur	339	Cargram	1237	474.00	144.47
53	137.00	Horishsondrokhathi	1396	Jethua	N/A	454.00	138.37
54	137.50	Horishsondrokhathi	1440	Jethua	N/A	434.00	132.28
55	138.00	Gunali	1174	Jethua	N/A	434.00	132.28
56	138.50	Nalta	4189	Jethua	N/A	412.00	125.57
57	139.00	Nalta	4138	Jethua	N/A	454.00	138.37
58	139.50	Nalta	4268	Jethua	N/A	454.00	138.37
59	141.50	Ghoshnagar	249	Jethua	N/A	N/A	150.87
60	142.00	N/A	N/A	Kanaidia	335	454.00	138.37
61	143.00	N/A	N/A	Kanaidia	2021	258.00	78.63
62	144.00	N/A	N/A	Kanaidia	1615	392.00	119.48
63	145.00	N/A	N/A	Kanaidia	2616	330.00	100.58
64	146.00	N/A	N/A	Kanaidia	981	433.00	131.97
65	147.00	N/A	N/A	Car kanaidia	195	361.00	110.03
66	148.00	N/A	N/A	Car kanaidia	202	330.00	100.58
Sl. No.	Chainage (km)	Left bank		Right bank		Width (Feet)	Width (Meter)
		Mouja name	Dag no	Mouja name	Dag no		
67	149.00	N/A	N/A	Jethua	2791	454.00	138.37

68	150.00	N/A	N/A	Jethua	2577	423.00	128.92
69	151.00	N/A	N/A	Jethua	821	495.00	150.87
70	152.00	N/A	N/A	Jethua	369	392.00	119.48
71	153.00	N/A	N/A	Jalalpur	2217	598.00	182.26
72	154.00	N/A	N/A	Jalalpur	2381	887.00	270.34

Source: Bangladesh Water Development Board, Divisional Office, Jashore, 2014.

The drainage capacity of the river has been reduced by siltation of the river. A land survey work was performed during the implementation of the Emergency Rehabilitation Works of Cyclone AILA Damages during the year 2009-2010 shows in the following Figure 5.5.

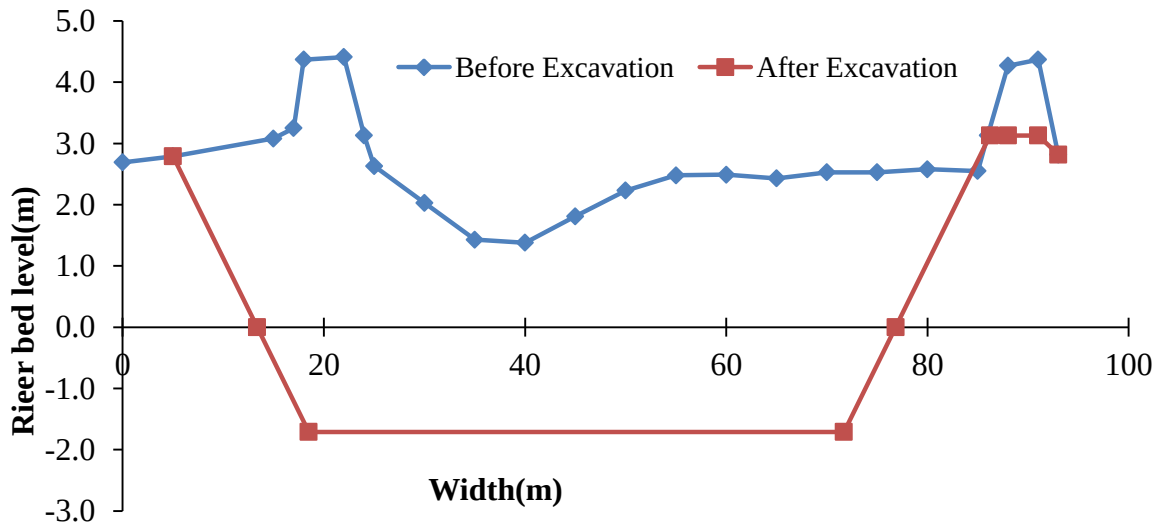


Figure 5.5: Actual and proposed section of Kobadak river for Emergency Rehabilitation works of Cyclone AILA Damages during the year 2009-2010.

Source: Bangladesh Water Development Board, Divisional Office, Jashore.

The Figure 5.5 shows that before excavation of the river almost the river bed has filled by deposition of silted material. Therefore the drainage capacity of the river has been reduced remarkably. As the study area is protected from river flooding by an encircled embankment of the river, the water level of the surrounding rivers remains higher than internal drainage level during the monsoon (May to October). Consequently, the flow velocity of drainage channels remains very slow for several days when a flood wave passes through the surrounding rivers.

5.2.1.6 Poor Operational Performance and Maintenance of Drainage Systems

To get the better service from any type of equipment or structure it is very urgent to do some maintenance work regularly. The drainage system of the study area also need as the same but the respective authority don't consider this. Poor Operational performance and maintenance of drainage system is responsible for the prolonged water logging of the study area. Many problems associated with the operation of storm water drainage systems are linked to water logging in the study. Inadequate maintenance of existing natural drains due to lack of comprehensive and planned maintenance program, equipment, adequate budget, staffing, proper monitoring program and institutional set up to effectively operate and maintain the drainage network.

5.2.1.7 Siltation

The river Kobadak is one of the tidal river of Bangladesh and it is link with the Bay-of Bengal passing through the Sundarban. When the high tide comes then much amount of silted material brings to the river deposited to the river bed, canals and low lands of the study area. Following Figure 5.6 illustrates that the main natural drainage system of the study area lost its runoff capacity and increased impervious area due to siltation.

Figure 5.6: Siltation of Kobadak river

Rain water carry out different construction materials like bricks, sands, and stones; leaves; household wastes; street sweepings etc. therefore increased impervious surface of storm water drainage and created favorable condition for water logging by reducing the runoff capacity of the drainage system. The flood control embankment and sluice gate across the rivers and canals has created siltation problem as riverbed has been raised and reduced the carrying capacity.

5.2.2 Causes of Water Logging through House Hold Survey

To investigate the actual causes of water logging of the study a house hold survey has been performed. Different people have given their opinion regarding this but all of them claimed the siltation of the river Kobadak as the main causes for the water logging. As per the house hold survey the causes of water logging in different location of the study area are described in the following Table 5.3. Among the total 230 nos. of respondent, about 78% of the respondent of the Tentulia union, 81% of the respondent of the Tala union, 75.6% of the respondent of the Islamkathi union, 73.3% of the respondent of the Kumira union of the study area has given their opinion that siltation of Kobadak river is the main cause of water logging of the selected area.

Table 5.3 : Main causes of water logging as per the respondent opinion of the study area

Sl. No.	Union Name	Causes of Water Logging (%)		
		Low land	Lack of drainage system	Siltation of Kobadak river
01	Tentulia	2.0	20.0	78.0
02	Tala	1.7	16.7	81.7
03	Islamkathi	5.6	17.8	75.6
04	Kumira	3.3	23.3	73.3

Figure 5.7 shows the average of four union's respondent's opinion regarding causes of water logging of the study area. About 77.1% of the respondent of the study area has given their opinion that the siltation of the river Kobadak, 19.4% of them thought the lack of drainage system and 3.1% of the respondent said that low land as the main cause of water logging the selected study area.

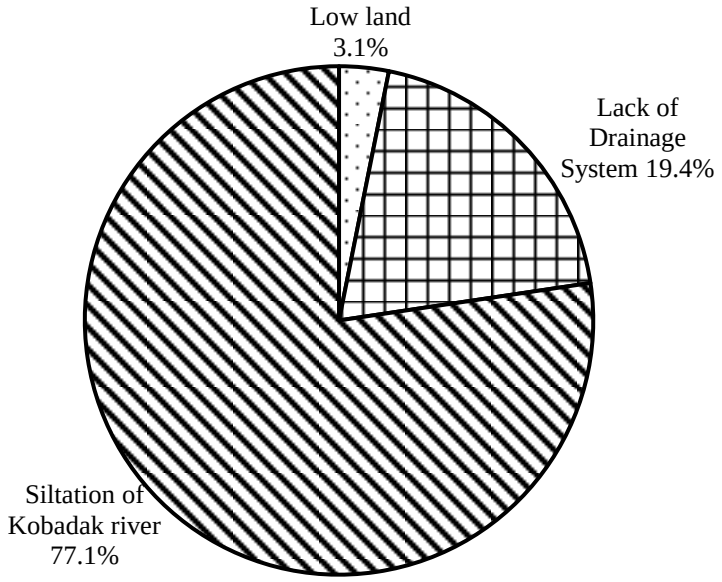


Figure 5.7: Main causes of water logging as per the respondent opinion of the study area

5.3 Impact of Water Logging

Water logging has a significant negative impact in all the sector of the society. The effects can be divided into two categories such as immediate effect and long term effect. The effect which is observed in immediate of the water logging is called immediate effect and which are detected after long lasting flooding is called long term effect. The water logging is responsible for creating problem for all sector of the human life some of them are described below. Impact was evaluated through field survey, Key Informant Interviews (KII) and house hold survey

5.3.1 Impact Evaluation through Field Survey and Key Informant Interviews (KII)

5.3.1.1 Damage of Infrastructure

Water logging of the ground contributes to subsidence, dampness and other damage of property. Water logging causes the damage to roads (both pucka and earthen) especially in the rainy season of every year. It leads to the movement problem and interrupts the journey of that area. Figure 5.8 illustrates that road in the study area severely damaged due to water logging.

Figure 5.8: Pucka road damaged due to water logging in the study area

5.3.1.2 Damage of Structures

Due to prolonged water logging in the study area the structures have been affected seriously. The substructure of the pucka houses in the low laying areas remains underwater due to water logging. The brick foundations losses its longevity by being affected with corrosive effect of salinity and damping is the after effect. These houses become badly damaged during the period of water logging. In slums and low income areas, most of the people are used to live in katcha and vulnerable houses. Water enters into houses and the floor and walls remain wetted for a long period. Sometimes they can't live in the houses and had to shift their living areas, which again creates an economic burden for the poor people. This water logging decreases

the longevity of katcha houses. Figure 5.9 shows that the wall of the building has been affected due to the water logging and the katcha houses have been destroyed.

Figure 5.9: Damages of structure for water logging in the study area

5.3.1.3 Impact on Health

Water logging has an adverse effect in health sector. As the rural area this effect is more significant than the urban areas. Sometimes, they don't have access to potable water and so had to rely on surface or shallow groundwater sources that are polluted. The rural area communication facilities, health care facilities and other necessary facilities is not sufficient and also during flooding this become more complex to the people. The community clinic play a very important role for primary treatment, pregnancy health care, and other emergency treatment of the rural areas. Figure 5.10 shows that one of the community clinic of the study area has been flooded and not possible to get any service from there.

Figure 5.10: Affected community clinic by prolonged water logging in the study area

5.3.1.4 Impact on Education

Due to prolonged water logging in the educational institution the students can't continue their education normally they involved with some bad practice that creates social problems. Following Figure 5.11 shows the situation one of primary school of the study area affected by water logging. From this picture everybody can realize that what difficulties are facing in the field of education in the selected study area.

Figure 5.11: Prolonged water logging in the primary school in the study area

5.3.1.5 Impact on Drinking Water

Due to water logging the portable water source become contaminated by the surface water. For this reasons the shortage of drinking water is the common phenomenon of the flooding area. The peoples need to collect the drinking water from market of other sources. Figure 5.12 shows the condition of the drinking water source affected by water logging.

Figure 5.12: Contamination of drinking water source for water logging.

5.3.1.6 Economic Impact

Water logging damages both of pucka and katcha roads and reduces the life time of the existing various underground utility services such as water, telephone, sewerage etc. It needs a huge cost to replace these facilities and increases the maintenance cost for the authority. Damage to substructure, brick foundations, katcha houses in slums and low-income areas due to water logging means the huge economic losses for the inhabitants. Figure 5.13 shows the condition of affected road and houses due to water logging. This figure indicates that the most of the houses and road communication facility must be reconstructed again that has the direct impact on economy.

Figure 5.13: Destruction of passage and houses due to water logging of the study area

5.3.1.7 Loss of Income Potential

During flooding water enters into houses and the floor and wall remains wetted for a long period and it damages the household goods, stored food grains etc. The effects of water logging also leads to direct financial costs, loss of income potential, as the poor people may use their home for workplace. Water logging hamper traffic movements; therefore, creates an obstacle for communication and timely supply of goods, which means the loss of time, reduced production and economic losses.

5.3.1.8 Depleting of Trees

In the earlier the study area was free from flooding and different types of trees were grown. Water logging affects the plants life and depleting many of them due to prolonged water logging of the study area. Figure 5.14 shows the injured trees in the study area due to prolonged water logging. Due to depleting of trees of the locality the economy as well as the ecosystem can be destroyed.

Figure 5.14: Depleting of plant due to water logging in the study area

5.3.1.9 Impact on Rice Production

Three different kinds of rice are cultivated in three different times in the study area round the year. They are named as Aus, Aman and Boro. The Aus rice planted in the month of March-May and harvested in the month of June-August. Aman rice planted in the month of May-August and harvested in the month of November-January. Similarly, Boro rice planted in the month of December-February and harvested in the month of April-May. The Figure 5.15 shows the cropping calendar of the study area.

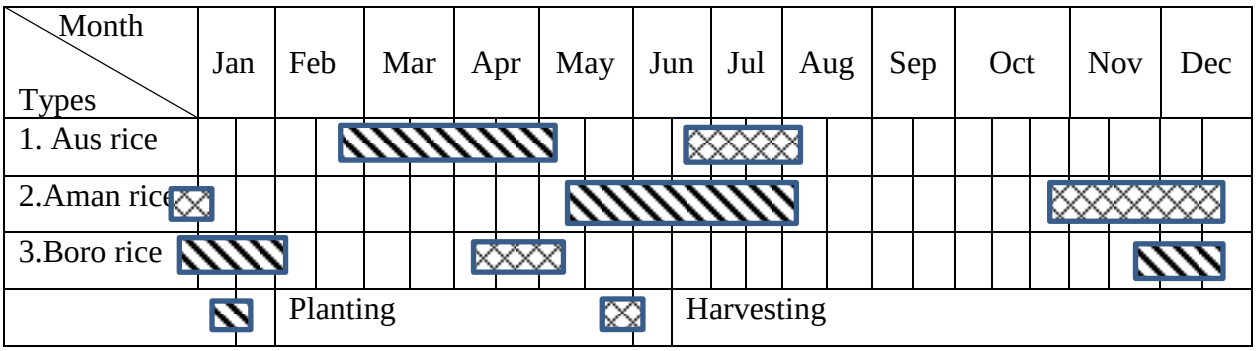


Figure 5.15: Cropping calendar of the study area

Aus and Aman rice production is mostly depend on monsoon rainwater on the other hand the Boro rice is wholly depend on irrigation in the winter season. For this reason Aus and Aman rice production is seriously fluctuating with the climatic condition. Some necessary data was collected through field survey from the upazila agricultural office of the study area as shown in Table 5.4.

Table 5.4 : Year-wise cultivation area in the study area

Sl. No.	Name of Rice	Area under Cultivation(ha)				
		Year				
		2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
1	HYV Aman	10250	15790	7092.85	14880	8700
	Local Aman	1550	300	1600	1270	700
	Total Aman	**11800**	**16090**	**8693**	**16150**	**9400**
2	HYV Aus	348	2360	1131	1795	1500
	Local Aus	2	40	5	10	10
	Total Aus	**350**	**2400**	**1136**	**1805**	**1510**
3	HYV Boro	11320	11550	1280	1295	15250
	Hybrid Boro	4300	4700	15375	15520	1250
	Total Boro	**15620**	**16250**	**16655**	**16815**	**16500**
Total Rice		**27770**	**34740**	**26484**	**34770**	**27410**

Source: Upazila Agriculture Office, Tala, 2013.

Figure 5.16 shows the condition of rice production of the study area.

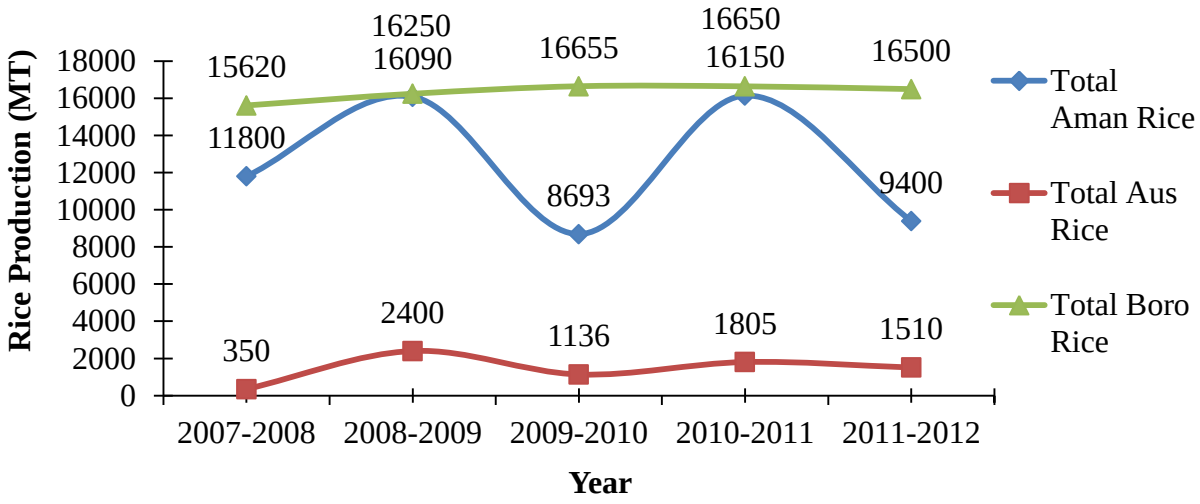


Figure 5.16: Yearly rice productions in the study area

Figure 5.16 shows that mainly the Aman rice production has been affected seriously. The study area was affected in the month of November, 2007 by SIDR, in the month of May, 2009 by AILA and in July, 2011 by water logging. Therefore the Aman rice production became half in the year of 2007, 2009 and 2011 due to prolonged water logging in the study area.

5.3.2 Impact Evaluation through House Hold Survey

A household survey was performed to find out the socio economic status of the water logging from different location and community of the study area. From the survey it is found that various types of people are living together in the study area. Those are different in occupation, religious, age, education etc. The survey questionnaire contains various important data of the study area. The respondent personal information is the first quire of this section. In this part the details information of the respondent has been collected. Every respondent personal data have been stored in this section. Among the total 230 respondent about 18% are male and 82% are female. It is also found that 18% of the household head of the family himself/herself has given the necessary information (Appendix-2). In this section the impact of water logging of the selected study area are also delivered.

5.3.2.1 Impact on Resident

Housing land is the factual requirement of mankind. From the types and quality of houses of any region one can realize the natural condition of the area. House pattern can be different due to location, climate, geographic condition, economic condition and so on. Under this section necessary information regarding house ownership, type, area, condition, living status, water logging effect etc. have been collect from the respondent. The existence of the houses can represents the impact of the water logging of the study area. The water logging has direct impact on the structures for this reasons the maximum number of house has been constructed within five years. Figure 5.17 shows how long the same houses are been used by the stockholders of the study area. It's also shows that due to water logging problem about 52 % of the house has been reconstructed within five years of the selected study area. From the house hold survey it is also found that the

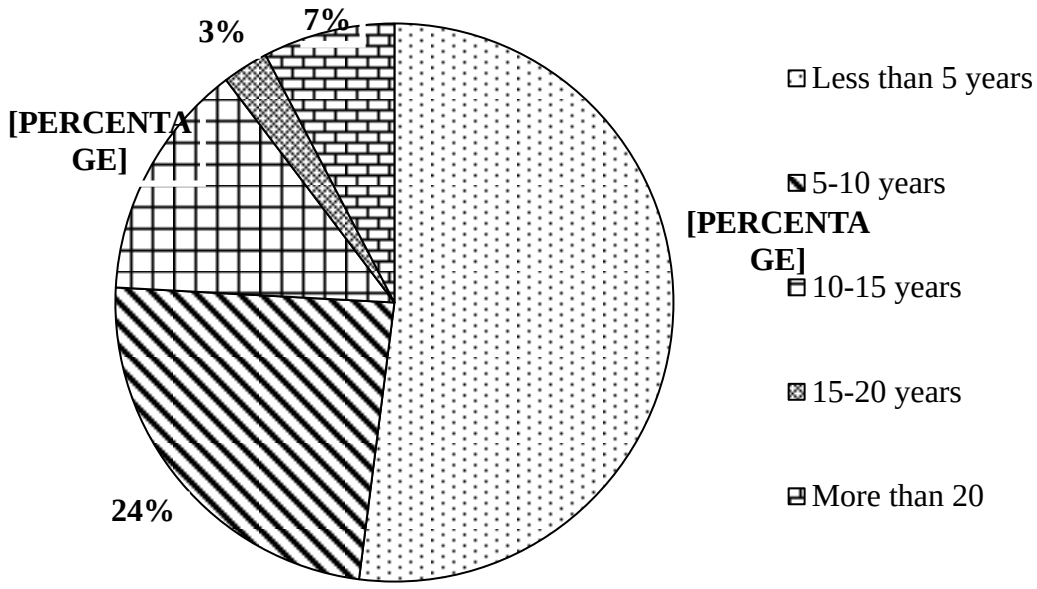


Figure 5.17: Duration of living (construction) of the existing houses in the study area.

The types of houses is also an important indicator of development of any area. Table 5.5 represents different types of houses in the study area.

Table 5.5 : Type of houses in the study area.

Sl. No	Union Name	Type of House						Avg. Area of Houses (sft)
		According to Storied		According to Construction Material				
		Single Storied	Two Storied	Pucka	Semi-Pucka	Tin Shade	Katcha	
1	Tentulia	100.00%	0.00%	8.00%	44.00%	16.00%	32.00%	323.04
2	Tala	98.33%	1.67%	8.33%	41.67%	0.00%	50.00%	355.84
3	Islamkathi	100.00%	0.00%	2.22%	27.78%	5.56%	63.61%	311.68
4	Kumira	96.67%	3.33%	13.33%	46.67%	30.00%	10.00%	281.53
5	Average	98.75%	1.25%	7.97%	40.03%	12.89%	38.90%	318.02

Table 5.5 shows that there are about 99% of houses are single storied, 1% two storied, 8% pucka, 40% semi-pucka, 13% tin shade and about 40% katcha houses in the study area.

From the survey data it is also obtained that the average area of the houses are 323 sft, 355 sft, 311 sft and 281 sft in Tentulia union, Tala union, Islamkathi union and Kumira union respectively.

5.3.2.2 Impact on Occupation

The study area is located in the rural area of the coastal region of the country. Most of the land is very fertile and suitable for various types of crop cultivation. For this reasons the main occupation of the people of the study area is farming. But due to the recent water logging problem crop production as well as the income has been seriously hampered. The land can't cultivate due to prolonged water logging. Most of the crops have been damaged repeatedly during monsoon of the recent years. For this reasons most of the farmer have been bound to change their main occupation. As per the field survey the following characteristics are found and shown in the Table 5.6. From the study it has found that presently only 16% of people are taking farmer as the main occupation and about 60% of people living with day laboring occupation. But as per BBS, 2011 survey it was 70.34% and 2.67% respectively.

Table 5.6 : Main source of income in the study area

Sl. No.	Main Income Source	Union Name				Average (January,2015)	As per BBS (2011)
		Tentulia	Tala	Islamkathi	Kumira		
1	Service	14%	7%	6%	3%	7%	4.21%
2	Business	10%	12%	3%	33%	15%	13.1%
3	Farming	10%	8%	12%	33%	16%	70.34%
4	Day Laboring	64%	72%	78%	27%	60%	2.67%
5	Poultry Farming	0%	0%	0%	3%	1%	
6	Shrimp/Fish Farming	2%	0%	0%	0%	1%	
7	Foreign Remittance	0%	2%	1%	0%	1%	.15%

5.3.2.3 Impact on Savings

Monthly income and expenditure is very complex and secreted things for any people. The respondent people were not interested to give the actual figure of expenditure. As per their given information about 77% people have no savings, 23% have small savings in the recent years for water logging problem as shown in the Table 5.7.

Table 5.7 : Monthly expenditure of household in the study area.

Sl. No.	Union Name	Expenditure per month		Household can't save money
		Min(BDT)	Max(BDT)	
1	Tentulia	3000	25000	76%
2	Tala	2530	23050	83%
3	Islamkathi	2000	11700	94%
4	Kumira	6000	23000	53%
5	Average	3382.5	20687.5	77%

5.3.2.4 Impact on Land-use Pattern

According to respondents opinion the land use pattern has been identified as shown in Figure 5.18. From the figure it is found that recently the land of the study is used 13% for residential, 36% for high agricultural land, 40% for low land and 11% for the other like river, canal, pond, lake etc. on an average

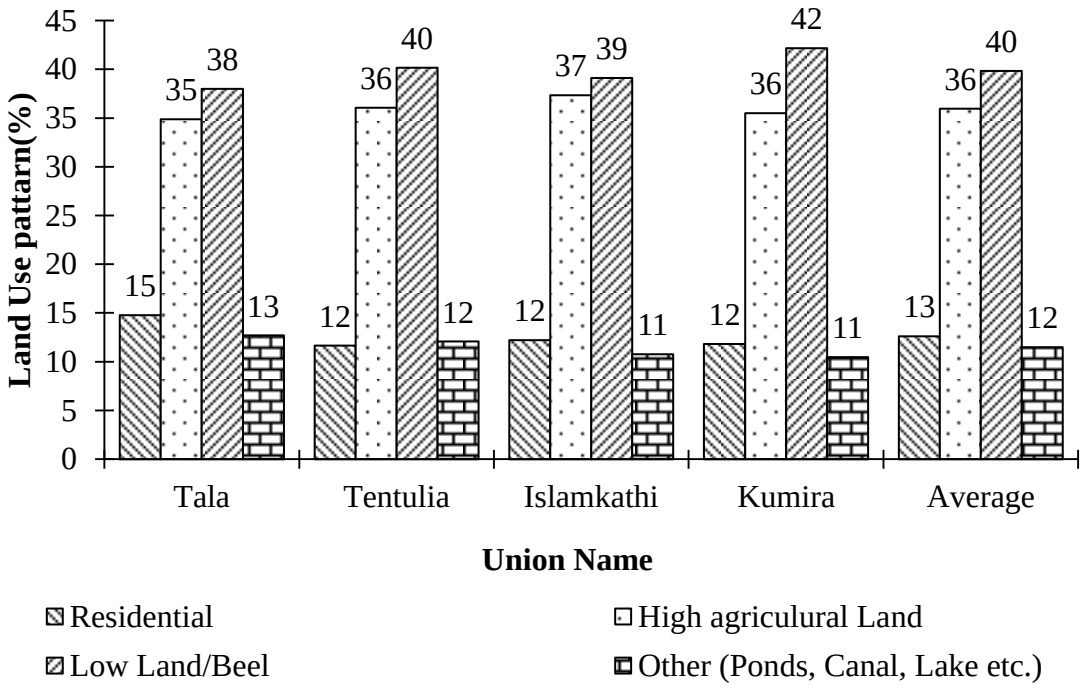


Figure 5.18: Land-use pattern of the study area

Due to water logging problem at present some of land is using as purpose of fish culture as low land but in the past time it was used as high agricultural land.

5.3.2.5 Impact on Land Value

Different category of land has different value. The value of land is mainly depending on type of land, location, the occupation of the people of the area, climate condition, communication facility etc. The most valuable land of the study area is commercial land. From the household survey following features have been found and shown in Table 5.8.

Table 5.8 : Land value of the study area.

Sl. No.	Union Name	Land Type	Minimum				Maximum				Average			
			Price of Land /Decimal				Price of Land /Decimal				Price of Land /Decimal			
			1990	2000	2010	Present (2015)	1990	2000	2010	Present (2015)	1990	2000	2010	Present (2015)
1	Tentulia	Residential Land	8500	9500	12000	15000	12000	14000	18000	40000	10360	12258	15240	25460
2		Agricultural High Land	1500	2100	4000	6000	4000	6000	9000	12000	3090	3992	6366	8592
3		Agricultural Low Land	1000	2000	2500	3000	2000	4000	6000	8000	1244	2728	3634	4854
4		Commercial Land	8000	13000	15000	25000	15000	30000	40000	65000	12170	16866	20590	38220
5	Tala	Residential Land	5000	7000	10000	16000	12500	15000	25000	45000	10350	12364	15967	26167
6		Agricultural High Land	1600	2000	4500	6500	5000	7000	10000	15000	3168	4157	6672	9113
7		Agricultural Low Land	1100	2000	2700	3700	2500	4000	6500	9000	1340	2705	3657	5128
8		Commercial Land	8500	13500	15500	28000	20000	25000	32000	60000	12583	17253	21117	38683
9	Islamkathi	Residential land	7500	9000	11500	15000	12000	14000	18000	40000	10317	12281	15278	24256
10		Agricultural High Land	1500	2100	4000	6000	4000	6000	9000	12000	3117	4051	6366	8637
11		Agricultural Low Land	900	1500	2000	3700	2000	4000	6000	8000	1267	2710	3646	4988
12		Commercial Land	8000	13000	15000	25000	15000	25000	32000	50000	12128	17025	20800	36850
13	Kumira	Residential Land	8500	10500	13000	16000	13000	15000	25000	42000	10450	12383	15917	25033
14		Agricultural High Land	2000	2800	4500	7000	4500	6000	9500	11500	3150	4073	6463	8627
15		Agricultural Low Land	1000	2000	2500	3000	2000	4500	5000	7500	1257	2713	3597	4830
16		Commercial Land	9000	13500	16000	24500	16000	23000	30000	60000	12350	17159	21017	37133

As per the survey data the minimum land value was found for the agricultural low land and the maximum land price was found for commercial land. The following Figure 5.19 shows the changes of land value with time during 1990-2014 of the study area.

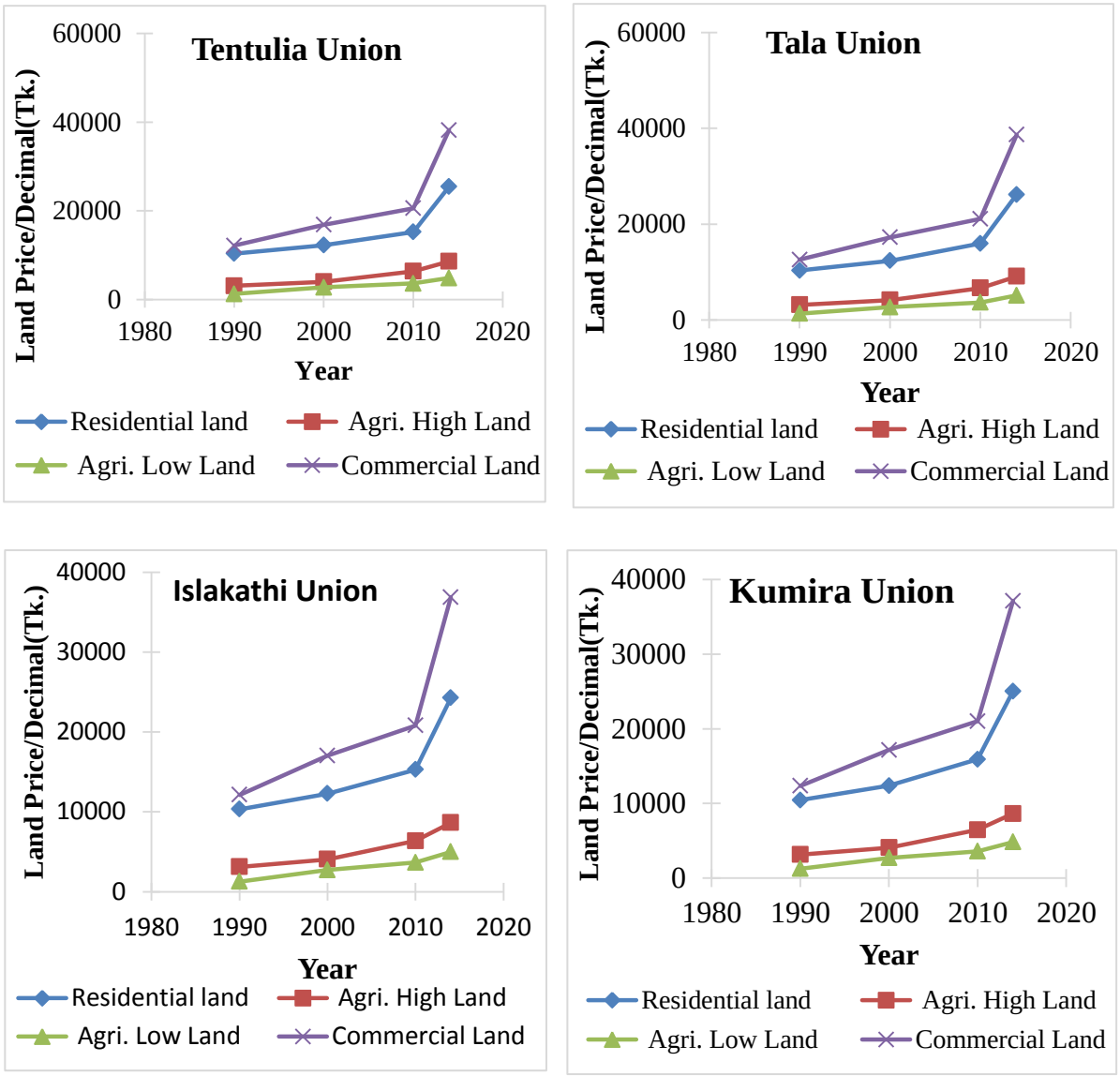


Figure 5.19: Land value of the study area

Due to water logging of the study area the rate of increment of agricultural land value is less than of residential or commercial land price. The Figure 5.19 stipulate that after the prolonged water logging of the study area the agricultural land price are not increased as the residential or commercial land price. Because both types of agricultural land can't use for cultivation.

5.3.2.6 Impact on Land Demand

Land is used for many ways so it is vary demandable property of the society. The study area is situated in rural region and most of the people are farmer for this reason most of the land of this area is used for agricultural purpose. There are some places for commercial use, some for residential use, some for agricultural use and some for other uses. From the survey it is found that about 83.7% respondent give the answer for residential land as the most demandable land of the study area shows in the following Table 5.9. Because they think shelter/homestead is the most important constituent than other requirements for their life.

Table 5.9 : Land demand of the study area

Sl. No.	Union Name	Maximum Demand of Land		
		Residential	Agriculture	Commercial
1	Tentulia	90%	2%	8%
2	Tala	94.8%	3.2%	2%
3	Islamkathi	93.3%	2.2%	4.4%
5	Kumira	56.7%	10.0%	33.3%
6	Average	83.70%	4.35%	11.93%

5.3.2.7 Impact on Essential Services

Essential services are the term which is mostly required for any locality for their normal life. For this survey work we consider the drinking water, fuel, light and sanitation as the essential services. Following Table 5.10 shows actual condition of the essential services of the study area. From the survey data analysis it has found that on an average 31% of the houses drink water from their own tube well on the other hand about 69% of the family drink water from the community tube well.

Table 5.10 : Essential services of the study area

Union Name	Drinking Water Source		Water Quality	Source of Fuel		Source of Light	
	Own Tube well	Community Tube well	Drinkable	LPG	Fire Wood	Electricity	Kerosene
Tentulia	12%	88%	100%	0%	100%	86%	14%
Tala	20%	80%	100%	2%	98%	88%	12%
Islamkathi	22%	78%	100%	0%	100%	42%	58%
Kumira	70%	30%	100%	0%	100%	60%	40%
Average	31%	69%	100%	0%	100%	69%	31%

Total 100% of respondents replayed that the drinking water quality is drinkable. About 100% of the family used fire wood as for cooking food (except Tala union 2% LPG). On the other hand about 69% of family get their light form electricity and 31% family used kerosene for lighting purpose in the study area.

5.3.2.8 Impact on Health and Healthcare

Health is wealth, if the people suffered by diseases then the development will be affected. Healthcare service is one of the essential demands for curing the diseases of any society. Healthcare facility is dominating by climate, seasons, development and other related elements of the society. By this survey data analysis it is found that within last one year about 51% family member affected by fever/cold/cough, 21% of them affected by diarrhea/ dysentery, 4% rheumatic/ asthma, 10% female disease, 11% skin disease, 2% diabetes and 2% heart disease. Table 5.11 shows the health and healthcare facility of the study area.

Table 5.11 : Health and healthcare facility of the study area

Sl. No.	Union Name	Disease Name						
		Fever/Cold /Cough	Diarrhea/ Dysentery	Rheumatic/ Asthma	Female disease	Skin Disease	Diabetes	Heart disease
1	Tentulia	30%	32%	2%	18%	14%	4%	0%
2	Tala	33%	30%	2%	12%	20%	2%	2%
3	Islamkathi	68%	19%	1%	6%	3%	0%	3%
4	Kumira	73%	3%	10%	3%	7%	0%	3%
5	Average	51%	21%	4%	10%	11%	2%	2%

Figure 5.20 shows the percentage where the people usually go for treatment. As per the respondent opinion of the study area about 18% of the people get treatment from government hospital, 12% of them get treatment from private clinic and about 67% of the people get treatment from the rural doctor.

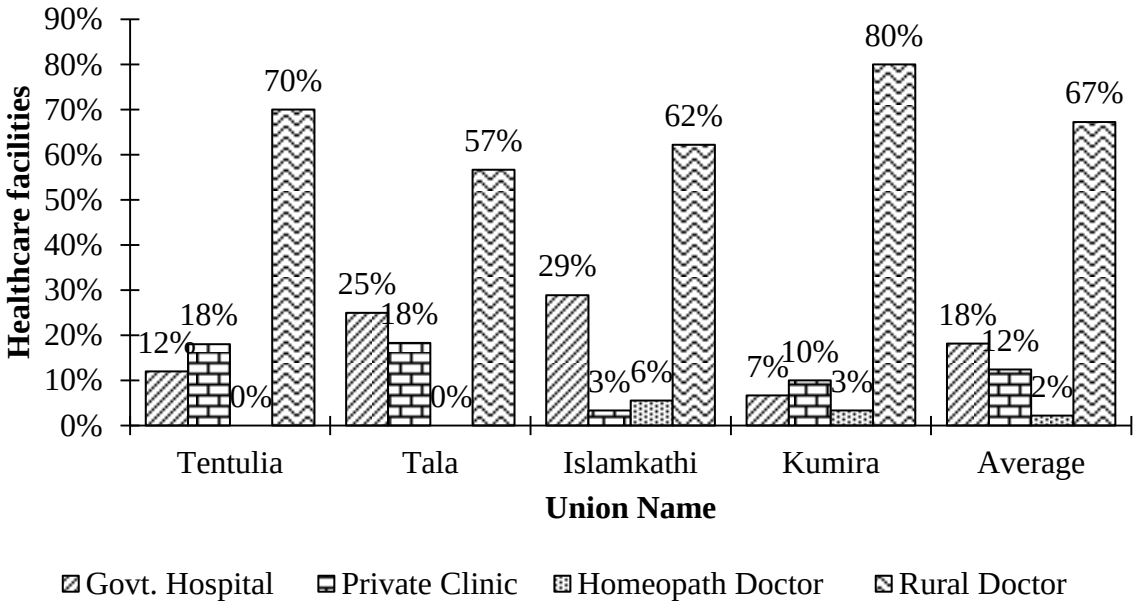


Figure 5.20: Type of healthcare facilities people usually chosen for treatment

5.3.2.9 Impact on Education

Education is very essential requirement for modern life. No nation can develop without education. For this reasons some information has been collected from the respondent about the education. It is very important to know whether all the family members can able to get education. The following Figure 5.21 shows the real picture of the study area education status.

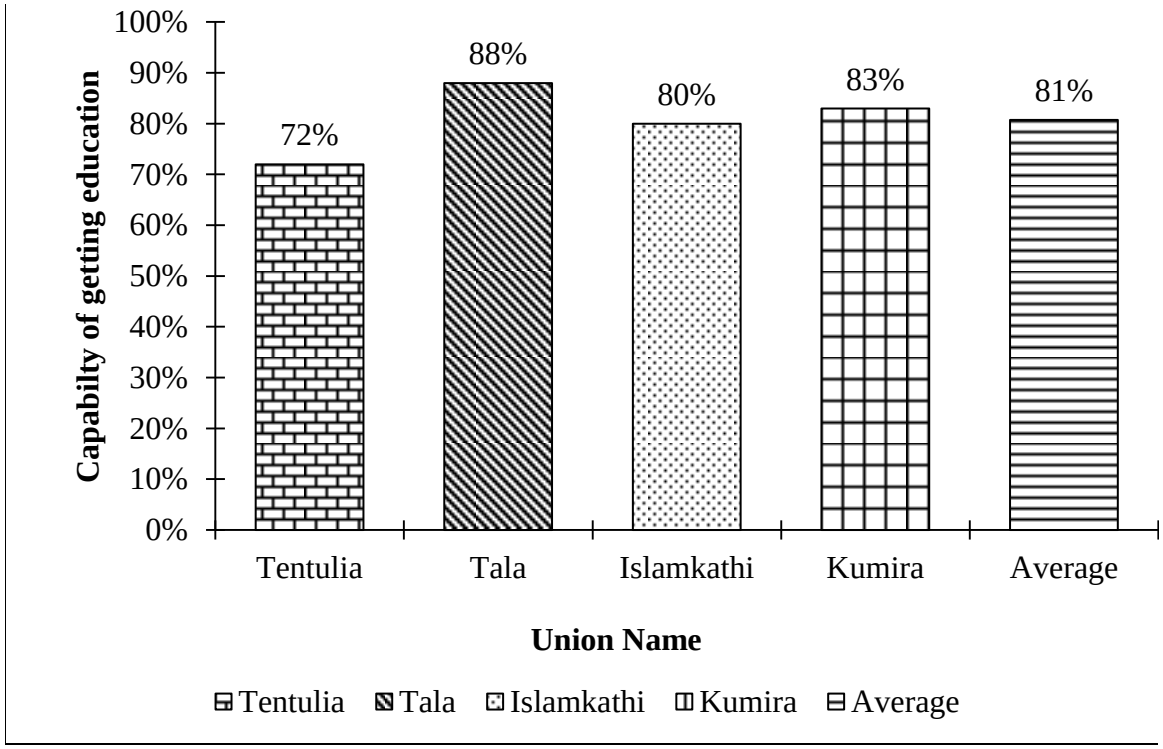


Figure 5.21: Family members can go to educational institution of the study area

From the survey it has found that about 81% family members go for education. Rest of the 19% household members cannot go for education. About 52% of the respondent give the answer that insolvency due to water logging is the main causes for not going to school.

5.3.3 Investigation of Salinity Related Variables and Acidic Condition of Plant Nutrients

As a part of rural region the economy of the study area depends on agriculture. Soil and water are the main elements of the ecosystem. Different types of parameters has been tested to find out the effect of water logging of the study area. Subsequently the test results of soil and water samples are described below.

5.3.3.1 Chloride (Cl^-)

Chloride concentration is one of the important component for both of soil and water for ecosystem. Although chloride is essential to plants in very low amounts, it can cause toxicity to sensitive crops at high concentrations. By investigation of the soil samples it has found that the maximum chloride concentration was 0.08g/kg, 0.315g/kg, 0.356g/kg and 0.490g/kg of Tentulia union, Tala union, Islamkathi union and Kumira respectively. The Figure 5.22 and Table 5.12 shows the chloride concentration of the soil samples at different time of the study area. From the figure it is shown that the chloride concentration become higher in the month of May and November for the Islamkathi and Kumira union because this area is closed to the river Kobadak.

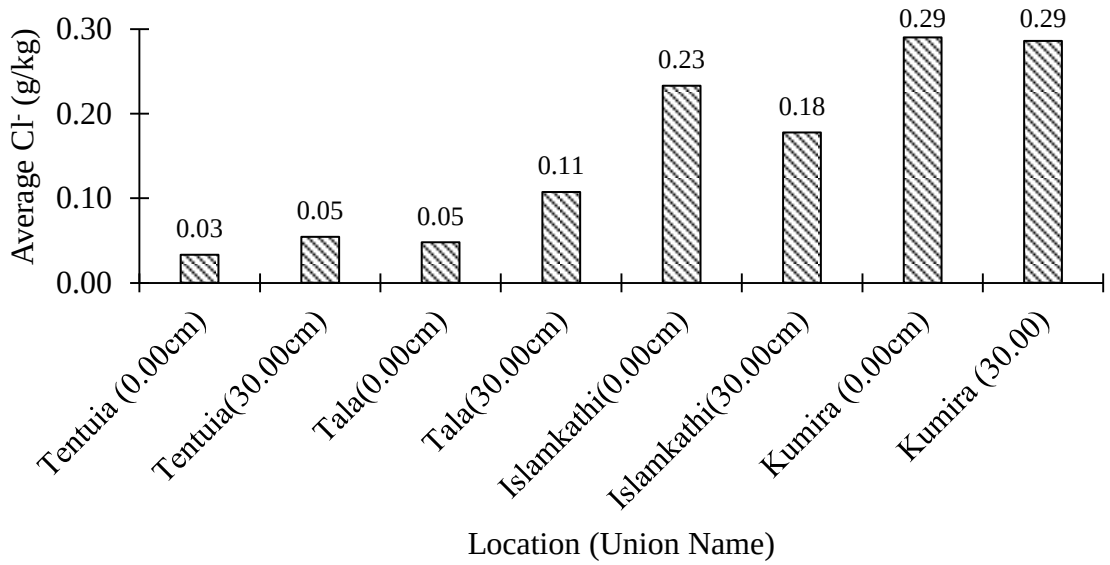


Figure 5.22: Chloride concentrations of soil sample at different location of the study area

Table 5.12 : Chloride ion concentration of the soil sample in the study area

Sl. No	Location (Union Name)	Depth (cm)	Testing Date/Value(g/kg)							Standard Value of Cl^- for plant
			16.09.14	20.10.14	21.11.14	20.01.15	20.03.15	28.05.15	20.07.15	
1	Noapara Primary School (Tentuia)	0	0.055	0.015	0.002	0.040	0.050	0.040	0.030	1g/kg
2		30	0.045	0.107	0.002	0.080	0.063	0.049	0.035	
3	Gopalpur (Tala)	0	0.045	0.025	0.027	0.070	0.065	0.082	0.020	
4		30	0.045	0.075	0.042	0.110	0.150	0.315	0.015	
5	Islamkathi Bazar (Islamkathi)	0	0.081	0.025	0.288	0.270	0.350	0.356	0.260	
6		30	0.090	0.040	0.260	0.120	0.190	0.325	0.220	
7	Kumira Bazar (Kumira)	0	-	0.020	0.262	0.340	0.420	0.490	0.210	
8		30	-	0.085	0.170	0.310	0.380	0.550	0.220	

Generally irrigation water is classified with chloride concentration for below 70mg/L generally safe for all plants, 70-140mg/L sensitive plants show injury, 141-350mg/L moderately tolerant plants show injury and above 350mg/L can cause severe problems. Table 5.13 and Figure 5.23 shows the chloride concentrations of the water samples of the study area at different time.

Table 5.13 : Chloride concentration of the surface water sample in the study area

Sl. No	Location (Union Name)	Source	Testing Date/Value(mg/L)							Standard Value of Cl^-
			16.09.14	20.10.14	21.11.14	20.01.15	20.03.15	28.05.15	20.07.15	
1	Noapara Primary School (Tentuia)	School Play ground	-	-	45.0	70	85	80	22.5	Below 70mg/L safe for all plants, 70-140mg/L sensitive plants show injury, 141-350mg/L moderately tolerant plants show injury and above 350mg/L can cause severe problems
2	Gopalpur (Tala)	River	30.0	180	20.0	160	290	260	25.0	
3	Gopalpur (Tala)	Ambagan	-	-	12.5	50	-	-	12.5	
4	Islamkathi Bazar (Islamkathi)	River	32.5	80	20.0	40	375	340	12.5	
5	Kumira Bazar (Kumira)	River	-	30	22.0	30	360	180	10.0	

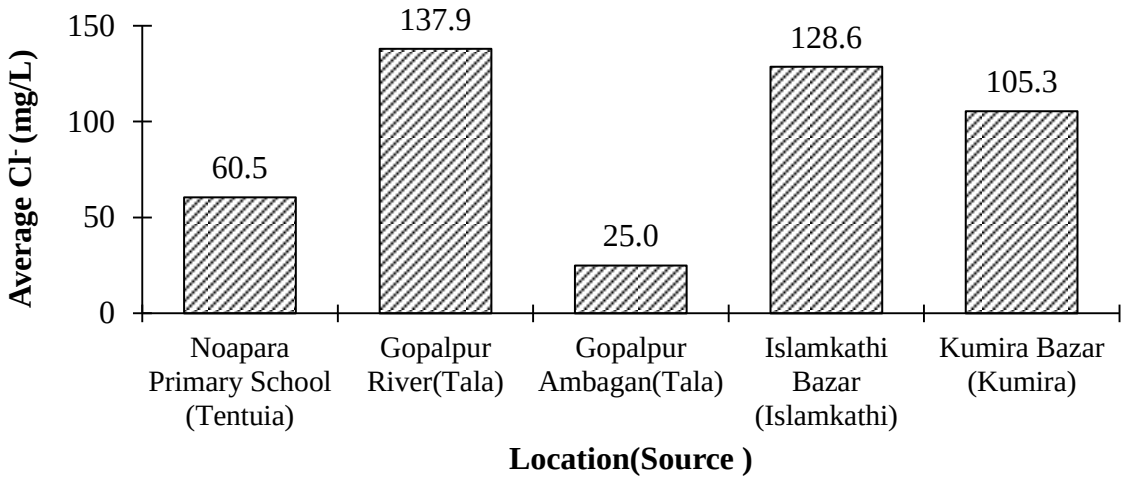


Figure 5.23: Chloride concentrations of surface water sample at different location

From the Table 5.13 it has found that the maximum chloride concentration was 85 mg/L in the Noapara Primary School playground of Tentulia union, 290mg/L in the Gopalpur (river water), 50mg/L in the Gopalpur ambagan of Tala union, 375mg/L in the Islamkathi (river water) of Islamkathi union and 360mg/L in the Kumira (river water) of Kumira union. From the Figure 5.23 also shows that the average value of chloride concentration has been found all of the source below 140mg/L.

Paddy/rice can grow with maximum soil Cl^- concentration of 1050mg/kg without any yield loss (threshold ppm). From this it is understandable that the reduction of rice production has not occurred by chloride concentration of the study area during water logging.

5.3.3.2 Soluble Sulphate (SO_4^{-2})

Sulfur occurs primarily in the sulfate (SO_4^{-2}) form in the soil. Elemental sulfur (S) may be used as a source of this nutrient, but it must first undergo a biological oxidation process that is dependent upon the Thiobacillus bacteria to produce sulfate. This process is produces large amounts of acid, and occasionally elemental sulfur is used to decrease soil pH. Fertilizer materials containing sulfate do not acidify the soil, although pH may decline slightly for a short period (salt effect). The sulfate ion is a major contributor to salinity in the soil and water. Both soil and water samples has been analyzed for soluble sulfate (SO_4^{-2}) ions as shows in the Table 5.14.

Table 5.14 : Soluble sulfate (SO_4^{-2}) concentration of the soil sample in the study area

Sl. No	Location (Union Name)	Depth (cm)	Testing Date/ SO_4^{-2} (mg/kg)						
			16.09.14	20.10.14	21.11.14	20.01.15	20.03.15	28.05.15	20.07.15
1	Noapara Primary School (Tentuia)	0	51	80	11.0	90	19	240	200
2	Noapara Primary School (Tentuia)	30	104	90	2.0	70	70	160	190
3	Gopalpur (Tala)	0	68	130	7.4	0.0	74	180	210
4	Gopalpur (Tala)	30	26	90	8.0	0.0	21	140	460
5	Islamkathi Bazar (Islamkathi)	0	140	30	187.5	160	160	220	225
6	Islamkathi Bazar (Islamkathi)	30	79	69	142.5	130	429	220	230
7	Kumira Bazar (Kumira)	0	-	96	175.0	240	180	280	290
8	Kumira Bazar (Kumira)	30	-	53	120.0	250	320	240	330

The following Figure 5.24 shows the average value of soluble sulfate (SO_4^{-2}) concentration of the study area at different location of the study area.

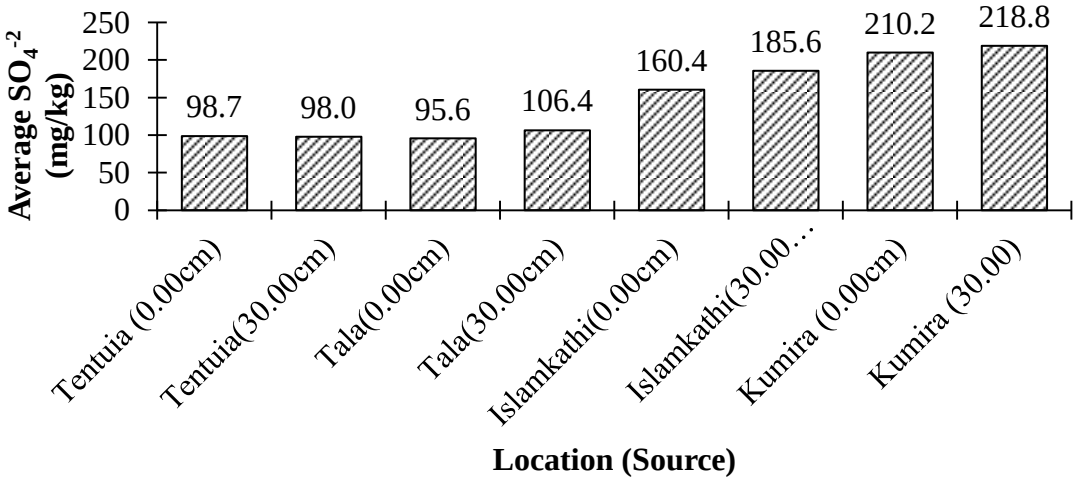


Figure 5.24: SO_4^{-2} of soil sample at different location of the study area

The optimum ranges of sulfate (SO_4^{-2}) in irrigation water is 25-200mg/L and the maximum limit is 240 mg/L. Table 5.15 and Figure 5.25 shows the soluble sulfate (SO_4^{-2}) concentration of the water sample in different seasons of the study area.

Table 5.15 : Soluble sulfate (SO_4^{-2}) concentration of the water sample in the study area

Sl. No	Location (Union Name)	Source	Testing Date/ SO_4^{-2} (mg/L)						Standard Value SO_4^{-2} for Irrigation Water
			16.09.14	20.10.14	20.01.15	20.03.15	28.05.15	20.07.15	
1	Noapara Primary School (Tentuia)	School play ground			5.0	6.0	228	200	Optimum ranges: 25-200mg/L Maximum limit: 240mg/L
2	Gopalpur (Tala)	River	2.0	1.0	0.0	8.0	260	160	
3	Gopalpur (Tala)	Ambagan			14.0			210	
4	Islamkathi Bazar (Islamkathi)	River	0.0	1.0	15.0	4.0	234	230	
5	Kumira Bazar (Kumira)	River		1.0	6.0	5.0	252	225	

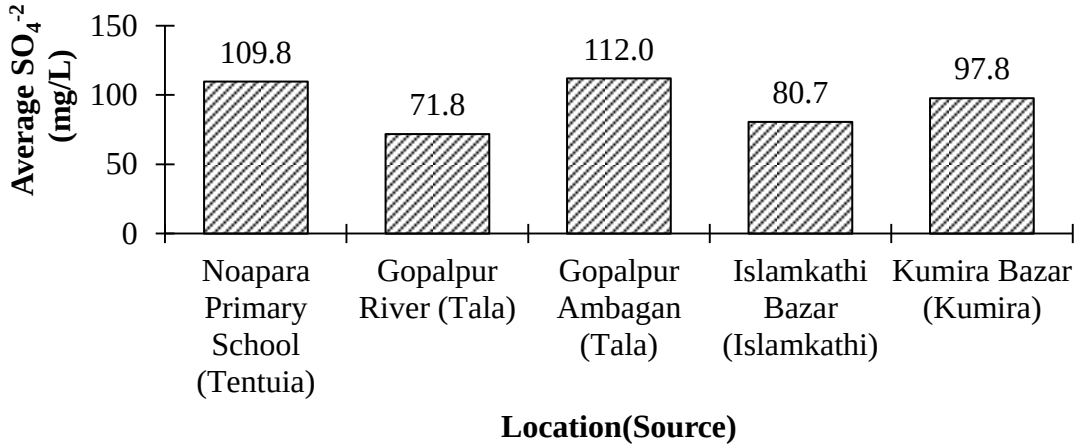


Figure 5.25: SO_4^{-2} of water sample at different location of the study area

From the laboratory investigation of the soil and water sample it has found that the average value is lies between the optimum range (25-200 mg/L) of sulfate (SO_4^{-2}) concentration for irrigation water.

5.3.3.3 Soluble Nitrate (NO_3^-)

Plants absorb most of their Nitrogen (N) in the ammonium (NH_4^+) or (NO_3^-) forms. The availability of these two forms of N for plant uptake largely depends on the liberation of inorganic N from organic sources or the application of fertilizers which contain either NH_4^+ or NO_3^-. Table 5.16 and 5.17 shows the experimental result in different seasons of soluble nitrate (NO_3^-) concentration of the soil and water samples of the study area.

Table 5.16 : Soluble NO_3^- concentration of the soil sample in the study area

Sl. No	Location (Union Name)	Depth (cm)	Testing date / NO_3^- (mg/kg)			
			16.09.14	20.01.15	28.05.15	20.07.15
1	Noapara Primary School (Tentuia)	0	1.9	4.1	1.8	1.9
2	Noapara Primary School (Tentuia)	30	1.0	5.1	1.6	1.4
3	Gopalpur (Tala)	0	1.7	5.2	1.8	1.7
4	Gopalpur (Tala)	30	1.4	5.1	2.0	1.8
5	Islamkathi Bazar (Islamkathi)	0	0.8	0.0	1.0	1.2
6	Islamkathi Bazar (Islamkathi)	30	0.6	0.4	2.2	2.3
7	Kumira Bazar (Kumira)	0	-	0.0	1.4	0.6
8	Kumira Bazar (Kumira)	30	-	0.0	2.2	1.0

Table 5.17 Soluble nitrate (NO_3^-) concentration of the water sample in the study area

Sl. No	Location (Union Name)	Source	Testing date/ NO_3^- (mg/L)				Standard NO_3^- (mg/L)
			16.09.14	20.01.15	28.05.15	20.07.15	

1	Noapara Primary School(Tentuia)	School Field	-	3.9	0.0	3.7	Optimum range for irrigation water: 0 -10 mg/L
2	Gopalpur (Tala)	River	0.4	0.1	0.2	0.4	
3	Gopalpur (Tala)	Ambagan	-	0.4		0.6	
4	Islamkathi Bazar (Islamkathi)	River	0.4	0.6	0.6	0.3	
5	Kumira Bazar (Kumira)	River	-	9.2	0.0	0.2	

Figure 5.26 shows the average value of soluble nitrate (NO_3^-) concentration of the soil samples of the study area.

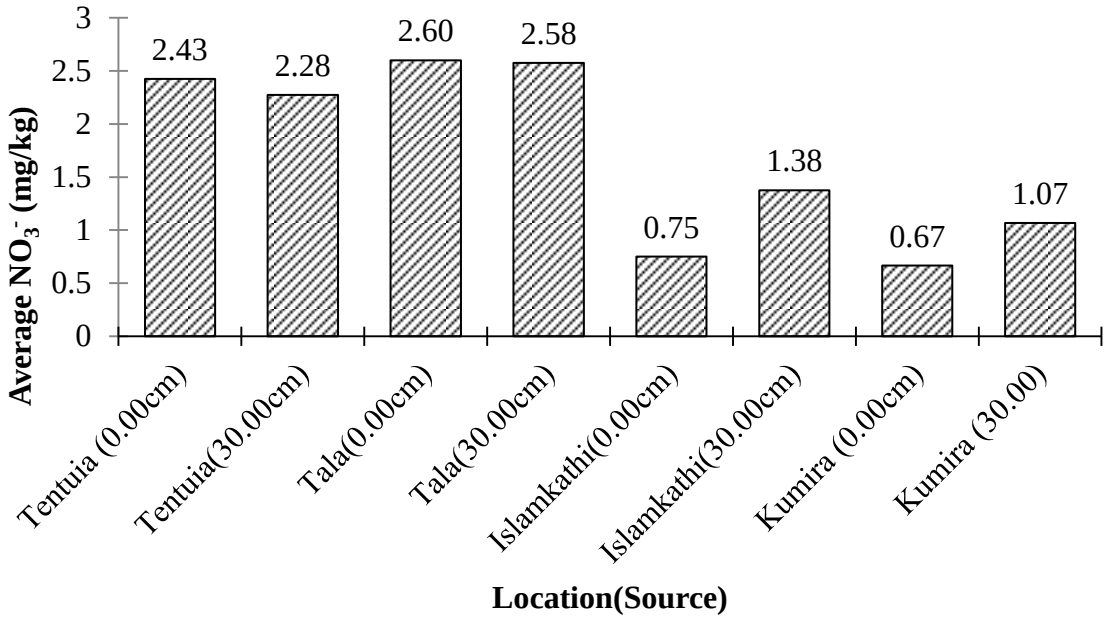


Figure 5.26: Nitrate (NO_3^-) concentration of soil sample of the study area

The optimum ranges of nitrate (NO_3^-) in irrigation water is 0-10mg/L and the maximum limit is 50mg/L. From the laboratory investigation of both the soil and water samples it has found that all the samples the nitrate (NO_3^-) concentration was belongs to the optimum range 0 - 10mg/L.

5.3.3.4 pH

Soil pH is the most important factor which governs availability of nutrients in soil. The pH range of 6.5 to 7.5 is the optimum for availability of most of the nutrient elements of soil. Table 5.18 and Figure 5.27 represents the pH value of the soil sample of the study area.

Table 5.18 : pH of the soil sample in the study area

Sl. No	Location (Union Name)	Depth(cm)	Testing Date/ pH							Standard Value of pH
			16.09.14	20.10.14	21.11.14	20.01.15	20.03.15	28.05.15	20.07.15	
1	Noapara Primary School (Tentuia)	0	7.39	8.3	8.04	8.06	8.35	6.14	7.86	Optimum range: 6.5 to 7.5
2	Noapara Primary School (Tentuia)	30	7.32	8.39	7.94	8.07	8.49	5.75	7.77	
3	Gopalpur (Tala)	0	6.91	8.24	8.07	8.08	8.41	5.95	7.81	
4	Gopalpur (Tala)	30	7.27	8.3	8.17	8.04	8.15	6.02	7.84	
5	Islamkathi Bazar (Islamkathi)	0	7.55	8.3	7.89	7.74	8.07	5.63	7.78	
6	Islamkathi Bazar (Islamkathi)	30	7.63	8.4	7.96	8.05	8.01	5.62	7.87	
7	Kumira Bazar (Kumira)	0	-	8.2	8	7.94	8.31	5.5	7.7	
8	Kumira Bazar (Kumira)	30	-	8.31	7.96	8.15	8.41	5.59	7.75	

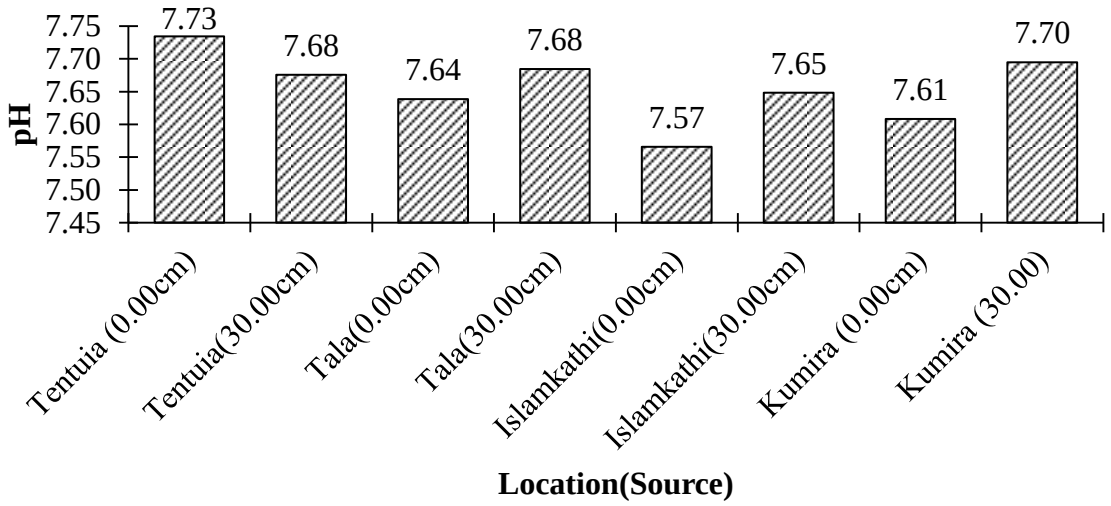


Figure 5.27: pH of the soil sample in the study area

The normal range of pH for irrigation water is 6.5 to 8.4. Following Table 5.19 and Figure 5.28 represents the pH value of the water sample of the study area.

Table 5.19 : pH of the water sample in the study area

Sl. No	Location (Union Name)	Source	Testing Date/pH							Standard Value of pH
			16.09.14	20.10.14	21.11.14	20.01.15	20.03.15	28.05.15	20.07.15	
1	Noapara Primary School (Tentuia)	School play ground	-	-	7.3	7.8	6.9	6.9	7.3	Optimum range for irrigation water: 6.5 to 8.4
2	Gopalpur (Tala)	River	6.8	7.0	7.2	6.9	6.9	7.1	6.3	
3	Gopalpur (Tala)	Ambagan	-	-	6.9	6.7	-	-	7.3	
4	Islamkathi Bazar (Islamkathi)	River	7.0	7.3	-	7.3	6.0	7.1	7.1	
5	Kumira Bazar (Kumira)	River	-	6.9	7.0	7.4	7.3	6.8	4.7	

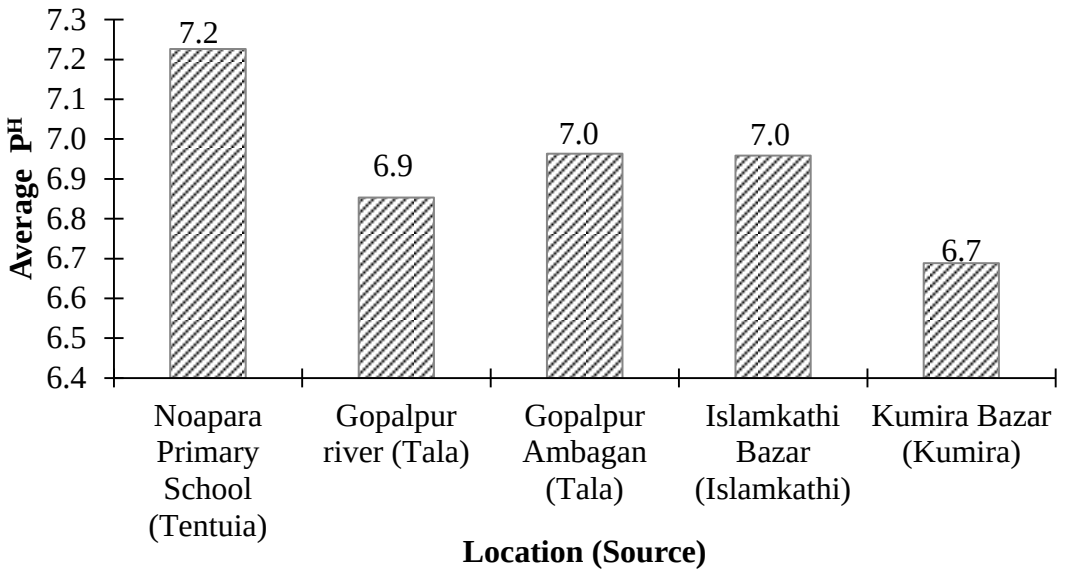


Figure 5.28: pH of the water sample in the study area

From the experimental result is found that the pH of the water of the study area not cross the normal limit of the standard range for irrigation water 6.5-8.4.

5.3.3.5 Electric Conductivity (EC)

Electric Conductivity (EC) is an indirect measurement of ions by an electrode. This includes negatively charged ions (e.g., Cl^-, NO_3^-) and positively charged ions (e.g., Ca^{++}, Na^+). A soil whose EC > 4 ds/m (25°C), pH < 8.5 and ESP < 15% is categorized as saline soil, and if the EC < 4 ds/m then the soil is classified as the non-saline soil. The Figure 5.29 shows the experimental result of soil samples EC value of the study area.

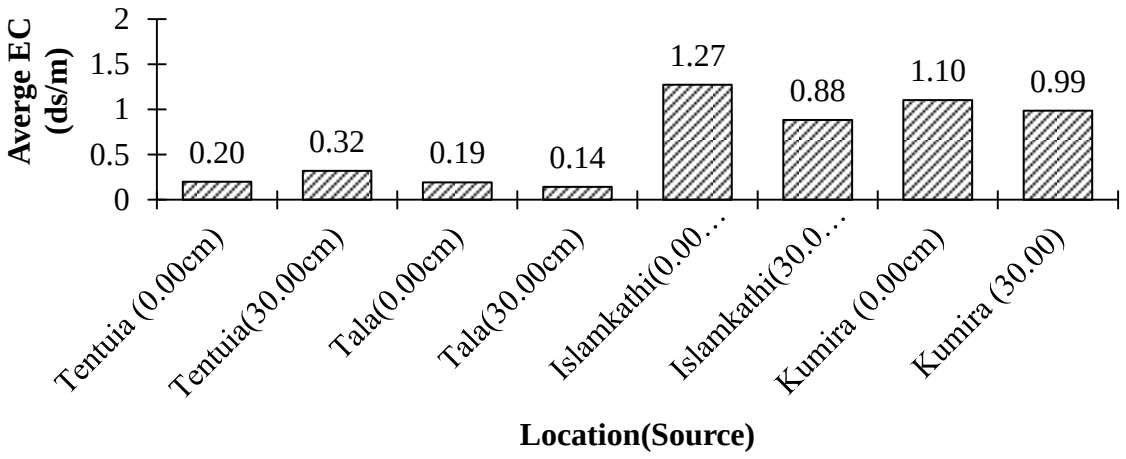


Figure 5.29: EC of soil sample in the study area

The Table 5.20 shows the experimental result of water samples EC value of the study area.

Table 5.20 : Electric Conductivity (EC) of the water sample in the study area

Sl. No	Location (Union Name)	Source	Average EC(ds/m)
1	Noapara Primary School (Tentuia)	Play ground	0.33
2	Gopalpur (Tala)	River	0.24
3	Gopalpur (Tala)	Ambagan	0.14
4	Islamkathi Bazar (Islamkathi)	River	0.53
5	Kumira Bazar (Kumira)	River	0.40

From the laboratory investigation the maximum EC value was observed 1.27dS/m so the study area soil and water can be consider as the non-saline soil.

5.3.3.6 Soil Salinity and SAR index

In saline soils, sodium joins with chlorine to form a salt, NaCl. The presence of salt in the soils reduces the availability of water to plants and, at high enough concentrations, can kill them. Sodium has a negative effect on most plants due to its toxicity, when it accumulates in certain tissues of the plant, and its capacity to harm the soil structure by competing with other cations for adsorption (the adhesion of the cation to the surface of some soil components). When a soil contains a level of sodium that might prove harmful to crops, it is said to be sodic. Soil sodicity should not be confused with soil salinity, which refers to the total quantity

of salts in the soil, without specifying which salts are more prevalent. The Figure 5.30 shows the SAR of the soil samples of the study area.

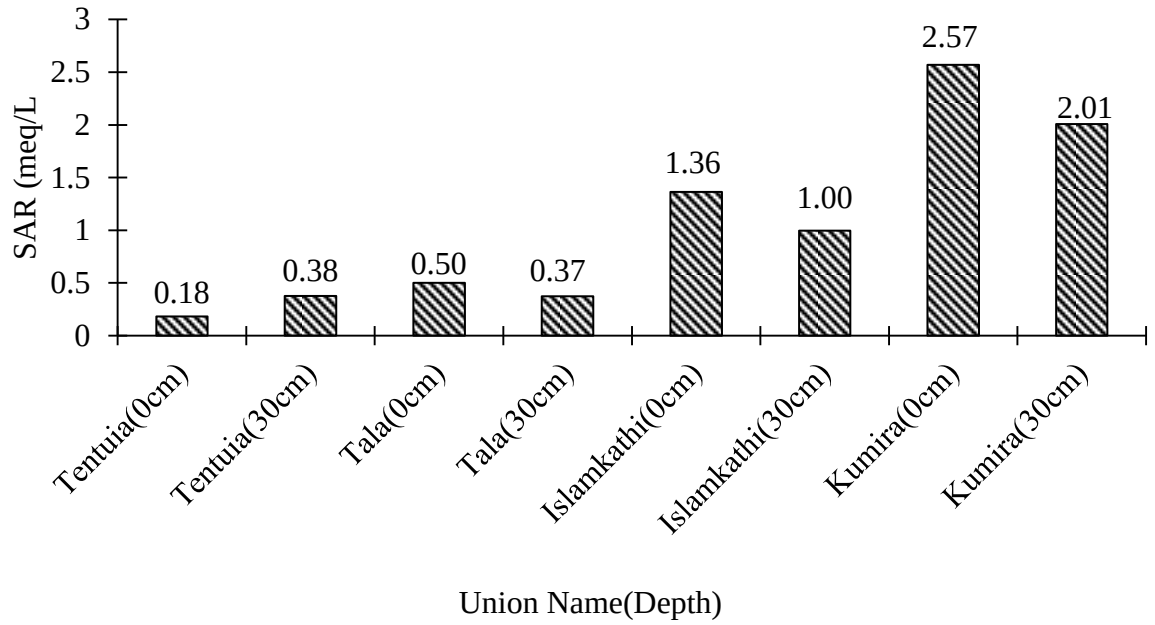


Figure 5.30: SAR of soil samples in the study area

The minimum value of SAR has found 0.18meq/Lin Tentulia union and the maximum SAR value was found 2.57meq/L in the Kumira union of the study area. The normal limit if SAR is 13meq/L.

5.3.3.7 Plant Nutrients

Nutrients can exist in the soil in various forms, viz. dissolved in the soil solution, adsorbed on the soil particle surface or as constituents of the solid phase (sparingly soluble minerals, organic matter, and occluded material). These sources are not independent; inter-conversions between them are possible. The availability of a nutrient refers to that fraction of the nutrient which is accessible to plant roots. It is often observed that the total status of a particular nutrient in soil is high but the plants grown on this soil suffers from deficiency of that element. This indicates, the extent of availability is a big concern in question of plant uptake and consequent growth. Thus, a portion of the total content becomes available for plant uptake depending on some soil conditions, viz. soil pH, soil texture, organic matter content,

flooding, nutrient interaction, temperature, etc. The Table 5.21 shows the test result of different nutrients concentration of the soil samples of the study area.

Table 5.21 : Different nutrients content of the soil samples of the study area.

Sl. No	Location (Union Name)	Depth (cm)	Total Nitrogen (%)	Potassium (meq/100g)	Phosphorus (µg/g soil)	Calcium (meq/100g)	Magnesium (meq/100g)
1	Noapara Primary School (Tentuia)	0	0.176	0.65	26.83	26	6.37
2		30	0.101	0.46	25.18	31.09	6.25
3	Gopalpur Ambagan (Tala)	0	0.09	0.22	17.48	13.05	5.31
4		30	0.078	0.3	11.8	16.69	5.88
5	Islamkathi Bazar (Islamkathi)	0	0.112	0.51	21.96	18.18	5.94
6		30	0.12	0.6	21.95	21.79	6.55
7	Kumira Bazar (Kumira)	0	0.091	0.4	17.01	15.29	6.42
8		30	0.107	0.4	17.12	14.53	6.85
Optimum Limit for Clayey soil			0.271-0.36	0.271-0.36	15.76-21.0	4.51-6.0	1.126-1.5
Optimum Limit for Sandy soil			0.227-0.30	0.181-0.24	18.1-24.0	4.51-6.0	1.126-1.5

Nitrogen: Nitrogen (N) as essential macronutrients, are required for growth by all animals and plants. Lack of these nutrients can restrict growth. Farmers regularly apply fertilizers containing N to crops to increase yield. Plants absorb most of their N in the ammonium (NH_4^+) or (NO_3^-) forms. From the soil sample investigation Table 5.21 it is found that all of the location Nitrogen content is less than the optimum limit (0.271-0.36%).

Potassium: Soil Potassium (K) exists in four forms, each differing in its availability to crops. Mineral K varies from 5000 to 25000 ppm, exchangeable K from 40 to 600 ppm, and solution K from 1 to 10 ppm. Potassium is held tightly in feldspars and micas, which are very resistant to weathering. Fixed or non-exchangeable K is present within clay minerals, such as illite, vermiculite and chlorite. Exchangeable K is held on negatively charged soil colloids by

electrostatic attraction. From the soil sample investigation Table 5.21 it is found that all of the location Potassium content is excess than the optimum limit.

Phosphorus: Phosphorus (P) does not occur as abundantly in soils as N and K. Although the total concentration of P in the soil varies between 0.02 and 0.10%, it has no relationship with the availability of P to plants. From the soil sample investigation Table 5.21 it is found that in the Phosphorus content in Kumira and Gopalpur union exist within the limit but in the other Tala and Tenulia union it is excess than the optimum limit.

Calcium and Magnesium: Magnesium (Mg) requirements of crops are about the same as that of Phosphorus (P) while Calciu**m** (Ca) requirement is greater. In contrast, Ca and Mg are associated with soil colloidal fractions and behave like K. From the soil sample investigation Table 5.21 it is found that all of the location Calcium and Magnesium content is excess than the optimum limit.

5.4 Suggestions or Mitigation Measures for Solving the Water Logging Problems

From this study some suggestions or mitigation measures can be proposed for solving the prolonged water logging of the study area. Subsequent steps can help to overcome water logging problem of the study area described below:

5.4.1 Protection of the Natural Drainage System

An integrated drainage system is very essential for drainage out the storm water. The natural drainage system is depleting in the study area in many ways. River Kabodak is the main drainage path of the study area. The storm water comes to the river by surrounding water bodies and canals. So for smooth and sustainable solution of the water logging problem action should be taken for saving the natural drainage system and water bodies.

5.4.2 Improvement of Drainage system

The drainage capacity is reducing by many ways for the same catchment area of the study area. So the drainage system should design in such way that the storm water can pass smoothly without making any water logging in the surrounding area. The drainage capacity adjustment technique can be the effective process for designing the drainage system of the study area. Appropriate dredging and buildup embankment on the both side of the river and canals may be taken for adjusting the drainage capacity of the study area and its surroundings.

5.4.3 Complete Drainage Development Plan and Improvement of Drainage Management System

The existing storm water drainage is not sufficient to drain out the excessive rainwater during the monsoon in the region. Besides, the conventional or traditional drainage system leads to increased water logging by erosion, siltation, blockage, shrimp culture and such on. For the appropriate solution of the water logging problem a comprehensive drainage development plan should be exchanged with other utility organizations. A close coordination and factual effort among all the related utility organizations and also improvement of drainage management system can help to develop an effective and sustainable drainage system.

Planning, design, operation and maintenance of the drainage systems is a challenge for different authorities because of unplanned development activities, and the effectiveness of storm water management systems can be directly linked to the efficacy of flood management. For effective and sustainable management of the drainage greater emphasis needs to be placed upon:

- Dialog concerning Bangladesh and neighboring country India to get the sufficient quantity of water from the river Ganga to Padma and connecting the upper part of the river Kabodak with the river Padma to get the continuous flow;
- Harmonization between different authorities and agencies those are responsible for different aspects of infrastructure provision and management;

- Cooperation between government and non-governmental organizations and promotion of effective partnership with civil society and the private sector;
- Training and human resource development for improved planning, design, and operation of the drainage systems;
- Awareness building program among the local people to realize the importance of the drainage system.

5.4.4 Awareness Program against Closing of Drainage Path

The existing drainage system is blocked by illegal occupied such as (1) Barrier construction in the river, canals for shrimp culture and irrigation. (2) Construction of different infrastructures i.e. religious, political, public, educational and so on. Public awareness build up program can take an important role against closing the drainage path.

5.4.5 Rise the Existing Roads, Embankment and other Structures

Due to sea level rise, ice melting and siltation of the river bed the water level (high tide and low tide) of the river become high through the monsoon. For this reasons the roads, embankments and structures plinth level of the water logged area should be make some higher than the highest flood level.

5.4.6 Adaptation to Prolonged Water Logging Problem in Agriculture Sector

Recently the water logging problem is the common problem for all the coastal area of Bangladesh. For prolonged water logging problem most of the crops as well as the trees are going to deplete. For sustainable development of the study area we need to think about the agriculture sector to adapt the adverse effects of water logging, a number of measures should be promoted for food security and general economic crisis. Various adaptation to water logging for agriculture sector of the study area have been identified through studying, review of various documents and consultations are listed below:

- **Crops and Plants:** Emphasis needs to grow the salt and water tolerant varieties crop and plants also for period of cultivation, short maturing varieties, fertilizer and soil fertility management system. Figure 5.31 shows the floating crop cultivation system;

Figure 5.31: Floating crop cultivation during water logging.

- **Livestock:** Development of livestock species tolerant to climatic conditions particularly flooding. For sustainable expansion of livestock the subsequent sector must be in account i.e. Animal health, diseases, feeds, food production, animal insurance and special breeding;
- **Fisheries:** Technology generation for increasing shrimp and fishery productivity, dredging of rivers, channels, and community based management of water bodies and rehabilitation of fishers. Management of water reservoir, improved sanctuaries, disease control, improvement of fish landing sites and market infrastructure development, climate resilient species development and management practices, protection of fish habitat from intrusion of salt water and establishment of improved hatchery.

5.4.7 Necessary Dredging Work of River Kobadak

The siltation of the river Kobadak is the main causes of the water logging. Maximum time of the year the selected study area become prolonged water logged. No crop can cultivate in that

time. During the Aman crop cultivation the local people used pumps for discharged the water of the study area. Following Figure 5.32 shows the pumping of stagnant water to the river Kobadak in the year 2012.

Figure 5.32: Pumping of stagnant water to the river Kobadak of the study area

Since the water logging problems become common for the study area and creates negative impact in the all sectors development of the study area. The respective authority Bangladesh Water Development Board (BWDB) has taken some initiative for solving the water logging problem by dredging the river Kobadak as the following Table 5.23 and Figure 5.32 shows the details.

Table 5.22 : Dredging work implemented by BWDB to solve the water logging problem of river Kobadak

Sl. No.	Main Design	2013-14 Financial Year Work(1st Phase)

1	Average Bottom Width(m)	Average Top Width(m)	Dredging depth(m)	Bottom Level mPWD	Avg. Bottom Width(m)	Average Top Width(m)	Dredging depth(m)	Bottom Level mPWD
2	32.37	53.00	3.70	(-) 1.68	10.00	15.00	2.00	0.75

Figure 5.33: Improved situation of Kobadak river drainage system after completion of 2013-14 Financial year work (1st phase) dredging work of the river and canals.

Source: BWDB, Jashore

After implementation of the dredging work of 2013-14 financial year, some part of the study area become safe from prolonged water logging in the year 2017. Figure 5.33 shows the improved picture of the Figure 5.32 of the same location this time the water is passing without any interruption through the river Kobadak.

CHAPTER VI

Conclusions and Recommendations

6.1 General

This research responds to the need for an assessment of effect of water logging in the south western coastal zone of Bangladesh. This chapter discuss about the conclusions of the research and the recommendations for the future works on causes and effect of water logging in the study area.

6.2 Conclusion

The main conclusions drawn from the present study are as follows

- Water logging in the study area is the consequence of blockage of the upstream of Kabodak river, negative effects of Coastal Embankment Project (CEP) and unplanned development.
- Flooding due to rainfall is also a severe problem for the study area that is inundated for several month mainly due to the drainage congestion.
- The structures of the study area has also affected seriously for prolonged water logging.
- The substructure of the pucka/katcha houses in the low laying areas remains underwater due to water logging.
- The brick foundations losses its longevity by corrosive effect of salinity and damping.
- Water logging causes damage to roads (both pucka and katcha) in the rainy season every year leading to the movement problem and interrupts the journey.
- Crop production has been hampered due to prolonged water logging, especially the Amon rice production is mainly reduced half in each alternative year.
- The educational institutions of the study area became flooded for long time and the students can’t continue their learning.
- Due to prolonged water logging of the study area the agricultural land price are not increased as the residential or commercial land price. Because both types of

agricultural land become ideal and the land can't be used for cultivation. Presently only 16% of people are alive taking farming as the main occupation and about 60% of people living with day laboring occupation.

- Due to the prolonged water logging of the study area the population growth rate of the study area has been decreasing significantly. In the study area there were 3,07,695 people in 2001 and after ten years in 2011 its total population became 3,11,236 (BBS, 2012). The yearly population growth rate of the study area is 0.115%, whereas the overall national growth rate is 1.078%.
- The maximum chloride concentration was 0.080g/kg, 0.315g/kg, 0.356g/kg and 0.490g/kg of Tentulia union, Tala union, Islamkathi union and Kumira respectively Paddy/rice can grow with maximum soil Cl^- concentration of 1g/kg without any yield loss (threshold ppm). So, rice production has not occurred by chloride concentration of the study area during water logging.
- The optimum ranges of sulfate (SO_4^{-2}) in irrigation water is 25-200mg/L and the maximum limit is 240mg/L. From the laboratory investigation of the soil and water sample it has found that the average value is lies between the optimum range (25-200 mg/L) of sulfate (SO_4^{-2}) concentration for irrigation water.
- The soil sample the nitrate (NO_3^- concentration was low (<10mg/L) for all location and water samples result was within the optimum range 0 -10mg/L.
- After completing first stage dredging work of Kobadak river by Bangladesh Water Development Board, water logging situation has been improved in year 2017.
- Finally it can be concluded that proper dredging work of the surrounding drainage path can be helped to safe the study area from prolonged water logging.

6.3 Recommendations

The recommendations for the future work are given below:

- Change of dissolved oxygen in the soil due to water logging can be examined for survival of plant of the study area.
- Detailed digital topography survey can be performed by using total station or other instrument to know the actual ground level of the study area.

- A digital map can be prepared by using Global Information System (GIS) software for the inter connecting canals and rivers of the study area.
- Different experiment can be done in details for different fields like education, health, income, etc. of the study area to find out the actual effect of water logging.
- A correlation between rainfall and drainage capacity of the study area can be made to overcome the water logging.

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APPENDIX-1

KHULNA UNIVERSITY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

Socio-economic Survey Questionnaire

Socio-economic and Environmental Survey Questionnaire 2014

Location: Date of Survey ঃ.....

Village: Union: .....

Post Office: ……. Upazila: .....

Name of the Head of the Family: ----------

Name of the Respondent: ---------- Mobile No. ----------

Signature ----------

a. Personal Information of the Respondent:

1. Name of the Respondent.....
2. Sex (√) (1) Male (2) Female (3) Female Headed Household
   (4) Other ----------
3. Relation with Head of the Household

b. Housing Information (√)

1	House Ownership	(1) Single Owner Occupied (2) Joint Ownership (3) Government (4) Rented (5) Other (Mention)-------
2	(If Rented) Monthly Rent	Tk./month------
3	If owner Occupied, Source of Ownership	(1) Owner by Inheritance (2) Owner by Gift (3) Govt./Govt. leased Property /Leased Property (4) Owner by Purchase (5) Khas Land Leased (6) Other ----------
4	House Type (√)	a. (1) Single Storey (2) Two Storey (3) Three Storey (4) Four Storey (5) Five Storey (6) Six Storey +
		b. (1) Pucka (2) Semi-Pucka (3) Tin Shed (4) Katcha House (5) Wooden House (6) Temporary (6) Other (Mention) ----------
5	Area of the House (Apprx.)	----------sft
6	No. of Room (Other than Kitchen)	(1) One (2) Two (3) Three (4) Four (5) Five (6) Five +
7	Use of the House/ Structure (√)	(1) Residence (2) Commercial (3) Office (4) Mixed Use (5) Other ----
8	Condition of the House/Structure (√)	(1) Good (2) Dilapidated (3) New (4) Old

9	Duration of living in the House (√)	(1) Less than 5 years (2) 5-10 years (3) 10-15 years (4) 15-20 years (5) 20 +
10	Please give detailed information if the House was hampered due to water logging	

c. Occupation of the Household Head and Monthly Income

Sl. No.	Source of Income	Main Occupation (√)		Secondary Occupation (√)		Monthly Income (Tk.)		Remarks
		Before 2010	After 2010	Before 2010	After 2010	Before 2010	After 2010	
1	Service							
2	Business							
3	Farming							
4	House Rent							
5	Day Laboring							
6	Poultry Farming							
7	Shrimp/Fish Farming							
8	Cottage Industry							
9	Retired							
10	Foreign Remittance							
11	Other (Mention)							
	Total :							

d. Monthly Expenditure of the Household

Sl. No.	Item of Expenditure	Expenditure (Tk.)	Sl. No.	Item of Expenditure	Expenditure

					(Tk.)
1	Food		6	Health	
2	House rent		7	Education	
3	Water		8	Transport	
4	Dress		9	Recreation	
5	Electricity		10	Social Expenditure	
6	Telephone		11	Other (Mention)	
7	Fire wood/LPG/Other Fuel				
8	Other				
	Total:			Total:	

(3) How much is your monthly savings? Tk.:----------

(4) What is your total current savings? Tk.:----------

e. Land-use pattern in your area? (√)

Type of Land	Land Use (%)				
	1990	2000	2005	2010	2013
Residential Land					
High Agricultural Land					
Low Land/Beel					
Other Land					

f. 1.Give some idea about land price in your locality.

Location of the land	Price of Land /Decimal			
	1990	2000	2010	Present (2014)

Residential land					
Agricultural	High land				
	Low land				
Commercial land					

g. Land for which land use has more demand in your area?(√)

(1) Residential (2) Agriculture (3) Commercial (4) Garden (5) Fish Farm (6) Other-------

h. Essential Services

Code -01 Source of water	Code-2- Quality of Water	Code-3 Water Collection Problem	Code-04 Distance of Source	Code-05 Source of Fuel	Code-06 Source of Light
(1) Piped Water	(1) Drinkable	(1) Far Away	(1) Up to 25 m	(1)LPG gas	(1) Electricity
(2) Own Tube Well	(2) Not Drinkable	(2) Takes long time to collect	(2) 25m-50m	(2) Fire Wood	(2) Kerosene
(3)Community Tube Well	(3) Saline	(3) Remains out of order for long	(3) Above 50 m	(3)Kerosene	(3) Candle
(4) Canal/river	(4) Arsenic Contaminated	(4) Other		(4)Cow Dung	(4) Solar Power
(5) Pond/Well	(5) Other			(5)E. Heater	(3) Other
(6) Other				(6) Other	

Code-07 Drain	Code -08 Sanitation	Code -09 Toilet Ownership
(1) Katcha	(1) Katcha latrine	(1) Single owner
(2) Pucka	(2) Pucka latrine	(2) Joint owner
(3) No drain	(4) No latrine	(3) Community ownership
		(4) Other

i. Health and Healthcare

Code-1 Diseases suffered by family members during last one year	Code-2 Where the family members usually go for treatment	Code-3 Distance of healthcare facility	Code-4 Annual expenditure on health (aprox.)	Code-5 Problem related with health facility
1.Fever/Cold/Cough	1.Govt. Hospital	1.Less than one km	1. Tk. 1000	1.No community Clinic nearby
2. Diarrhoea/ Dysentery	2. Private Clinic	2. 1 -2 km	2. Tk. 1001 - 5000	2. No qualified doctor available
3. Jaundice/ Pneumonia	3. Upzaila Health Complex	3. 2-3 km	3. Tk. 5001 - 8000	3. Hospital far away
4. Rheumatic/ Asthma	4. Homeopath Doctor	4. 3-4 km	4. Above Tk. 8000	4 No free medicine in the hospital
5. Female disease	5. Rural Doctor	5. Above four km		5. No free treatment
6. Skin Disease	6. Kabiraj			6. Other ----------
7. Diabetes	7. Other			
8. Heart disease				
9. Other----------				

j. Education

Do your family members go to education institution? (1) Yes ☐ (2) No ☐

(1) If not, what are the reasons? (√)

(a) Insolvency (b) Not interested in education (M) Go for work (N) Do not feel need for education.

k. Natural and other Disaster

k/1. Is there any water-logging in your area? (1) Yes ☐ (2) No ☐

If yes, what are the reasons for water-logging ? (1) Low land (2) No drainage system (3) Other ----------

For how long water-logging continues ?

(1) Few hours (2) Seven days (3) One month (4) Two month (5) Three month (6) Four month (6) Six month (7) More than six month

k/2 Did your house got flooded during following years ? (1) Yes ☐ (2) No ☐

If yes, answer the following questions

Important years of flood	Level of Water in the House			Loss due to Water logging					Helped (Name & Amount)	
	Below plinth (ft)	Up to plinth (ft)	Above plinth (ft)	Agriculture	Fish firm	House	Road	Health (Diseases Name)	by Govt.	by NGO/ Others
1988										
1998										
2008										
2009										
2010										
2011										
2012										
2013										
2014										

l. Write the problems in your locality in order of priority

Priority No.	1	2	3	4	5
Problem Code					

Use for office purpose only

Description of the data entry:

Name of the data collector: ----------Date of interview: ----------Time: --------

Name of the investigator: ----------Date: ----------

APPENDIX-2

Information of the respondent

Sl. No	Union Name	Gender of Respondent				Total Number of Respondent
		Male		Female		
		Number	%	Number	%	
1	Tentulia	5	10.00	45	90.00	50
2	Tala	15	25.00	45	75.00	60
3	Islamkathi	15	16.67	75	83.33	90
4	Kumira	6	20.00	24	80.00	30
Total/Average (%)		41	17.92	189	82.08	230

APPENDIX-3

BWDB, Divisional Office Jashore

থিসিস টপিকস্: ওটার লগিং এন্ড ইটস ইমপ্যাক্ট ইন দ্যা সাউত-ওয়েস্টার্ন কোস্টাল যোন অব বাংলাদেশ ঃ এ স্টাডি অন তালা উপজেলা, সাতক্ষীরা ডিস্ট্রিক্ট ।

এম. এস. সি থিসিস এর জন্য প্রয়েজনীয় তথ্য ও উপাত্ত

১. কপোতাক্ষ নদের প্রফাইল(দৈর্ঘ্য, প্রস্থ ও গভীরতা/স্পট লেভেল)
২. কপোতাক্ষ অববাহিকার আর এল/স্পট লেভেল
৩. কপোতাক্ষ নদের বিভিন্ন মৌসুমের ওয়াটার লেভেল (১০-১৫ বছরের)
৪. কপোতাক্ষ নদের বাধের প্রফাইল
৫. স্লুইস গেট বা অন্যান্য গেট সম্পর্কীত তথ্য
৬. জলাবদ্ধতা নিরসনের জন্য গৃহীত প্রকল্প সমূহ

APPENDIX-4: Interpretation of soil test values based on critical limits

A. Loamy to Clayey Soils of Upland Crops

Sl. No.	Nutrient element	Very Low	Low	Medium	Optimum	High	Very high
1	N (%)	< 0.09	0.091-0.18	0.181-0.27	.271-0.36	0.361-0.45	>0.45
2	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
3	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
4	S (µg/g) soil	< 7.5	7.51-15.0	15.1-22.5	22.51-30	30.1-37.5	>37.5
5	K (meq/100g)	< 0.09	0.091-0.18	0.181-0.27	0.271-0.36	0.361-0.45	>0.45
6	Ca (meq/100g)	< 1.5	1.51-3.0	3.1-4.5	4.51-6.0	6.1-7.5	>7.5
7	Mg (meq/100g)	< 0.375	0.376-0.75	.751-1.125	1.126-1.5	1.51-1.875	>1.875
8	Cu (µg/g)	< 0.15	0.151-0.3	0.31-0.45	0.451-0.6	0.61-0.75	>0.75
9	Zn (µg/g)	< 0.45	0.451-0.9	0.91-1.35	1.351-1.8	1.81-2.25	>2.25
10	Fe (µg/g)	< 3.0	3.1-6.0	6.1-9.0	9.1-12.0	12.1-15.0	>15.0
11	Mn (µ/g)	< 0.75	0.756-1.5	1.51-2.25	2.256-3.0	3.1-3.75	>3.75
12	B (µg/g)	< 0.15	0.151-0.3	0.31-0.45	0.451-0.6	0.61-0.75	>0.75
13	Mo (µg/g)	< 0.075	0.076-0.15	0.151-.225	0.226-0.30	0.31-0.375	>0.375

B. Sandy Soils for Upland Crops of Upland Crops

Sl. No.	Nutrient element	Very Low	Low	Medium	Optimum	High	Very high
1	N (%)	< 0.075	0.076-0.15	0.151-.226	0.227-0.30	0.31-0.375	>0.375
2	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
3	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
4	S (µg/g) soil	< 6.0	6.1-12.0	12.1-18.0	18.1-24.0	24.1-30.0	>30.0
5	K (meq/100g)	< 0.06	0.061-0.12	0.121-0.18	0.181-0.24	0.241-0.3	>0.3
6	Ca (meq/100g)	< 1.5	1.51-3.0	3.1-4.5	4.51-6.0	6.1-7.5	>7.5
7	Mg (meq/100g)	< 0.375	0.376-0.75	0.751-1.125	1.126-1.5	1.51-1.875	>1.875
8	Cu (µg/g)	< 0.15	0.151-0.3	0.31-0.45	0.451-0.6	0.61-0.75	>0.75
9	Zn (µg/g)	< 0.375	0.376-0.75	0.751-1.125	1.126-1.5	1.51-1.875	>1.875
10	Fe (µg/g)	< 2.25	2.26-4.5	4.51-6.75	6.76-9.0	9.1-11.25	>11.25
11	Mn (µ/g)	< 0.75	0.756-1.5	1.51-2.25	2.256-3.0	3.1-3.75	>3.75
12	B (µg/g)	< 0.12	0.121-0.24	0.241-0.36	0.361-0.48	0.481-0.6	>0.6
13	Mo (µg/g)	< 0.045	0.046-0.09	0.091-.135	0.136-0.18	0.181-.225	>0.225

Source: FRG, BRAC

APPENDIX-5: Classification of Land Type

Highland	Land which is above normal flood-level
Medium highland	Land which normally is flooded up to about 90 cm deep during the flood season
Medium lowland	Land which normally is flooded between 90 and 180 cm deep during the flood season
Lowland	Land which normally is flooded between 180 and 300 cm deep during the flood season
Very lowland	Land which normally is flooded above 300 cm during the flood season

APPENDIX-6: Test Result of Soil sample from SRDI, KHULNA

কৃষিই সমৃদ্ধি

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
কৃষি মন্ত্রণালয়
মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট
আঞ্চলিক গবেষণাগার, দৌলতপুর, খুলনা।

নং- মৃত্তিকা/গবে-দৌ/খু-কারি/৬-১৮/২০০৯/ ৪৫৮ তারিখ ঃ ১০/০২/২০১৬ খ্রিঃ।

প্রাপকঃ মোঃ আজমল হোসেন গাজী
রোল নং-১১০১৫৫৯
এম এস-সি ইঞ্জিঃ প্রোগ্রাম
সিভিল ইঞ্জিঃ বিভাগ
কুয়েট, খুলনা-৯২০৩।

বিষয় ঃ মাটির নমুনার বিশ্লেষিত ফলাফল প্রেরণ প্রসংগে।

উপর্যুক্ত বিষয়ে আপনার ০৭/১২/২০১৫ ইং তারিখের আবেদনের প্রেক্ষিতে জানানো যাচ্ছে যে, আপনার প্রেরিত ০৮ (আট) টি মাটির নমুনার বিশ্লেষিত ফলাফল এতদসংগে প্রেরণ করা হলো।

ল্যাব নং	নমুনা নং	এলাকা	গভীরতা (সেমিঃ)	পটাশিয়াম (মিলিতুল্যাংক/ ১০০ গ্রাম মাটি)	মোট নাইট্রোজেন (%)	ফসফরাস	ক্যালসিয়াম	ম্যাগনেসিয়াম
						(মাইক্রোগ্রাম /গ্রাম মাটি)		
১২৮৩১	১	গোপালপুর আমবাগান	০.০০	০.২২	০.০৯০	১৭.৪৮	১৩.০৫	৫.৩১
১২৮৩২	২	গোপালপুর আমবাগান	৩০.০০	০.৩০	০.০৭৮	১১.৮০	১৬.৬৯	৫.৮৮
১২৮৩৩	৩	নোয়াপাড়া প্রাঃ বিদ্যাঃ	০.০০	০.৬৫	০.১৭৬	২৬.৮৩	২৬.০০	৬.৩৭
১২৮৩৪	৪	নোয়াপাড়া প্রাঃ বিদ্যাঃ	৩০.০০	০.৪৬	০.১০১	২৫.১৮	৩১.০৯	৬.২৫
১২৮৩৫	৫	কুমিরা বাজার	০.০০	০.৪০	০.০৯১	১৭.০১	১৫.২৯	৬.৪২
১২৮৩৬	৬	কুমিরা বাজার	৩০.০০	০.৪০	০.১০৭	১৭.১২	১৪.৫৩	৬.৮৫
১২৮৩৭	৭	ইসলামকাটি বাজার	০.০০	০.৫১	০.১১২	২১.৯৬	১৮.১৮	৫.৯৪
১২৮৩৮	৮	ইসলামকাটি বাজার	৩০.০০	০.৬০	০.১২০	২১.৯৫	২১.৭৯	৬.৫৫

(মোঃ জয়নাল আবেদিন)
ভারপ্রাপ্ত কর্মকর্তা
ফোন ঃ ০৪১-৭৭৪৩০২।
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অনুলিপিঃ
১। অফিস কপি।

APPENDIX-7: Classification of Soil

Soil Classification	***EC**	**pH**	***SAR***
Normal soil	<4	<8.5	<13
Saline soil	>4	<8.5	<13
Sodic soil	<4	8.5-10	>13
Saline- sodic soil	>4	<8.5	>13

*EC, Electrical conductivity; SAR, sodium adsorption ratio; pH, level of alkalinity/acidity. Source: Scherer (1996).