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„ Analysis of riverbank erosion, depositions, particle size analysis & land-use changes due to the river bank erosion in flood plain areas of Sangu river in Bangladesh"

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Abstract

Bangladesh is a country located at the Southeast Asia. The nation is flood prone and riverine. Heavy erosion and deposition of materials along the river banks due to water flow and flood are natural phenomena which cause channel movement. However, the application of geographic information systems and remote sensing provide both qualitative and quantitative tools for land cover change and river channel monitoring. The aim of this study is to evaluate the implication of eroded and deposited banks along the Sangu River, secondly; the particle size analysis of this river bank area, Thirdly; to assess the land use change caused by the influence of river bank erosion in this region. This is one of the unpredicted and critical occurrences of disasters which is affected by the amount of rainfall, river morphology, soil structure, floods, the topography of river and the adjacent regions. The study has been conducted Sangu flood plain area of Anowara and Banshkhali Upazila Sangu river, which are already identified as one of the most erosion prone areas in Bangladesh. For this study, we have analyzed the bank erosion of Sangu River due to the regular shifting of river channels by remote sensing approach. To calculate the particle size analysis in this area we have used hand auger method. In the flood plain area the length of this river is 11 km. LandSat image analysis of the last 28 years at 5 years interval represent the historical change of both bank alignment of the river course. During the last 28 years, total eroded area is 7070.70 Hectare and the average is 25.752 Hectare per year. In the same way, total deposition is 437.87 Hectare in the last 28 years and the average is 15.68 Hectare every year. In this area, the erosion is more severe then deposition as most of the sediment is washed out by rivers water flow and substantial part of the land has already been converted for commercial uses like shrimp cultivation which might deteriorate the soil fertility in future could increase the salinity of this area. From soil particle size analysis determines which areas more eroded, which areas are less eroded. Besides most clay mineral and depositions parts are sandy minerals. In addition, it is important to control erosion in other to save property, agricultural lands/crops, and infrastructures such as buildings, bridges and culverts that are located along the riverside. It is expensive and time consuming to treat bank erosion which is not particularly susceptible to engineering analysis.

Kurzzusammenfassung

Bangladesch ist ein fluss- und hochwassergefährdetes Land. Erosion und Ablagerung von Flussufern durch Wasserfluss und Hochwasser sind natürliche Phänomene, die eine Kanalbewegung verursachen. Fernerkundungs- und geografische Informationssysteme bieten Werkzeuge für quantitative und qualitative Landnutzungsänderungen und die Überwachung von Flusskanälen. Das Hauptziel dieser Studie ist es, die erodierten und abgelagerten Ufer des Sangu-Flusses zu schätzen, zweitens; die Partikelgrößenanalyse dieses Flussufers, drittens; die Beurteilung der Landnutzungsänderung durch die Erosion des Flussufers dieses Gebietes.Es ist eine der unvorhersehbarsten und kritischsten Arten von Katastrophen, die von der Menge der Niederschläge, der Bodenstruktur, der Flussmorphologie, der Topographie des Flusses und der angrenzenden Gebiete sowie von Überschwemmungen betroffen ist. Die Studie wurde im Sangu-Überschwemmungsgebiet von Anowara und Banshkgali-Upazila-Sangu Fluss durchgeführt, die bereits als zwei der erosiongefährdetsten Gebieten in Bangladesch identifiziert wurden.Für diese Studie haben wir die Ufererosion des Sangu-Flusses aufgrund der regelmäßigen Verschiebung von Flusskanälen durch Fernerkundung analysiert. Zur Berechnung der Partikelgrößenanalyse in diesem Bereich haben wir die Handschneckenmethode verwendet. In der Auenlandschaft ist dieser Fluss 11 km lang. Die LandSat-Bildanalyse der letzten 28 Jahre im Abstand von 5 Jahren stellt die historische Veränderung der beiden Uferausrichtungen des Flusslaufs dar. In den letzten 28 Jahren betrug die gesamte erodierte Fläche 7070,70 Hektar und der Durchschnitt 25,752 Hektar pro Jahr. Auf die gleiche Weise beträgt die Gesamtablagerung in den letzten 28 Jahren 437,87 Hektar und der Durchschnitt 15,68 Hektar pro Jahr. In diesem Gebiet ist die Erosion stärker als die Ablagerung, da der größte Teil des Sediments durch den Wasserfluss der Flüsse ausgewaschen wird und ein großer Teil des Landes bereits für kommerzielle Zwecke wie die Garnelenzucht umgewandelt wurde, die die Bodenfruchtbarkeit in Zukunft beeinträchtigen könnte, könnte den Salzgehalt dieses Gebiets erhöhen. Aus der Bodenpartikelgrößenanalyse wird bestimmt, welche Bereiche stärker erodiert sind, welche Bereiche weniger erodiert sind. Neben den meisten Tonmineralien und Ablagerungen sind Teile sandige Mineralien. Die Erosionskontrolle ist daher sehr wichtig, um landwirtschaftliche Flächen, Immobilien und Infrastrukturen wie Brücken, Durchlässe, Gebäude usw. entlang der Flüsse zu erhalten. Die

Behandlung der Ufererosion ist in der Regel teuer und nicht besonders anfällig für ingenieurtechnische Analysen.

Content

LIST OF FIGURE:

LIST OF TABLE:

Chapter One: Introduction

1.1 Introduction

Bangladesh is a developing nation constituted by lots of rivers and landmass. The country has in excess of 700 Rivers which comprise of tributaries and distributaries, creat a system of the waterway framework. Altogether, it has around 2,400 kilometers bankline at 283 Zilas, 85 towns and urban communities focuses are vulnerable to erosion. The majors and important rivers in Bangladesh which incorporate the Jamuna, the Padma (The Ganges) and the Meghna have erosions a large number of hectares of the floodplain, which makes a huge number of individuals shelterless and need protects each year. (Isalm et al., 2012).

Bangladesh landmass processes around 654 km long coastline inside the Bay. The caostal zone record to one-fifth of the nation's all-out region, it has a normal rise lesser than one meter over the mean sea level. The prominent worldwide sea level rise of around one meter in this century can prompt collection of the seaside zone with seawater .The predicted land loss along the coast will increase to 17%, and it is likely to displace more than 30 million population (Huq et al., 1995). These group of people might move to the northern direction in the un-inundated areas, which can lead to population increase, and the environment will be further intensified. Other horticultural and ecological issues identified with this a worldwide temperature alteration and potential ocean level rise will in general causes more issues for Bangladesh (Islam, 2001).

It is a horrible feeling to think that many islands in the offshore regions of Bangladesh, which includes Kutubdia, Bhola, Swandip, Manpura and Hatiya, where millions of people reside will face extinction. However, the world heritage site and largest mangrove forest Sundarbans are also in threat for wide-ranging shrimp's farms and other agricultural-related lands. In 2002, Ullah expressed that the Sundarbans was pronounced as the world legacy because of its rich biodiversity which fills in as home to in excess of 315 types of birds species, 13 trees species and four non-timberland sorts of vegetation. The issue of an Earth-wide temperature boost and sea level rise can prompt flooding of some land territories in Bangladesh, which has been considered by ecological researchers.

1.2 Significance of the Study

Bangladesh is a River surrounded country where hundreds of rivers have been flowing through the country in a crisscrossed pattern. Sangu River is considered as a significant river; the people of Chittagong region are dependent on this river for their lives and livelihood. However, the erosional activities of the river bank are becoming a concern for the people living in the region. Over the decades, the morphological features of the river have changed due to its erosional and depositional works, but this morphological change has not been investigated thoroughly. In spite of the fact that a few investigations are found that centered on the effect of Riverbank erosion in Bangladesh, the territory where the physical changes have occurred because of the fluvial procedures have not been recognized. Moreover, there's also a need to know the sediment texture of Sangu River, which can help to ascertain the probable reasons for the erosion and deposition in some specific locations of the river. The rationale behind selecting this area for the recent study is to investigate the characteristics of erosional and depositional works in the Sangu River. Furthermore, this study has identified the land-use changes on both sides of rivers that are associated with the erosion and deposition of the Sangu river. It is normal that the results of this investigation about the erosions , deposition and land-use change along the channel of Sangu River might be helpful to take preventive steps for protecting the river banks and to ensure a planned land uses that would not harm the inhabitants and the environment of this area.

1.3 Background of the Study

The people and resources of Bangladesh are under the threat of Riverbank erosions due to the geographic region and geological settings. (Rana and Nessa, 2017). Consistently about 10,000 hectares of land is eroded by the river in this nation (Islam, 2014). Many individuals move from the bank of the Sangu River consistently as a result of not having enough procuring sources and safe house to live (Rana and Nessa, 2017). The effect of Riverbank erosion on the common assets and financial state of the uprooted populations was multilateral (Iva et al. 2017). The effects of Riverbank erosions on the channel is long lasting, and it takes decades to create the losses that a family has gained by Riverbank Erosions (Islam et al. 2017).It is to be important for the policymakers and advancement specialist to evaluate the financial state of the shelterless individuals who relocated and lost their properties because of the morphological procedures of the river (Rahman, 2010). This study does not focus on the socio-economic aspects of the people living alongside the Sangu River, the identified location of erosion and deposition prone areas of this river will be helpful to assess the socio-economic conditions in the future studies. Also, the necessity of knowing the existing land uses and its changes for the last decades has propelled to choose this field of study.

1.4 Objectives of the Study

The major objectives of this study are -

1. To ascertain river bank erosional and depositional areas of Sangu River floodplain using spatial methods by applying GIS technique.

Why this objective is considered: Riverbank erosion is a catastrophic event in Bangladesh. But till now no detailed study has been found focusing Sangu River. By this study, we have tried to find the riverbank erosional and depositional processes and estimation of how much is accreted or eroded from this area. In chapter three, we described the erosion and depositions of the Sangu River identified by ArcGIS for the last 28 years.

2. To relate the changes of river channel from erosion and deposition to associated land-use characteristics

Reason for selecting this objective: Bangladesh is a farming-based nation. The greater part of the individuals is involved with agri-based business on a village level. Due to riverbank erosion, people lost their agricultural fields. Some parts of riverine areas are flooded with salt water, and which hampers the soil quality of the areas for usual agriculture productions like paddy and pulses. So, people are forced to convert their traditional firming system to shrimp cultivation. In this study, we tried to find out how much agricultural field covert to shrimp cultivation in the last 28 years. In the fourth chapter, we examine the land-use change in the Sangu river flood plain region because of the riverbank erosion and depositions.

3. To analyze the particle sizes of different floodplain landforms of the Sangu river.

Explanation of this objective: Structure of soil is most important foe the river bank erosions and depositions in the flood plain areas. Soil materials are control the rate of river bank erosions.. Clayey soil is stronger than sandy soil. So clayey-soil is less eroded than sandy-soil. Sandy soil is mostly washed out with river water. In the fifth chapter, we describe the soil particle size analysis in both parts of the river and find out the location of the sampling area.

4. To recommend the probable solutions for preventing the bank erosion of the Sangu River.

Interpretations of this objective: Bangladesh is a developing nation. Lots of people are faced the lots of problem causes of river bank erosions. To solve this problem, we need to take the proper steps. In this study, we recommended some solutions to this problem, which can be more effective methods for a developing country like Bangladesh. In the Sangu riverbank zone, there has not been taking any remarkable appropriate step to control this problem. In the sixth chapter, we recommend some suggestions in this regard.

1.5 Limitations of the Study

Restrictions for this study originated from choosing just 11 km fragment of Sangu River, yearly recorded previous satellite photography of the study areas, and watershed scale information needs for exact figuring's measurements as more then to gauges. A full set of annual aerial photographs of the study segment would benefit this study by increasing the accuracy of the annual erosion rate estimations. Furthermore, suspended sediment data for the entire range of flows of the Sangu and Karnafully Rivers would eradicate error derived from load estimate techniques. The erosion rates used in this study were derived from the aerial photograph analysis and applied for many unmeasured lengths of channel banks. The outcome of this research should be considered as a possible example of erosion rates and an example of the potential source of fine sediment and sampling point that bank erosion could be for the Sangu river. For the particle size analysis need more precisely analyzed in the lab for more accuracy and need to study more about this soil particle size in both sides of the river.

The impact of riverbank erosions on water quality in the watershed can possibly be noteworthy, and erosions control measures would be an important 'Best Administration Practice' (BMP) in the Sangu River watershed. Significantly if BMPs to reduce bank erosion were instituted in the eroding areas like the ones measured in this study. According to the title of this study, these objectives are not enough. For this study, we need more study the morphological process of this river. We would need to calculate the river water flow and morphological process daily and have to collect the soil sample from the river at different time variations. Those samples were needed to do a lab test by wet chemistry analysis. After estimation of the clayey fractions by Stokes law, we can determined how much sediments are deposited in every period. Also, we need to study to find out another source to cultivate the shrimp in Bangladesh. For the time and fund limitations, we studied the trends analysis of these rivers last 28 years, land-use changes because of riverbank disintegration and Particle size examination of the two sides of the stream.

Some other limitations of this study is given below:

i) **Lack of Accessibility:** The areas of erosion and deposition were somehow inaccessible that has made the data collections challenging. Many researchers had to spend more time to reselect the sample locations.

ii) **Absence of accessibility of the Secondary information of the Study zone:** As stated before, many few studies have been found focusing on the Sangu River. Moreover, no such study was found that might give an idea about the changing pattern of land uses due to the erosion and deposition of the river.

iii) **Lack of Instruments of soil particle analysis:** Researcher had faced difficulties in managing modern instruments to collect and analyses soil sample. That is why he decided to do the analysis using the hand to create an assumption alongside the lab analysis.

iv) **Lack of Manpower:** The study became difficult when the researcher could not manage an assistant for the field work.

v) **Unfavorable Weather:** During the sample collection, it was raining that hampered the field work. The researcher had to reschedule the work for many times that consumed more times for soil sample collection.

1.6 Organization of the Thesis

This thesis has been organized with various chapters. The brief overview of the chapter, as given follows:

Chapter 1- Introduction: This includes the background, significance, objectives, Limitations of the study.

Chapter 2- Literature Review, Hypothesis and Study Questions: This chapter is included in the literature review of this study, some hypothesis related to this study and research questions.

Chapter 3 – Methodology: The chapter provides more insight about the techniques and methods that was implemented to collect and analyses data from the beginning to the end of this project.

Chapter 4 - Pattern Analysis of River Bank Erosion and Sediment Budget: Describes the different erosion and deposition side of the Sangu Rivers in yearly based.

Chapter 5 - Particle Size Analysis: Describe the molecule size examination in the Sangu riverbank disintegration and statement side.

Chapter 6 - Land Use Change because of the riverbank erosion: Discusses the land-use change because of the riverbank disintegration in the Sanug River.

Chapter 7 - Findings, recommendations, and conclusion: Describe the total findings, some effective recommendations to solve this problem in the study area.

Chapter 02: Literature Review, Hypothesis and Research Questions

2.1 Literature Review

Riverbank erosion is a common issue in many countries; however, the nature and effect of erosions may different. It is a major issue for the financial sector of our nation as well. Flood plain sediment of quaternary development represents a large portion of the terrains of Bangladesh. The geographical setting of Bangladesh between the large mountain part of the Himalaya and the most important bay is Bay of Bengal, due to this relations Bangladesh also influence by most powerful tropical rainstorm. The total catchment zone of the actual rivers flow is about 1.65 million square km, which simply 7.5% exists in the edge of Bangladesh (Sarker et al., 2003) that makes 1200 km^3 of rivers flow each year, only 10 % of which is created inside Bangladesh.

2.2 River Bank Erosion

The word Erosion is a Latin expression called "rodere" which signifies 'steadily diminish', a similar cause that gives us the word 'rodent'. Essentially erosion means soil expulsion from the lowers surface. As per Dictionary.com, it is characterized as the procedure whereby the earth surfaces are eroded by different operators which incorporate breezes, water, waves and so on. From an alternate purpose of perspectives, the origination of erosion may fluctuate. From an organic perspective, Erosion is "the changing of a surface by mechanical activity, rubbing, warm extension constriction, or effect." The importance looks somewhat changed in the agriculture. In agriculture, soil erosion is characterized as the washing endlessly of agricultural field’s upper soil through normal natural physical circulations wind, water or thermal energy related with cultivating exercises, which incorporate with agricultural ploughing. In the field of Geology, "Erosions includes the development of extricated or endured materials starting with one area then onto the next. This may happen because of the operators of gravity, erosions, moving water and moving ice." In normal term, erosions is the procedure whereby soil and shake particles from the world's surface are evacuated through exogenic procedures like water stream, wind or by some other regular or human exercises, which is then shipped and stored in different spots. The procedure includes a soil weathering process brought about by water powers or wind powers (Oldeman, 1991-92). Despite the fact that erosion is a natural procedure, inordinate riverbank erosion can prompt desert infringement, environmental breakdown, farming profitability brought about via land degradations and sedimentation of waterways.

2.3 Discussion about River Bank Erosion

Riverbank erosions include a geo-morphological procedure along the alluvial flood plain rivers. Additionally, the procedure incorporates wearing of the banks along the stream waterway because of bank routing, bank change and alteration in bed height and geography response to adjusted bank obstruction and stream conditions. Bank erosions happens normally and without this stream it is beyond the meander. The serious riverbank erosions prompt overwhelming relocations along the bank line of the streams and its effect on the financial change.

2.4 Impacts of River Bank Erosion

There is a more noteworthy effect of riverbank erosions on society, individuals, condition, nature and culture. High increment in erosion can prompt decrease water quality, which adversely impacts stream conditions, and it can prompt loss of indigenous species. Nevertheless, plants are developing on the bank determines the strongest of the bank soil and give overhanging trees, grasses, shrubs and reeds which give sanctuary to aquatic species and other aquatics life forms. The tree root which develops along the bank creates an environment to live fish and different aquatics creatures. The amphibian species rate also decrease, when the riparian vegetation is destroyed. Riverbank erosion can prompt shallower, more extensive streams with uniform sandy beds that are not appropriate for environment for some amphibian life forms. Additionally, Erosions made by riverbanks can quickly exposed, appropriated surfaces that can fill in as a point of convergence for wild plants colonization and infiltration into stream scenes. At the point when the silt settles at the base, it's made the living space for some top surface living plant and animals. The vast majority of the riparian territories are considered as areas for both cultural and environmental importance. The quickened erosions of the riverbanks can legitimately impact the social relics, for example, structures, wharves, landmarks and embankments. Erosions of the riverbanks can adversely impact the social associations between individuals concerning extraordinary territories of the scene. Riverbank erosions additionally assume a significant role in financial changes. The displaced of individuals generally experience generous financial hardship and impoverishment, which causes of the individuals need to leave their original places. (Islam et al., 2011).Due to erosions , the uprooted experience the bad effects of poverty, earnings disintegration, occupation change, removal shelters, social obliteration, decrease the quality of livelihood and numerous others.

2.5 Mechanics of Bank Erosion

Bank Erosions incorporates a geomorphic procedure which happens because of changes in channel measurements along the horizontal enlarging. There are high effects of bank erosions in the investigation zone brought about by moving Stream River that will in general erode the banks, extend the channel through undermining and bank giving in procedure. Be that as it may, the bank line accessible in the investigation zone is erratic, and there are broad bank reverting in many territories along the waterway Sangu during the rainy season. The reasons for river banks failures in the study zone include:

- Direct effect of the erosions along the Riverbank
- River Bank Erosions caused because of the impact of leakage from the banks at low-level stream release;
- Underwater erosion alongside the river bank toe during the falling stage of the river;
- Liquefaction of saturated silty and sandy bank material;
- Scour around the waterline which is caused by wind wash or wave of passing vessels
- Sloughing of the saturated bank is mainly caused by quick drawdown.

2.6 Riverbank Morphology determines the magnitude of Bank Erosion

Rainwater run up down mixed get together to made a water flow. This area is makes a space where opening channel where stream runs. A river is a term used for a redirect and the water in it. The watershed area fills in as the zone where water is being given in the channel. A watershed model is a portrayed path close by a river system. A stream has different types of land structure through channel. The main water channel system processes involved sedimentation, erosions and transportation.

The buildup particles which move to the lower come to in a channel is called residue load. Nevertheless, the suffering system of the stones, which involve slopes, is the major driver of the sediment weight, and this sediment generally traveled with the movement of streams. The higher water speed, the more effect and capacity in a river system for load transportation. The transported sediment is commonly deposited in an alluvial plain. There are three basic channels plans which recognize the alluvial fields, which consolidates twisting, straight and fit (Unnayan Onneshan, 2011). Flooding brought about by substantial downpour which conveys a lot of bed load from mountains can move bed load which can all of a sudden be decreased. Most occasions, the particles of bed weight are stored by the relative size, where an alluvial plain is encompassed. An alluvial fan consist of gravel formed which as the topper layer of an alluvia plain. The outside of an alluvial fan is like as a cone segments area. The twisting profile towards the lower reach is a twisted and calculated cross-sectional profile. A delta is made pretty much a stream mouth which contains fine sand particles. The morphology of a delta depends massively on the fluvial and marine system.Regardless, flood plain involves typical embankment of the river and back lowlands which has the transitional district between an alluvial fan and a delta. An environmental embankment includes both silt and sand. Clayey stores scatter at the back bogs are wet and lower diverged from the regular levees. The drainage channels in the alluvial fan are connected each others, and it shows a braided shape. Exactly when large amount of water flashes from the mountains a flood made by this water, the most of the channels in alluvial areas change their directions, and the as of late structure channel is kept up until the next flood. Previous channel is left, and it supplies water as ground water. The lower lands at close to the gave up conduit keep up its features for the both deltas and floodplains. The stream morphology makes channel models and channel structures (Matsuda, 2004), and this essentially depends upon various factors, for instance, water surface inclination, significance, discharge, water speed, conduit bed materials and width of the channel, etc. These factors are not independent, yet they are interconnected to each other.

Previous erosions in the upper land at zone of a watershed and valleys include different slopes and channels. Regardless, the river bank erosions is results of the hydraulic movement or pressure of waters bodies in the river channel , which forces makes the channel deeper and wider. These techniques are also determines to be parallel erosions, and it builds up on the erosions, separately. The riverine improvement takes places in zones where expanding previous erosions, while channel with increasingly broad riverbed is molded by parallel erosions. Similarly, the eroded particles are stored in the valley base, the transportations of sediments help water flow and bear in lower part of the valley.

2.7 Causes of Riverbank Erosion

In the coast areas of Bangladesh, main causes of river bank erosions is depends on different factors like as waves , high monsoon wind, rivers flow, storms surges , tidal surges etc. (Ali 2000). The riverbank erosions generally happen through a included of three important components, for example, mass failure, sub-areal weakening and weathering (fluvial erosions).

Nevertheless, the sub-aerial procedures are determines to as "Preliminary" forms, which influence the bank before the fluvial erosions (Mengoni and Mosselman, 2006). Also, the sub-airborne procedures are controlled in the upper reaches by the fluvial erosions is situated at the center. There is an event of mass failure along the lower spans of a stream. Fluvial erosions includes the unit of particles from the outside of the bank along the water powers activity; mass failure can increase the breakdown of bank material affected by gravity; weakening procedure includes the change of soil segments which increment bank erodibility and hence increment bank erosions. Declination lines along the main channel of the bank and bank lines flowage liquefaction process could be affected by, or caused by shearing off the banks of the elements. This sort of erosions process functions when the flow of water is high and low in the rivers. Regardless, during the low water flow in the river, the degraded part or weathered materials of the river bank are start to new erosions which play a role to collapse by internal water pressure and wave functions. In the durations of low in the rivers, the water wave pressure against the embankment of channel is decreased, this enable water to move from the improvement indeed into the channel dividers by reducing and water moves from the course of action back to the redirect run-off which results to following erosions (Throne, 1982). Presently, the investigation regions are looked with mass failure and fluvial erosions along the riverbank erosions. At the point when the rainstorm time frame starts, plentiful precipitation happens in those areas and in the upper materials of the soil structure eroded. All the more seriously, fluvial erosions persuade in those parts since the natural waters flow is plaited. This type of erosional procedure can prompt mass failure in certain zones.

2.8 Environmental misfortunes

Normally, river bank erosions in a areas doesn't just influence its foundation or landmass, yet it additionally influences the earth in the region for short or long term. Erosions of the river sangu situated at Banshkhali and anowara Upazila has some natural issues appended to the fauna, greenery and fisheries in the regions. In the study most of the people also used to house based farming plantations. Likewise, Most of the house planted some regional based flat in their house open spaces. Because of serious river erosions, the trees populations are diminished, which may prompt desert invasions. The vast majority of the individuals here cut and sells youthful trees because of the invasions of the land. Diligence in erosions has prompted land loss, which is on the expansion just as the loss of farming and forestry. The new char land of the river side area need to long time to made the perfect soil layers for the perfect plantations. Likewise, the fisheries area is the most influenced division of the environments. The measure of fish cultivations is reducing with time durations. In one side the river bank erosions and other side the char land increase in the middle of the river, which decrease depth of the river and also change the directions spawning of fished items. Due to the bank erosions and the depositions process new char land are created in middle of the rivers and the rivers depth and flow directions are changed, the fishes spawning directions are also changed. The siltation procedure additionally influences the route of the stream by decreasing the quantity of fishes.

2.9 Changes in Soil Fertility

There is a remarkable change in the soil particles of the eroded part of river bank. Because of siltation, the upper part of the soil are covered a thin layer of sand, this layer isn’t so much rich. The loss of the topsoil makes lead to desolate land, which isn't valuable for rural reason. The upper part of the land is sandy and wasteful, which can prompt low crops generation and restricted yield species. Most occasions, some farming items, for example, pumpkin, peanuts and kaon are collected in the scorch lands (Bhuiyan et al. 2017).

2.10 Losses of Aesthetic Beauty

It is hard to express the loss of aesthetic value of the study area in terms of economically. As indicated by the nearby individuals, Most of the old people seen long areas paddy fields, house settlement, which parts alluded to as sandy char land, individuals move and lose town settlement in the rivers. There was an engaging region of the nearby plant species recorded from the neighborhood woodland zone, which isn't accessible in the study area. As the market diminishes, numerous individuals change their methods for money and move to a good area. Bangladesh is a under developed country most of place we saw that the unplanned structure, as like as in this area also we see lots of unplanned embankments and street which are really wretched conditions for the suffering peoples. This gigantic difference in river stage can prompt pressure with respect to tasteful issues in the examination region. Likewise, the infertile spot right now; was at one time a delightful town or profitable cropland. (Bhuiyan et, al; 2017).

2.11 Particle Size Analysis

Particle size analysis refers the soil elements arrangements of the fundamental particle of the soil. Molecule shape, According to the USDA classifications plot, soil is classified into three parts as per as characteristics and compositions of soil: sand (2.0–0.05mm), silt (0.05–0.002 mm), and clay (,< 0.002 mm) (Gee and Bauder, 1986). Actual particles size is also refers the percentage of sand, silt and clay in the soil. The texture of soil (% sand, silt, and clay) influences soil-water maintenance attributes, draining and erossional potential, plant nutrients quality, natural issue elements, and carbon-sequestration ability. The soil textural examination fills in as the fundamental part for informational index utilized for evaluating soil quality and manageability of agricultural practiced. Nevertheless, regular strategies for soil textural investigation are expensive ($7–$18persample) and tedious, requiring specific gear such as hydrometer, sedimentation chambers, pipettes, durations, and assets to process tests through research or business labs. Moreover, the innovation isn't promptly accessible to farming advisors, protectionists, and some special people whose are involved with the productions. The texture of soil investigation is made by first scattering the soil into major primary particles, trailed by segmentations and measurement of every molecule size.

Commonly, clay mineral particles are little enough to be assembled as clay particles size class. Then again, non-earth minerals, for example, quartz or feldspar break down rapidly before achieving such little estimates. Both synthetic and physical action of the earth in the soil is related to both components; Small particle size are defined as a in the high surface area how much particles as per unit area, while the mineral science can express the high potential ions in the soil.

In the compositions of soil found the fine particle size which determines the soil fertility, water content in the soil, ploughing capacity of the soil, which fill in as one of the fundamental distinct qualities for mixing soil particles and soil layers. The United State Department of Agriculture, the classifications of soil particles, is expressed on the soil particles size or textural surface triangle.The primary factor in charge of molecule size investigation is the scattering or decimation of soil totals into discrete units through compound chemical or mechanical procedures pursued by the detachment of the soil particles utilizing sedimentation and sieving techniques. The chemical dispersion is accomplished through the evacuation of solidifying substances which incorporate natural issue, iron oxides, just as supplanting the magnesium and calcium particles which will in general tie soil particles together in an amassed segment with sodium particles (encompassed by each dirt molecule and film of hydrated particles). Both magnesium and calcium particles are expelled from the arrangement through hexametaphosphate (Calgon) anions or complex oxalate process (Baver et al., 1972; Gee and Bauder 1986; Sheldrick and Wang 1993).

Particale size distributions (PSD) are vital for both basic and hydrological properties of the silt tests, which can be utilized to clarify the pace of course through the development layers. The molecule size dissemination is the most ideal method for gathering silt and soils for translations and appraisal reason (Blott and Pye, 2006; Di Stefano et al., 2010). Furthermore, particle size analysis can be utilized for penetrating coarse silt sizes which encourage simple boring, while better grain size decreases the rate of boring. The bulk soil sample is used for the investigations of environmental indicators and as sedimentary sample investigations (Watson et al., 2013). The textural analysis of the soil is most important parameters for understandings the characteristics of sediments contends.

In the present, there is no all inclusive model to recognize past depositional situations because of the molecule size information (McManus, 1988). The particles size distributions of soil indicate the flow energy of the sediment and different process of the sedimentations which influence the depositional area (Long; et al., 1996).

Normally, alluvial soil or flood plain area is unpredictable and it comprise of lots of sedimentary process which are depend on the different factors and which incorporate with physiographic and river flow (Long et al., 1996). The flood plain soil layer successions comprise of a wide scope of molecule ranges which extends from silt and clay connected with rock and sands of channel fills. Additionally, the PSD is a valuable analytical process which helps the investigations of previous alluvial flood plain settings, supporting the recognizable proof of long term changes related with the starting point of the alluvial flood plain and the distinguishing proof of explicit sub-situations (Dark and Allen, 2005). In 1988, McManus expressed that there are wide scopes of granulometric systems which are promptly accessible to the sedimentologist. In view of the investigation of silt tests from a beach front arrangement and floodplain, utilizing the instruments, for example, X-beam nephelometry, enraptured light or the dissipating of laser have promptly supplanted the more established techniques which depend incredibly on the pipette, coulter counter or hydrometer (Allen and Thornley, 2004). The x-ray scattering sets aside some effort for examination of a wide size scope of tests just as little size examples (Storti and Balsamo, 2010). Furthermore, the scattering examples are utilized to manage shape of the molecule from the light dissipating strategy, which was created by the Mie hypothesis (Allen, 1997).

2.12 Criteria for Suitability of Hand Drilling Techniques

Evaluating the right systems for hand infiltrating can massively depend upon the geological section, geo-morphological sensibility and sediments permeability.

2.13 The Geological Suitability

Topographical maintainability is intently connected with the strength of the strata during rock arrangements (Kane et al., 2013). The hand boring strategies are reasonable for unconsolidated sediments, which don't permit boring in hard arrangements. However, the sediments developments are appropriate for hand penetrating application, in particular for clay, delicate sand and sediment. Manual penetrating techniques are conceivable just in explicit geologic developments (Weight et al., 2013). Likewise, there is no accessible information's on topographical appropriateness in recent investigation, in spite of the fact that the hand drilling is generally utilized. This analysis has concentrated on the alluvial floodplain residue to assess the topographical appropriateness for manual boring techniques. With respect to the data over, the topographical reasonableness for manual boring strategy relies upon the delicate irregular flood plain developments.

2.14 Sediment Permeability of the soil particle

However, the penetrability highlight reasonable for physically penetrated wells relies upon the likelihood to physically bore a thin borehole in the porous ground, which can produce a massive flow rate (Kane et al., 2013). It is need to comprehend the kinds of sediments arrangement which have been penetrated either porous or impermeable. Porousness is the procedure whereby residue arrangement transmits water by going through it (RWSN, 2010). There are various kinds of sediment developments accessible during boring, which incorporate sediment and sand, mixed arrangements and clay. The table underneath demonstrates the order of the particles measures in alluvial silt tests.

- Sand and silt arrangement: This procedure permits simple progression of stream flow within the open area, which is easily accessible in the sediment particles sizes. The technique is penetrable. At the point when penetrated through this sort of development, water may fill the borehole without the problem, and it very well may be utilized for water system exercises or different purposes.

- Mixed developments: This technique comprise of sand, clay and sediment mixture. It enables water to stream gradually through the mixed developments, which are discussed as a semi-penetrable procedure. At the point when bored through this development strategy, it permits a moderate progression of stream flow in the soil.

- Clay: The clay properties of sediments are normally adhesive and don't enable water to stream effectively through its development, which makes it impermeable. At the point when bored through this arrangement technique, it is retards the water permeability in the well; this procedure determines the well to be unfilled.

Table 2.1: Classification of the particle sizes in a sediment sample (RWSN, 2010)

SN	Particle name	Particle size (mm)
1	Clay	<0.004
2	Silt	0.004 to 0.06
3	Sand	0.06 to 2

According to these classifications, silt, sands and mixed arrangements are profoundly recommended for hand boring procedures because of their developments which permit the progression of water and revive which can be effectively separated for water system purposes. Sandy sediment developments are increasingly penetrable in light of the fact that they permit the progression of groundwater effectively through open space, and they are additionally reasonable for hand penetrating techniques for layers.

2.15 The Geo-morphological Suitability

Geo-morphological appropriateness is characterized as the presence of a morphology surface which encourages the aggregation of unconsolidated materials, which incorporate the nearness of endured layers and limited water profundity. These zones are related with the base of the valley, and it is sometimes identified with a level territory with restricted slope (Kane et al., 2013). Nevertheless, hand boring is viewed as attainable dependent on unconsolidated alluvial arrangements (residue, sand and earth) with mixed layers of laterite or delicate sedimentary (PRACTICA, 2010). The mapping of hand drillingis normally reliant on the examination of existing information, which incorporate neighborhood hydrogeological data, exchange and meetings with individuals. Likewise, details data with respect to the current water focuses point for both past information and direct field perception, well logs, land maps, satellite pictures, field overviews, geographical maps, and transport radar geography data can give sign of the effective hand boring in the area (PRACTICA, 2010; Carter et al., 2010).

2.16 Land Use Change from River Erosion

The land-use or land cover change is normal terminology utilized for people's alteration of the world's earthbound surface. Generally land use change incorporate street development, forest area change, change of land or soil, farming improvement, beach front zone debasement, waste, mining, wetland alteration, change of harvest assortments, wetland adjustment, dam fabricating, the extension and centralization of urban situations just as other human exercises.

In 2009, Kashaigili described that for the sustainable ecosystems need to satisfactory utilization of land and the proper utilizations of water. From this findings, the examination features the significance of incorporating remote sensing's and essential learning in understanding the catchment assets elements are changeable and need to update the data about the policy makers proper land utilizations and sustainability of the catchments resources. Bangladesh is a mostly populated country in the world, because of increasing populations have more demand upon food and others most economics activities are depend upon the water resources.

Additionally, spillover from agrarian terrains can prompt surface water contamination, which can hurt sea-going lives (EGIS II, 2001). Late examinations demonstrate that decrease in biodiversity, land and water proficient and oceanic assets, just as untamed life territories, can prompt a noteworthy change in wetland-based human occupations and decrease in the financial exercises (Islam and Sadque, 1992).

2.17 Land use situation in Bangladesh

In the mid 1950s, Dudley Stamp presented the land use study in Bangladesh. He was made research with the Department of Geography at the University of Dhaka, he was made first land use map of Bangladesh. After the 1980s, the governments of Bangladesh coordinated the land use information at regular intervals. As of late, there are an extensive number of researchers which concentrated ashore use directed in the nation. Between these researchers most of them are worked with the land use change or land use classifications of Bangladesh. Furthermore, some researcher work also about urban areas of Bangladesh; the fundamental spot light on urban development or ecological changes incredibly rely upon urbanization. Late research completed by Dewan and Yamaguchi (2009; 2012) utilize satellite pictures from 1975 to 2003 and other accessible financial information which demonstrates that generous development is worked in zones because of populace development and monetary advancement. This has prompted a diminishing in water bodies, vegetation, developed land and wetlands. In 2013, Mamun distinguished the critical changes in land use design in Dhaka the capital city as a contextual investigation. What's more, a small scale level examination which spotlights on Thana in the capital city Dhaka completed by Raihan and Kaisar, 2012 demonstrates that the land use change happens in the previous ten years (1997 to 2006). In 2012, another smaller scale level examination was completed by Kumar and Ghosh in an island as an investigation regions and the discovery of the progressions which occurred during the previous 22 years. Another study by Rahman and Begum, the changes among the housestadt or settlement area, agricultural land area, and also surroundings areas of Sundarban mangrove forest over the past 30 years. For realizing the changing example of land use, Islam and Hassan (2011) distinguished the rural land use value in the study area and concentrated on the rural utilization of land, which is diminishing definitely. They anticipated that following 217 years, rural land would totally be supplanted by another type of land use. Also, they don't think about another factor while anticipating this predefined year of substitution.

In 2011, Chowdhury complete a initiatives study the whole land cover changes of Bangladesh. They took a brief period for contemplating between eight years (2000-2008) and furthermore limited their investigation ashore spread change location. Another examination completed in the nation (Dey et al., 2012) concentrated ashore disintegration just as the loss of land because of the characteristic and anthropogenic components. In the reason for doing this, the examination additionally centered around land debasement with respect to changing area use.

The vast majority of the investigations didn't accentuate land-use change identification but instead spotlight on the effects or outcomes on it. In 2008 Dewan and Yamaguchi recognized the connection between land spread changes, waterway and their outcomes demonstrates that there are quick changes in the land spread, which assume a significant job in increasing the flooding procedure. In 2008, Rasul made another study where he wants to showed different factors of land use changes. They found that institutional help, beneficial asset, separation to market and administration focus are in charge of the advancement of three different types of land-use frameworks in the city of Bandarban, a bumpy region in Bangladesh. In 2006, Ali gave more knowledge into the effect of shrimp cultivating on the rice environment while talking about the land-use change dependent on its movement.

2.18 Shrimp Cultivation

The creation procedure of shrimp is controlled and encased in the water body, which is alluded to as Shrimp development. Both freshwater and saline can be utilized for this development procedure. Nevertheless, shrimp is known as the swimming crustaceans which live in the hot saline marine water found in the tropics and subtropics (Anwar, 2013). The generation of cultivated shrimp has been expanding at the exceptional yearly rate somewhere in the range of 20% and 30% since 1990 (Primavera, 1999). Previously, shrimp cultivating was presented in the seaside zones, particularly in the South western khulna sathkira and some part of the Chittagong divisions area.

Nowadays, shrimp cultivations are developed around the seaside area, and Bangladesh supplies at least 2.5% of the world generation of shrimp which makes it the seventh biggest exporter positions in the world. Bangladesh export shrimp mostly to the USA and the Japanese markets (Acqua International, 2012). Shrimp cultivations are viewed as an important item since they fill in as one of the principle wellsprings of vocation in Bangladesh where more than 2.2 million individuals are straightforwardly associated with this division, and around 11 million of the all out populace are by implication included. In Bangladesh, Total 25 million hectors of areas are cultivated the shrimp cultivations this amount of land were supplied the 129.8 million pounds shrimp in the year of 2009-2010. By and large, fisheries add to about 5.5% of the national GDP and at any rate 7% of absolute fare salary, which makes the nation third significant exporter on the planet. A portion of the fishery products sending out shrimps, for example, crisp water scampi (Macrobrachium Rosenbergii) and Black Tiger (Penaeus Monodon) improves remote trade in this segment (Acqua International, 2012). What's more, the financial motivating forces enable nearby ranchers to develop more sections of land of grounds for shrimp cultivating, which are impromptu and indiscriminately extended. Likewise, for the shrimp cultivations need to marine saline water, this collected from rivers or canal comes from Bay of Bengal incorporate nearby cultivating frameworks in all sub-areas of the fishing's and handling frameworks utilizing inorganic synthetic compounds that are hurtful to the ecosystem (The Independent, 2002). The vast majority of the means utilized during the time spent impromptu shrimp development extraordinarily impact the dirt and horticultural yields, biodiversity, nature and maintainability in the beach front regions of Bangladesh. The extra exercises of shrimp ranchers with respect to shrimp generation require shirking in upsetting among the network or lower class just as thinking about their wellbeing status.

2.19 Hypothesis and Research Questions

- Some parts of the Sangu River are eroded, and the depositional materials occupy some other parts through the year.

Question: Why are many parts mostly eroded or deposited in Sangu River?

Questions: How much erosion and deposition are occurring in the Sangu River?

- In the Sangu River, flood plain area, are mostly affected by erosion, and some sediments are washed out.

Question: How much areas of the Sangu River are affected by erosion?

Question: If the deposition is lower than erosion, where the rest of sediment goes?

- The eroded area's soil is mostly abundant with clay and silt and the soil deposited areas are mostly sand and silt based.

Question: How is the soil composition at theerosion side of the Sangu River?

Question: How is the soil texture at the deposition site of the Sangu River?

- The different land utilization of both banks of the Sangu River is affected by the continuous erosion in the river channel.

Question: How does river bank erosion affect the land use change in this area?

Question: How much areas are changed due to the morphological movements of the river?

- Some of the agricultural lands of the Sangu river area convert to shrimp cultivation.

Question: How much agricultural land is transformed into Shrimp cultivation in this area?

Question: Why farmers of these areas are forced to convert their agricultural land to shrimp cultivation?

Chapter 03: Materials & Methods of the Study

3.1 Selection of the Study Area

"Sangu River is located at the latitude of 21'13'N and longitude of 92'37'E in the Northern Arakan Hills which form the boundary between the Chittagong Hill tracts and Arakan. It incorporates the locale running from the east and moves through the west over the area. It's some parts are mixed with Bay of Bengal along the piece of the deal km (173 km inside the Bangladesh region) at 22'6'N and 91'51'E towards 16.09 km in the southern part".(Banglapedia-2019)

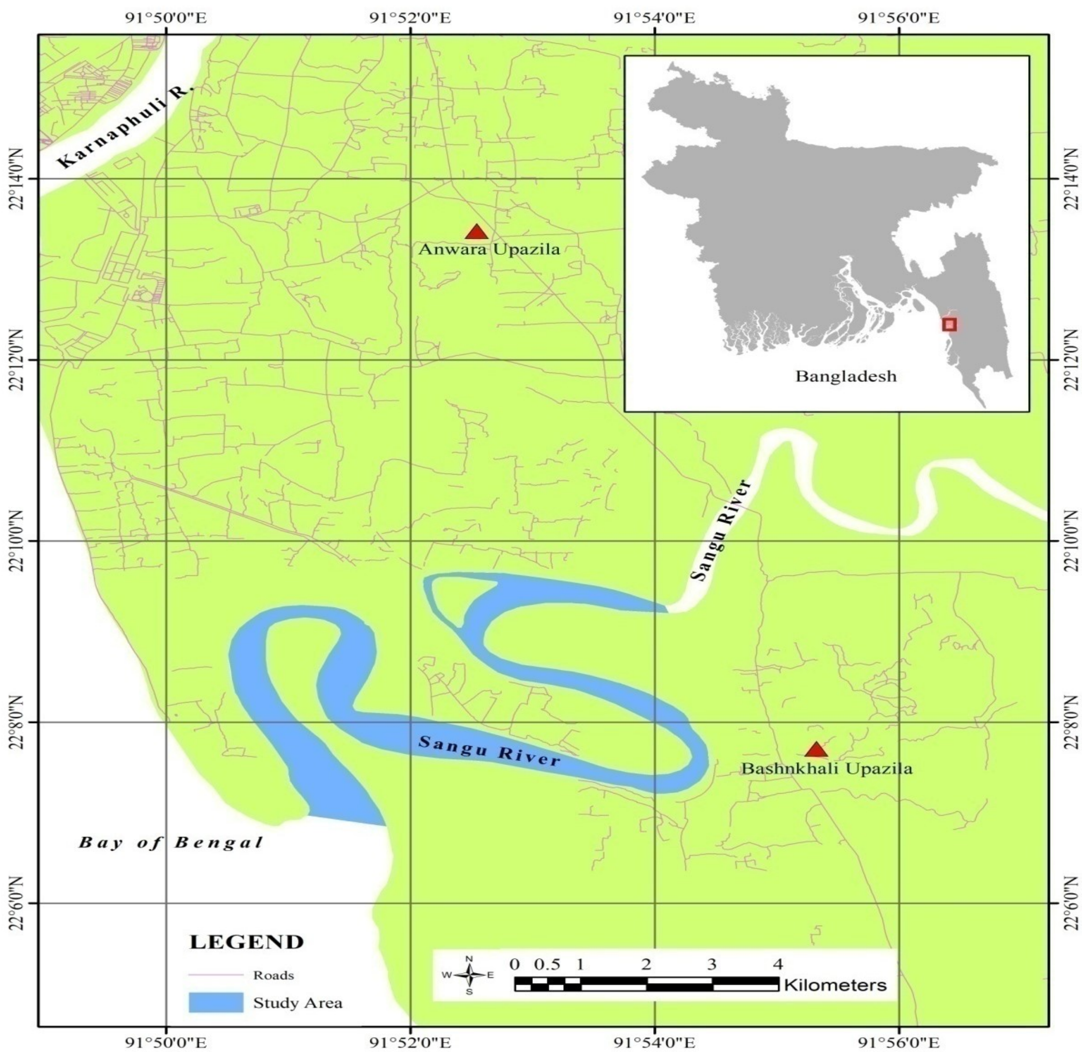

Figure 3.1: Location of the Study Area

The Sangu is considered to be an important river since it drains off the waters from three different locations, which include Bashkhali, Patiya, Upazilas and Satkania. In addition, it is correlated to Karnafuli river also with the Chand Khali river. The Sangua is a lower deeper river which is more dangerous during the raining season due to rapid currents. It is accessible up to 48.27 km from the inlet.

The bank of Sangua river erodes in different locations of Anowara,Banskhali, and Satkania. Among these three regions, Anowara and Bashkhali Upazila has been selected for conducting the present study

3.2 Description of the Study Area

Anowara Upazila: "Anowara Upazila (Chittagong region) territory 164.13 sq km, situated in the middle of 22°07' and 22°16' north scopes and in the middle of 91°49' and 91°58' east longitudes. It is limited by patiya Upazila on the north, banshkhali Upazila on the south, chandanaish Upazila on the east and Chittagong Bandar thana and Bay of Bengal on the west" (Banglapedia-2019). It has a total population of 228530, where 116642 are male, and 111888 are female (Bangladesh Population Census 2001). The average literacy rate is 47.2%. This Upazila has had total 28.32 km paved, 59 km semi-paved and 409.31 km mud road. Being a rural area, still, more than 40% of the population are practising the agriculture, and a substantial number of them have been living next to the river, mostly those whose main occupation is fishing (Banglapdia 2015).

Banshkhali Upazila: "Banshkhali Upazila (Chittagong region) territory 376.90 sq km, situated in the middle of 21°53' and 22°11' north scopes and in the middle of 91°51' and 92°03' east longitudes. It is encompassed by anowara Upazila and Sangu stream on the north, Chakaria Upazila on the south, lohagara and satkania upazilas and wide bumpy locales on the east, Bay of Bengal,Kutubdia channel and kutubdia Upazila on the west"(Banglapedia-2019). The total population of this upazila is 391320; where 205482 are male and 185838 are female(Bangladesh Population Census 2001). The transport system is still not developed here as it has only 173 paved roads while more than 750 km of the road remain unpaved. In this Upazila, about 60% of people are involved with agriculture, and the rest are incorporated into industries, daily work, construction, non-agricultural laborer and business (Banglapdia 2015).

In both theseUpazila (sub-district), dams are constructed in different locations to prevent riverbank erosion; however, these are not sufficient at all. The embankments of Sangu river in AnowaraUpazila are most developed by the Local Government Engineering Department (LGED). Moreover, the forest department has planted many trees beside the dam. On the other hand, in Banshkhali, most of the dams have been built by the local people. There are still vast areas of agricultural land located next to the river banks.

3.3 Data Sources

To make the primary map of the Study area arrangement of the satellite map, symbolisms were well known from Google Earth 7.0v, which was joined physically and utilized as primary study level investigations for highlight acknowledgment. For the particle size sampling and riverbank erosion and depositions, the map is collected from Google Erath map in all-time 15-meter resolutions. The most recent high-regulations satellites photographic given by Google Earth and NASA-GLCF (Global Land Cover Facility) Archive (uninhibitedly downloadable around the world) for Landsat TM and USGS for Landsat 8 satellite map are used to analysis the visual interpretations, land use identification and classification. Many primary and secondary data were required for this analysis. This data were gathered from various sources. Likewise, a portion of the data was gathered through the audit of the past investigations on Arial Beeland through examining later distributed and unpublished materials. Other optional information which comprises of spatial and non-spatial measurements was gathered from “Bangladesh office of International Union for Conservation of Nature” (BIUCN), “Bangladesh Agricultural Research Council” (BARC) and “Soil Research Development Institute” (SRDI) and from different journals and publications. Some important Satellite pictures and maps utilized for the investigation were gathered from the “Center for Environmental and Geographic Information System” (CEGIS). Total data like as Landsat TM, Landsat 7 and Landsat 8 OLI-TIRS sensors have a spatial resolution of 30m and 15m (Table 3.1)

Table 3.1: Satellite Image Meta Data Information (Data Source: USGS earth explorer website, accessed on 26th August 2018).

Year	Image ID	Acquisition Date	Sensor	Resolution
1989	LT04_L1TP_136045_19890121_20170204_01_T1	21-01-89	Landsat 4	30m
1994	LT05_L1TP_136045_19941213_20170110_01_T1	13-12-94	Landsat 5	30m
1999	LT05_L1TP_136045_19990125_20161219_01_T1	25-01-99	Landsat 5	30m
2004	LE07_L1TP_136045_20040115_20170122_01_T1	15-01-04	Landsat 7	30m
2009	LE07_L1TP_136045_20090128_20161222_01_T1	28-01-09	Landsat 7	30m
2014	LE07_L1TP_136045_20140126_20161119_01_T1	26-01-14	Landsat 7	30m
2018	LC08_L1TP_136045_20180129_20180207_01_T1	29-01-18	Landsat 8	15m

N.B: All the map take in path 135 and row 46, have no cloud and in the winter season, UTM zone 46 Northern hemisphere projection.

3.4 Data Collection Methods

As this research aimed at detecting the morphological changes of the river and subsequent land-use changes, it has implemented different techniques to gather data. Furthermore, analyzing particle sizes of riverbank sediment was another motive of this study. Thusly, this exploration depends on both preliminary and secondary data. Information gathering techniques are showed in the chart.

3.5 Mapping of Morphological Change through ArcGIS

Remote Sensing is defined, where the data about an article, territory, or wonder is procured from a separation, without contact with that item, region, or marvel.

The methodological steps of mapping in ArcGIS are demonstrated in the following figure (figure 3.2):

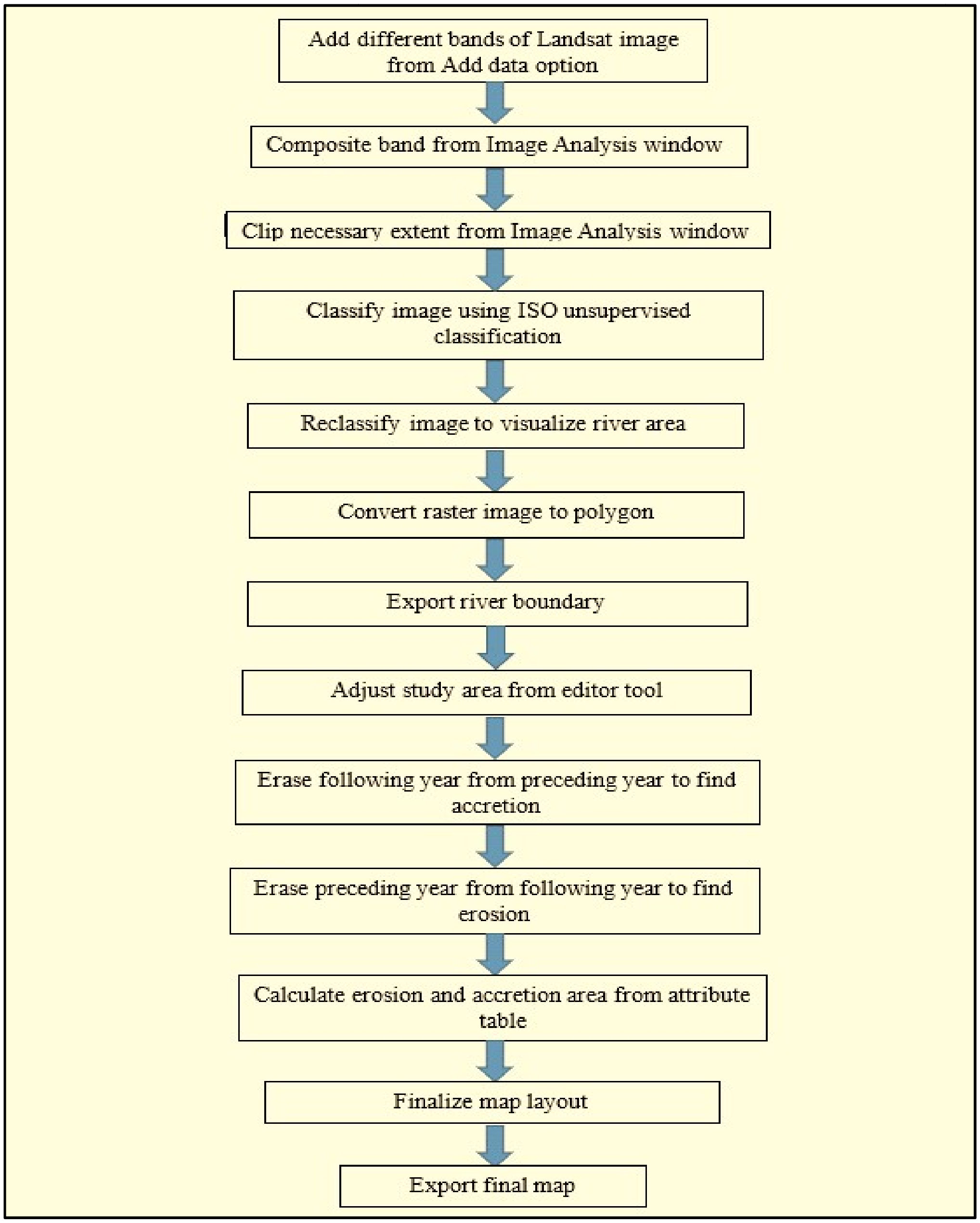

Figure 3.2: Methodology of River Course Change Mapping in ArcGIS.

The main idea of remote sensing innovation is the arrangement of pictures by signaling the transmitted and reflected electromagnetic radiation from an item, territory, or phenomena from the long distance. Spatial data is separated from the investigate of those pictures. Regularly, this data is ordered and converged with another type of investigation and application is called GIS (Lillesand et al., 2008).

This study has detected the erosional and depositional areas of the Sangu river and those areas were mapped through the use of ArcGIS application.

3.6 Application of Remote Sensing to Detect Land Use Change

This Study is additionally reliant on Secondary information. Present and past data on the river bank direct change in the overview zone have been produced from remotely detected information. Last 27 years satellite Pictures has been gathered for distinguish the adjustments in land use changes and morphology of Sangu River. In section four, land use changes because of the stream bank disintegration are discussed. The distinguished land utilizes from study areas, and procedures of creating maps (Figure 3.2) are delineated underneath:

Image classification:

The satellite pictures information were gathered from CEGIS, which are enhanced with Image classifications. There is an alternate assortment of shading sheds found in the pictures which were lumped together and carefully assembled into six classes. This classification was completed dependent on the statistical arrangement systems and the information of researchers in numerous fields that have visited the investigation region and the actual ground information gathered at the durational of images data collections. This six classifications descriptions are give below:

Fellow land: The fellow land is indicated by white color in the map. In this part of this area is not cultivating causes of river bank erosion.

Settlement: This class defined to villages settlements recognized by enormous trees that typically locate in the rural area and this class included the total rural system like as transportations, plantations little wetland etc. inside the settlement area

Sangu River: The main study part of this area, Sangu Rivers are long, but only study part is shown in this map.

Shrimp cultivation: Shrimp cultivation is a significant change in the study area. This part is converted from agricultural land because of the river bank areas agricultural system changes.

Char Land: In the river morphology, this is a normal term. When a river's from one side erodes then the sediment deposits in another bank. Some new land in Riverside is called char land.

Vegetation: In the river side area, every tree and agricultural land and permanent forestation are included in the vegetation.

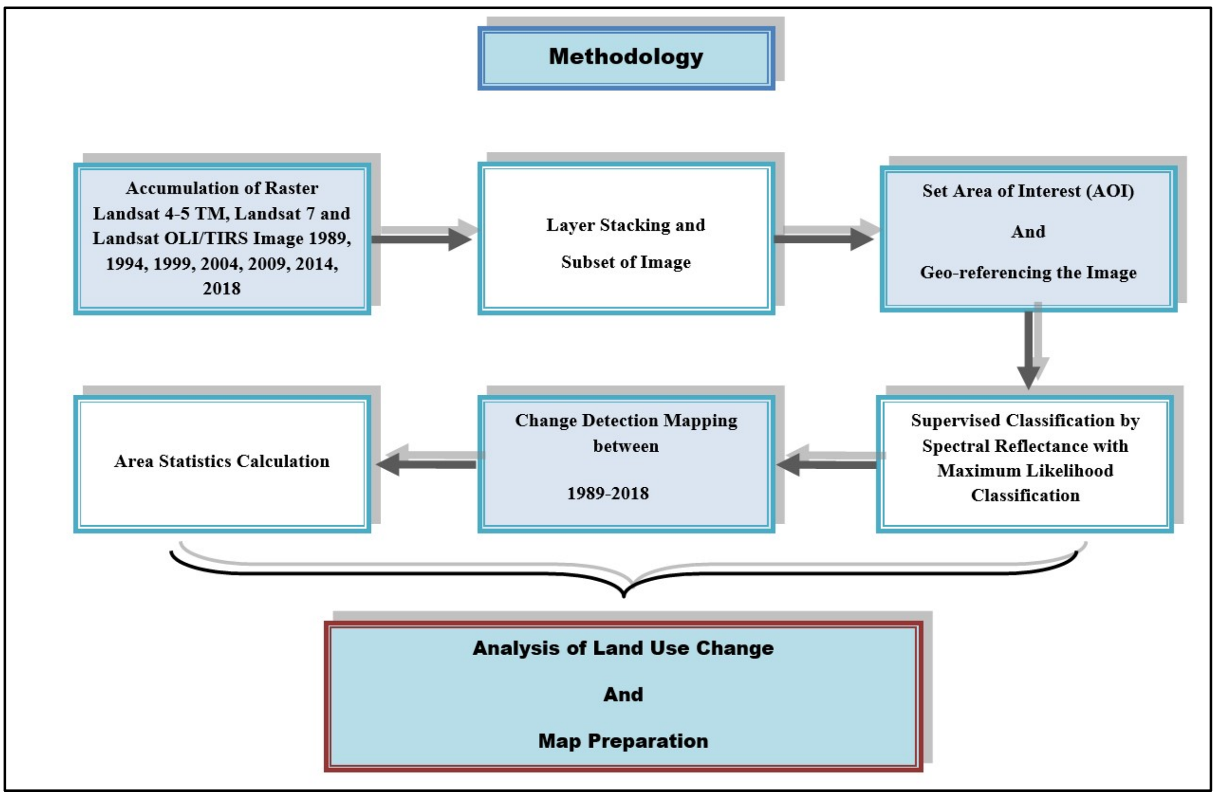

Figure 3.3: Steps of Preparing Land Use Chang Maps Using Remote Sensing

3.7 Particle Size Analysis

Sampling procedure: The easiest method for taking soil sections is utilizing the Hand Auger method. Goedenwaagen invented various types of hand auger method whose are really effective for this types of study. Schuurmen and Goeddewaagen described in details their previous study in 1971. Hand Auger have two parts one is 15 cm cylinder which inside diameter is 7cm. and others part is 100cm base pipe which goes to insidie the soil. We could measure the untill 100cm inside the soil. But sometimes this is 50cm is also used. Where soil is so hard 100cm is impossible to drill or boring, there used to 50cm hand auger. Outwardly of the cylinder and furthermore on the pole there are marks at every l0-cm distances. In the top of the Auger have a handle which give the Auger T shaped. This handle helps the auger push or pull in soil and rotates into the soil. In the bottom of the auger have a sharp cutting edge is cylindrical crooked which helps to soil cutting and fill soil into the cylinder. For taking the soil sample the auger push into the soil and twist several times until 10cm and pull out from the soil. This soil sample takes into a polybags to analysis in the lab. The sampling is made several times in several places with 50cm hand auger for this study. By this process we could collect the different soil layer sample until 50cm or 100 cm. If drilling into the clay soil, this is easiest when the auger put into water before drilling (Schuurman & Goedewaagen, 1971). On the off chance that proceedings with analysis are required on the boring locales, the gaps are loaded up with soil following testing has been done.

The soil samples for this research were collected as the following steps:

- ❖ The hand Augar (also called post-hole or Iwanaugar) is a straightforward hand tool used for drilling into soft soils down to the maximum of 1m or 50cm in small projects. In this study, the researcher used 50 cm, Auger.
- ❖ For the analysis of soil sample are collected from different part of the river bank in acrretions and erosions site of Sangu River.
- ❖ It is important to rotate the auger until it is filled with soil. Then, it can be separated from the soil type, which is available in different depths.
- ❖ Furthermore, the soil samples are collected inside the polybag for the EC and pH test. But the sample grain size distribution is calculated in the field.
- ❖ Collected soil samples are immediately sent to the Laboratory of SRDI to measure pH and EC of the samples.
- ❖ The particle size of the soil sample is done on the study sites based on the researcher's experience of understanding sediment coarseness.

- ❖ Notes were taken in the field for each sample regarding its texture.

Figure 3.4: Collection of Soil sample using bore-hole and determining the sediment texture in the field.

3.8 Sediment Budget:

At first, we measured the total area by the ArcGIS. For the erosion part, we measured 3 meters eroded and deposited part we measured the 2-meter deposited. Then we made an arithmetic calculation for assumed sediment budget of the study area.

$$\mathbf{M} = \mathbf{V} \times \mathbf{H}$$

Where, M= Total Materials, **V**= Total Volume, **H**= Height Of the eroded or deposited materials.

Total Sediment loss or deposition = Total area value from ArcGIS × Depth of this area (Erosion or deposition).

3.9 Data analysis and Presentation:

For soil particle analysis, we used the Hand Auger method. This process is statistical methods where needs many experts people for determines the soil texture.

All the collected soil samples have been analyzed in the field using the hand. The texture of the soil will be tried to understand from this analysis. The researcher had to spend huge time to get acquainted with the soil texture and will also need to make several attempts to identify the sediment type. Before implementing that non-digitalized knowledge at the field level, the researcher has practiced this method in the lab to make a comparison of the accuracy level. When he got the assurance about the accurate measurement of soil texture by hand, he went to the field and have tested the soil samples instantly.

The collected maps are digitized by ArcGIS 10.3v software to show the different yearly Accretions and erosions site of the study zone. On the other hand, using the ERDAS IMAGINE software, the change of river channel due to the erosion and deposition have been detected, and subsequent changes of nearby land uses are also identified through preparing the maps from Satellite images. All the collected information has been analyzed through MS Excel and SPSS 25 and presented in the flowing chapters using tables, charts, graphs, diagrams, figure and photographs.

Chapter 04: Erosion and Deposition of the Sangu River

The geographical location of Bangladesh made the deep relations with disaster regularly (Hossain and Ferdousi, 2004).Total populations is more than 1.60 billion, with the economic growth rate or GDP is 1.33 annually (UNDP, 2009), and maximum 75 % of the people lives in village regions (Agarwal and Bina, 1990). From the last centuries, riverbank erosions have caused lots of natural disasters in Bangladesh. Bangladesh has lots of delta and flood plain areas. This was happened causes of sloping hilly regions generically, absence of high land and lots part of plain land which is washed by river water. Around 700 small or big rivers and tributaries make the nation a land loaded with waterways (Siddique et al., 2014; RIC, 2008). Additionally, riverbank erosions are characteristic event natural disasters which happen each year (Baqee, 1997). Because of this, numerous individuals are shelterless (Das, 2011). This part expects to examine the measure of riverbank erosions research the connection between riverbank erosions and its effects ashore use change. Besides, the section will elaborate the sediment budget that is estimated from the Sangu river.

4.1 Trend Analysis of Riverbank Erosion in the Study Area

Banshkhali and Anowara Upazila are erosion prone Flood plain Upzila in Bangladesh. Sangu River is most important river for both Upzila but now this river plays intolerable role both Upzilas peoples. In the whole this river eroded somewhere part of both upzila. River bank erosions process and the rate of erosions and depositions of Banshkhali and Anowara Upazila from 1990 to 2018 years satellite pictures are analyzed by utilizing ArcGIS and shown in several figure. In this analysis we identified the erosion and depositions by river bank overlapping. In these maps, erosions and depositions addition are separately introduced by red and chartreuse green shading. The Riverbank of Sangu river in the study area are changed in different years is additionally showed in those pictures. Apparent presentations of the channel layout in different years information's help to find out the channel movement of this river from bank to bank.

In Bangladesh riverbank erosions is a most endemic and natural calamity. In the mature stages (for example the three compelling streams which incorporate the Brahmaputra, Ganges and Meghna) of the river several time the river made meandering shape, slow, braid. The perturbations play an important role in huge river bank in the river channel. Every year, more than millions of peoples are affected by riverbank erosions, which lost their crops land, properties and homestead land. It is studied that more 5% land affected by affected by River bank erosions. Numerous analysts asserted that bank erosions had occurred in around 94 out of 489 Upazilas of the nation (Rahman, 2010). In this investigation region; all maps have showed to the pattern of erosions and depositions of the Sangu rivers. The northern piece of the considerable number of maps is Anowara Upazila, and the Southern part is Banshkhali Upazila.

4.2 Yearly Erosion and Deposition Scenario From 1980-2018

Erosion and Deposition From 1990-1994

In 1990-1994 (five years), the erosion is more prevalent in Anowara Upazila than Bashkhali Upazila. The eroded area is more in the Gohira side but most of the depositeded part is north Juidandi area of the river.

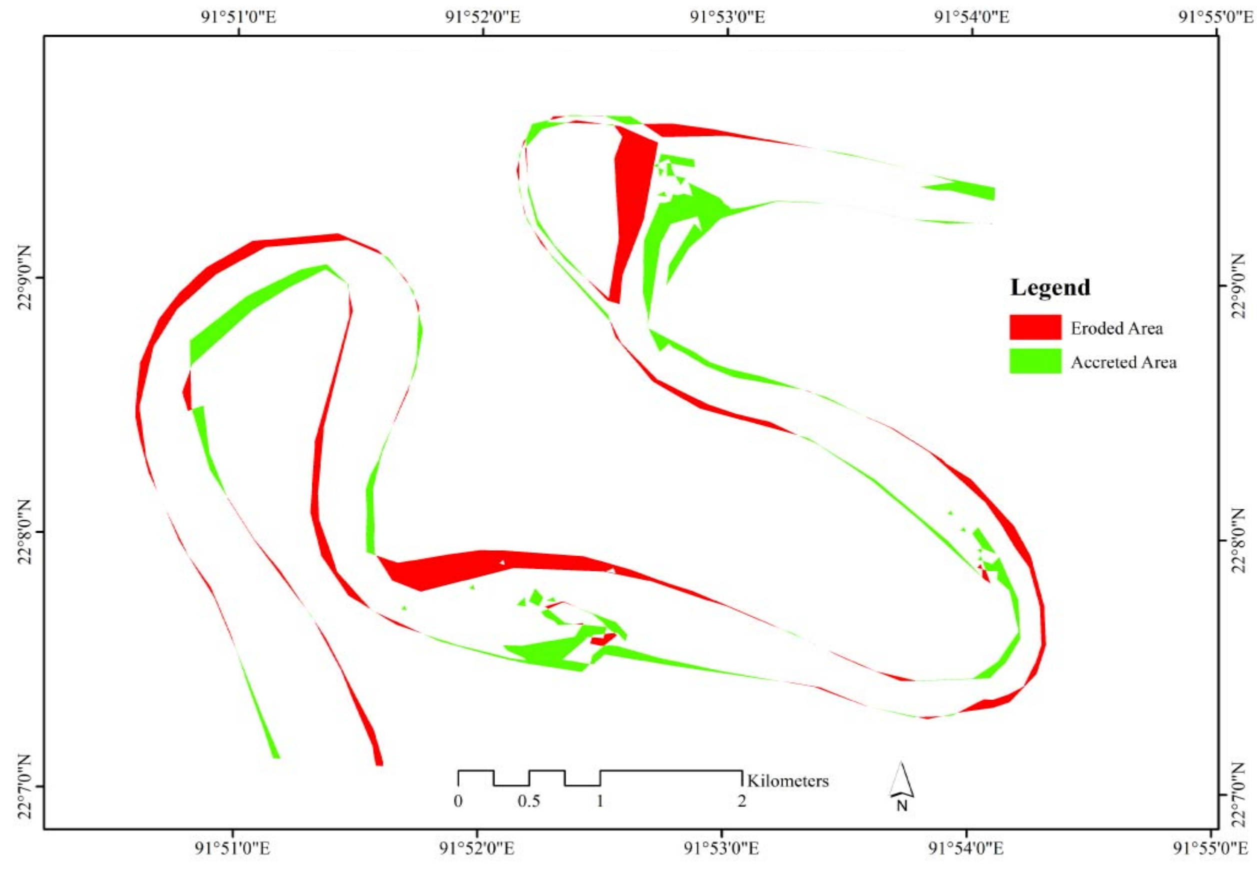

Figure 4.1: River course change in 1990-1994

The Southside of the juidandi is deposited in Anowara Upazila and slightly deposited in permasia part and North Barunchara (Char Jiudandi) of Banshkhali Upazila(Figure 4.1).In this period, the total 103.34 Hectare area eroded in the Sangu river, and 83.74 Hectare area is deposited (Table-4.1). The greatest bank erosions during 1990-94 happened at the east side, simply upstream and lower stream in Bashkhali part. Normally, there is an event of rotations and augmentation bank erosions processes. For example, the Jamuna has uniquely enlarged from the earliest starting point of 1970 to the 1990s. In any case, the yearly rate appears to have decrease essentially in the late nineties. The extensions of the rivers wide in last 28 years we lost 70,000 hacters land or 220 km length of the flood palin area of Bangladesh. In the durations 1984-92 period, the total river has eroded 40,150 hacteres floodplain areas and deposited 7,140 hactres land. In this situations the erosions rate is 5000 ha/year and depositions rate is 900 ha/year (ISPAN, 1995 Note: Rates inferred for the period 1984-92).

Erosion and Deposition From 1994-1998

In 1994- 1998, both parts of the river eroded and slightly deposited in Bashkhali Upozilla. In the Banshkhali Upazilas Sarenga and Barunchara areas, some parts are deposited (Figure 4.2). In this period, 170.70 Hectare area is deposited and 17.30 Hectare eroded (Table 4.1). In this context we also saw, the tope part of the Brahmaputra rivers flood areas are mostly flood effected regions and the low flood areas and crops are inundates regularly, the bank area also eroded in every days. In the time of 1995-2000, the erosions rate of the entire Brahmputra river in the left side Riverbank is 1500 hectares, and the right side riverbank is 1200 hectares (Islam et al.; 2017). In 2000, Thompson found that the Brahmaputra river course has changed to a great extent during the previous 250 years with indications of enormous scale separation somewhere in the range of 1776 and 1850 along 80 km from the eastern side of Madhupur toward the western part. In the third Assemble Report of the International Panels for climate change (IPCC) demonstrates, South Asia district is one of the most defenseless locales on the planet, which is affected by climatic changes. Additionally, the worldwide networks recognize Bangladesh as top-positioning most vulnerable nations on the earth.

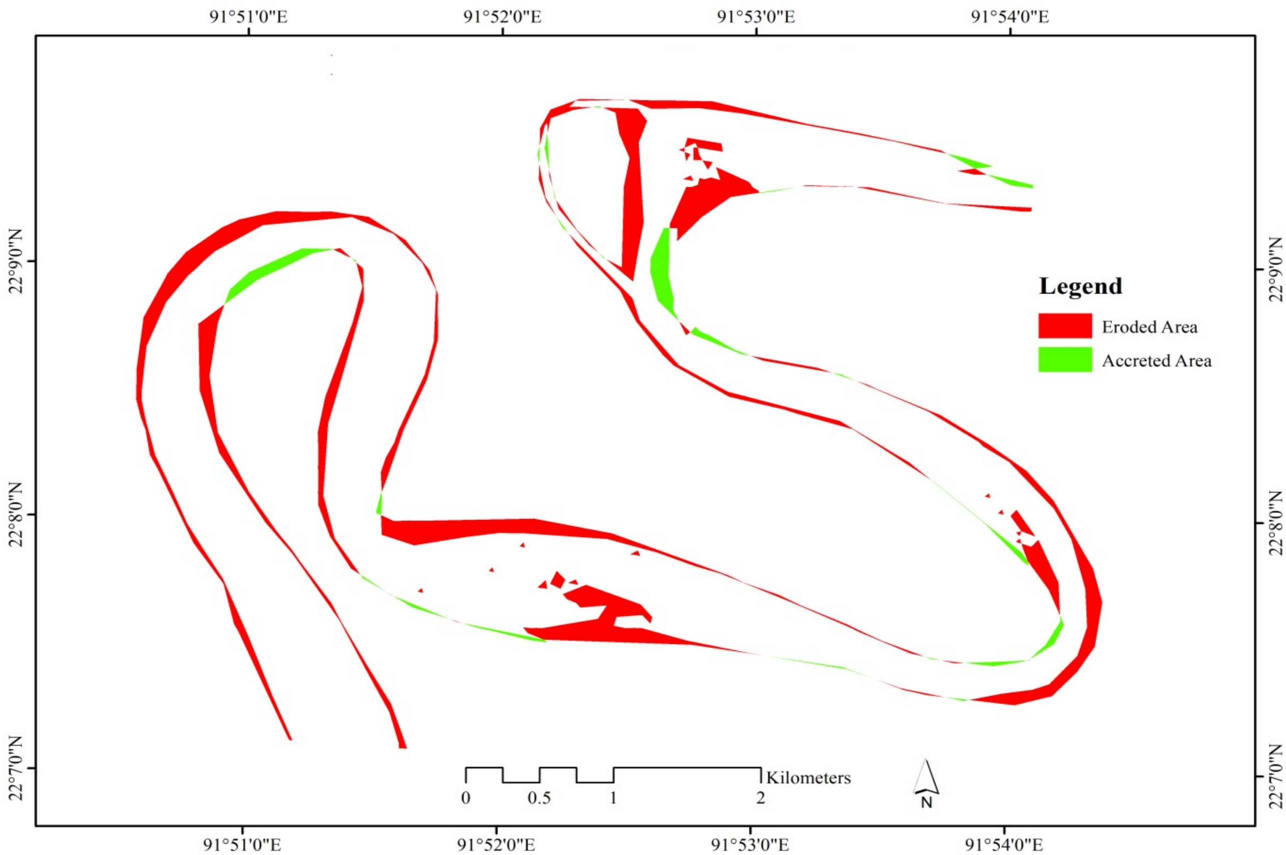

Figure 4.2:River course change in 1994-1998

Erosion and Deposition From 1998-2002

Riverbank erosion is difficult to predict, and it is a deadly type of natural disasters which depend on the impact of soil structure, the amount of precipitation, the geography of stream and contiguous regions, rivers morphology and floods. Such disasters have killed a lot of people due to the evacuation of agricultural land and homesteads.

During 1998-2002, the territory of erosions is more in the Anowara Upazila. Most part accreted in the Banshkhali Upazila some part in Sarenga and Barunchara part (Figure - 4.3). Absolute eroded part of Sangu River 110.31 Hectare and 58.71 hectares are deposited in the sangu river bank area.

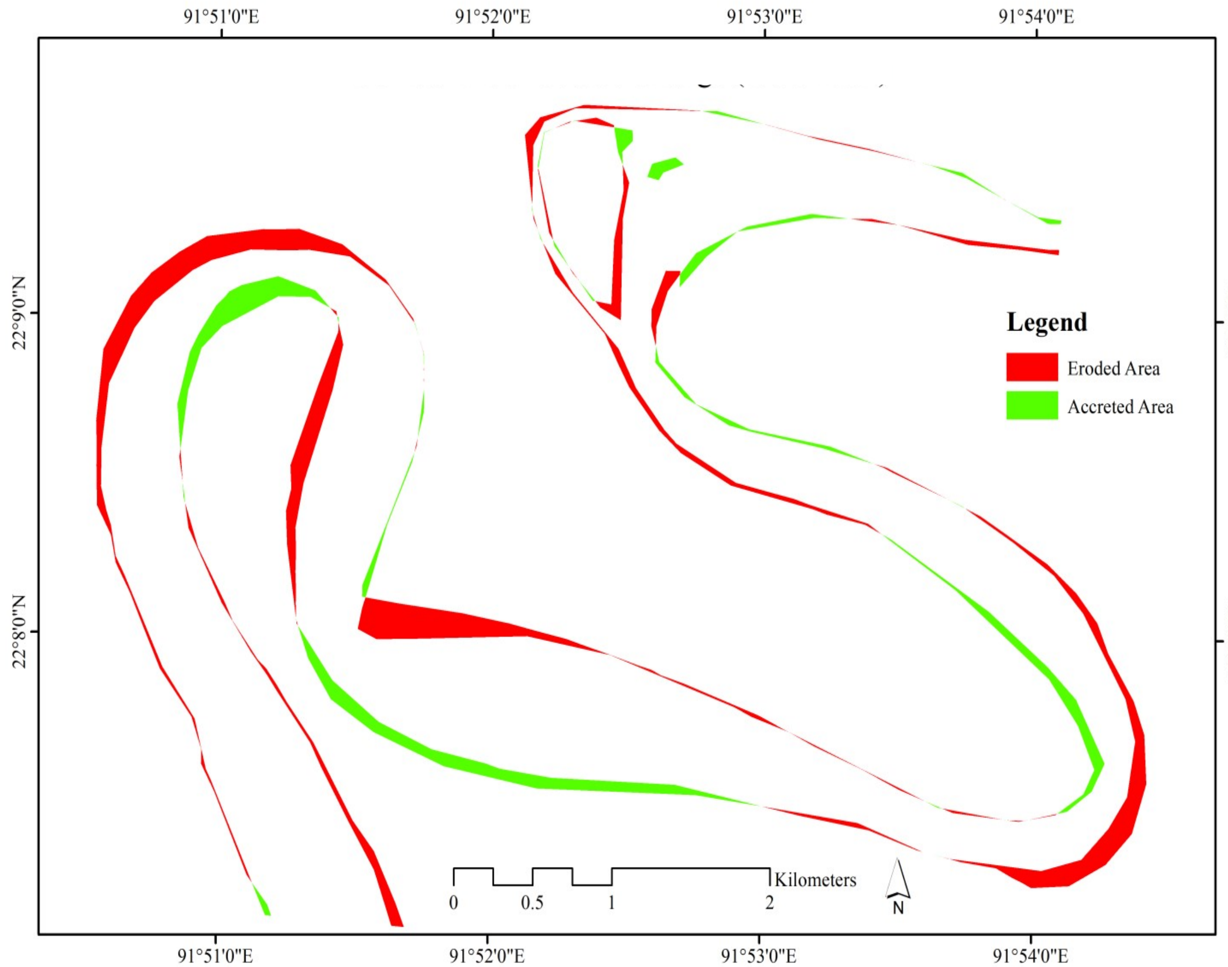

Figure 4.3: River course change in 1998-2002

Upward territories are more inclined to erosions than descending regions in the upward regions because of the speed of the wave is high (Table 4.1). In the last few decenniad (1973-2015), the total erosions along the rivers side was about 88,462 hactre. In this situation the rate of rivers bank erosions rate and widening process was changed differently (CEGIS, 2015). Bangladesh increase in susceptible rate to climate change is caused due to many socio-economic and hydro-geological factors. Thus, every year, a considerable area of the country is engulfed by river erosion. Riverbank erosions are a noteworthy administration issue in alluvial passageways.

Erosion and Deposition From 2002-2006

No fundamental example has yet been seen of the erosions degradation as a result of the inclusion of countless factors simultaneously. The intensity of river bank erosions is vary river to river, erosions basically depends on bank materials, water flow, water level variations, supply of water and sediment of the rivers. In this study area more eroded parts are Gohira and Char joidhandi side of Anowara Upazila. The erosion and deposition are severe both side of the Banshkhali and Anowara Upazila (Figure 4.4). In this duration, 76.30 hectares are eroded, and 63.27 hectares are deposited.

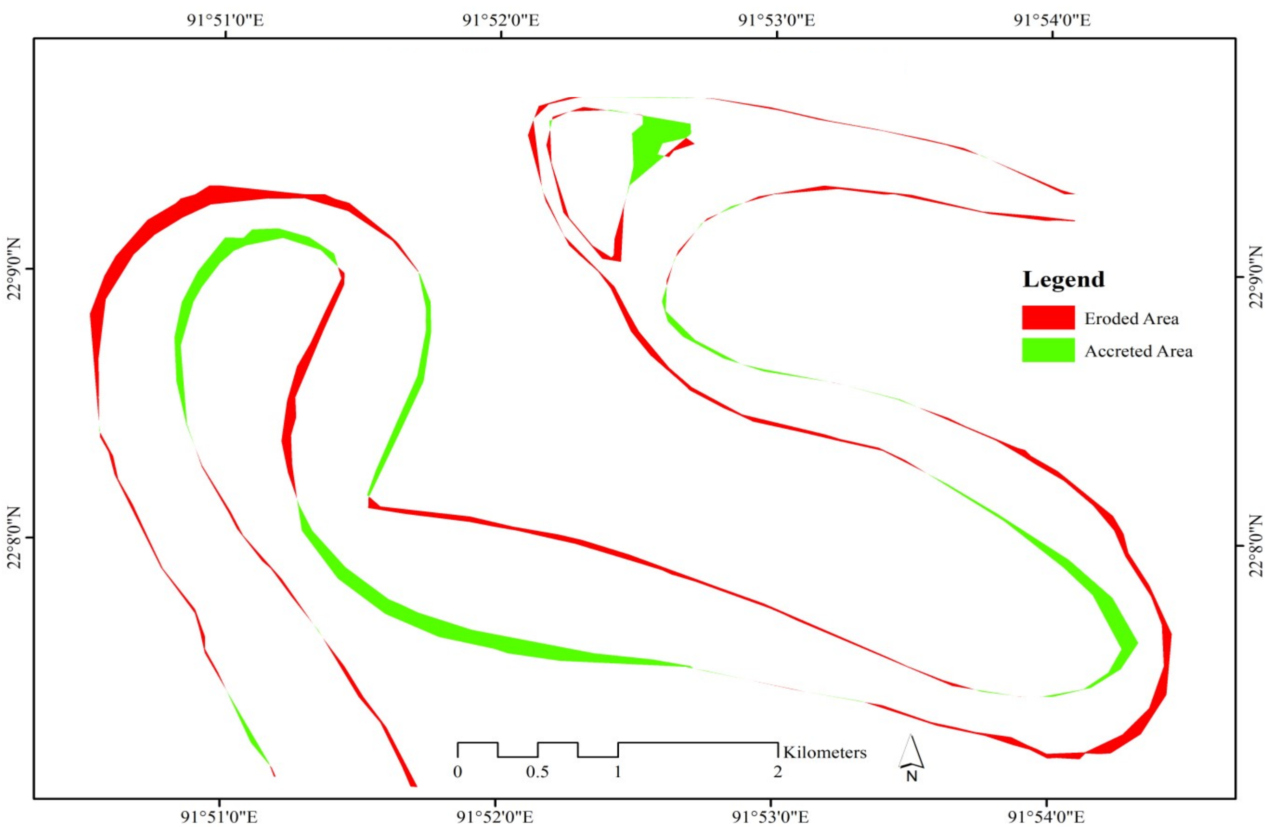

Figure 4.4: River course change in 2002-2006

In view of the assessed outcome and visual perception from the satellite photographs, there are extreme erosions at the lowest part of the river. The upper part of the rivers demonstrates moderate erosions close the lower part of the river and the left part of Banshkhali and Gohira

Upazila is affected extreme erosions and most noteworthy changes saw over in this period indicating real right bank line moving.

Erosion and Deposition From 2006-2010

The deposition area is more than the eroded area on both sides of the river. Most of the part deposited. In the Gohira part of Anowara Upazila and Ratarkul part of Bashkhali are slightly eroded in this period (Figure 4.5). During these periods more depositions take place in both the Upazilas. In this duration, the total eroded part only 45.24-hectare area and total deposited part is 102.60 Hectare area (Table 4.1). In the others side the mean yearly erosions of the two banks of the Jamuna from the 1970s to the mid 1990s was 3300 hectares (IRIN, 2008).

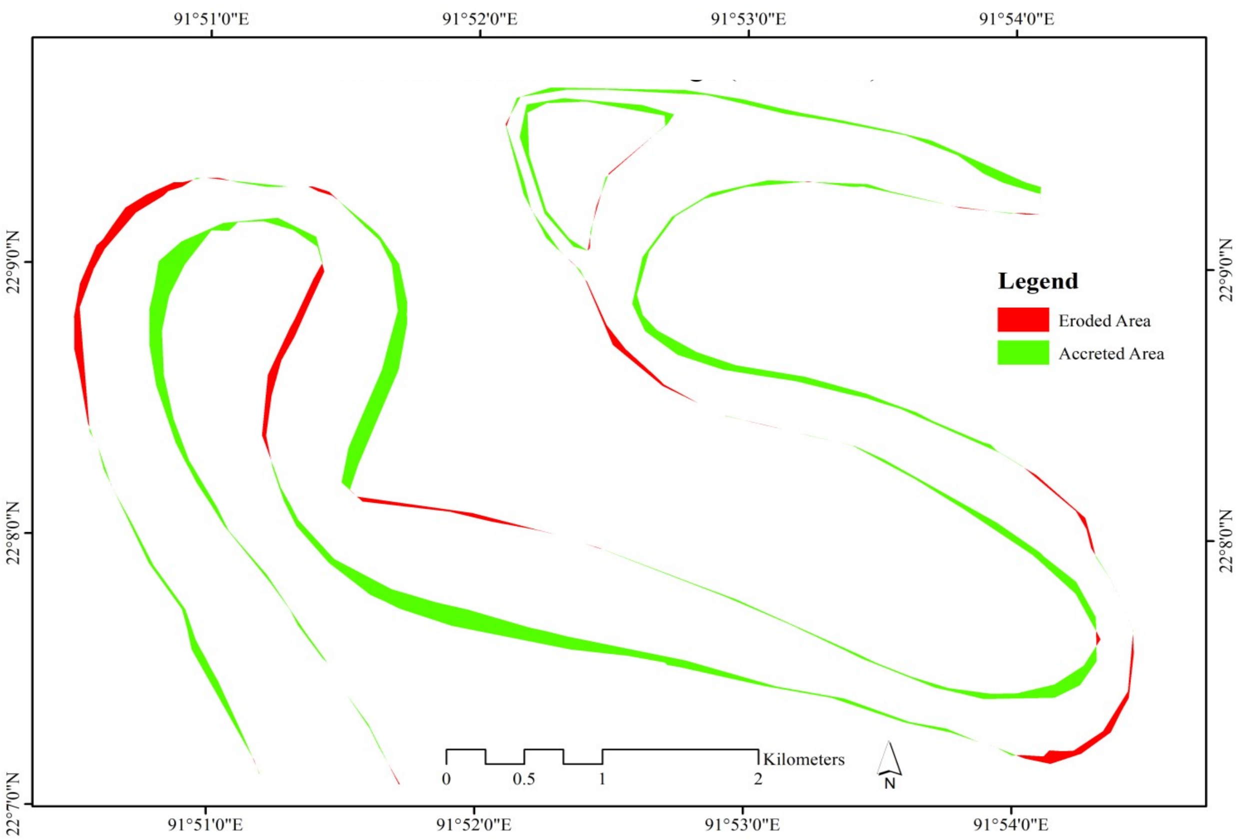

Figure 4.5: River course change in 2006-2010

According to CEGIS survey -2009, the procedures of the river bank of Jhumana-Bramhputra and Ganges-padma channels erosions is being influenced by either the liquefactions or flow rate of bank line or the oscillations of the river bank materials. Erosion & accretion along with the

Padma riverbank areas over the time affected about 1380 hectare of land and 200 hectares of settlement each year. In this riverbank erosion is also influenced by the river`s water discharge from the upper stream to the lower stream. The confluence point of Padma-Meghna maximum discharge of about 20,000 cusecs, while the maximum discharge at the lower part of Meghna is about 160,000 cusec and the slop rate is 5cm/Km (Haskoning, 1990). Nevertheless, in the river process at the copulations lack needs wide river bed at a few kilometers in different channels, which create combination with enormous engendering sand bars. This gradually shifts the lower Meghna towards the east direction. (Nath, 2013).

Erosion and Deposition From 2010-2014

Human activities can cause changes to watershed hydrology and sediment loads which result in relatively rapid geomorphic adjustments of stream channels, including expanded part of bank erosions and parallel channel movement in river systems (Knox, 2006; Owen et al., 2011).

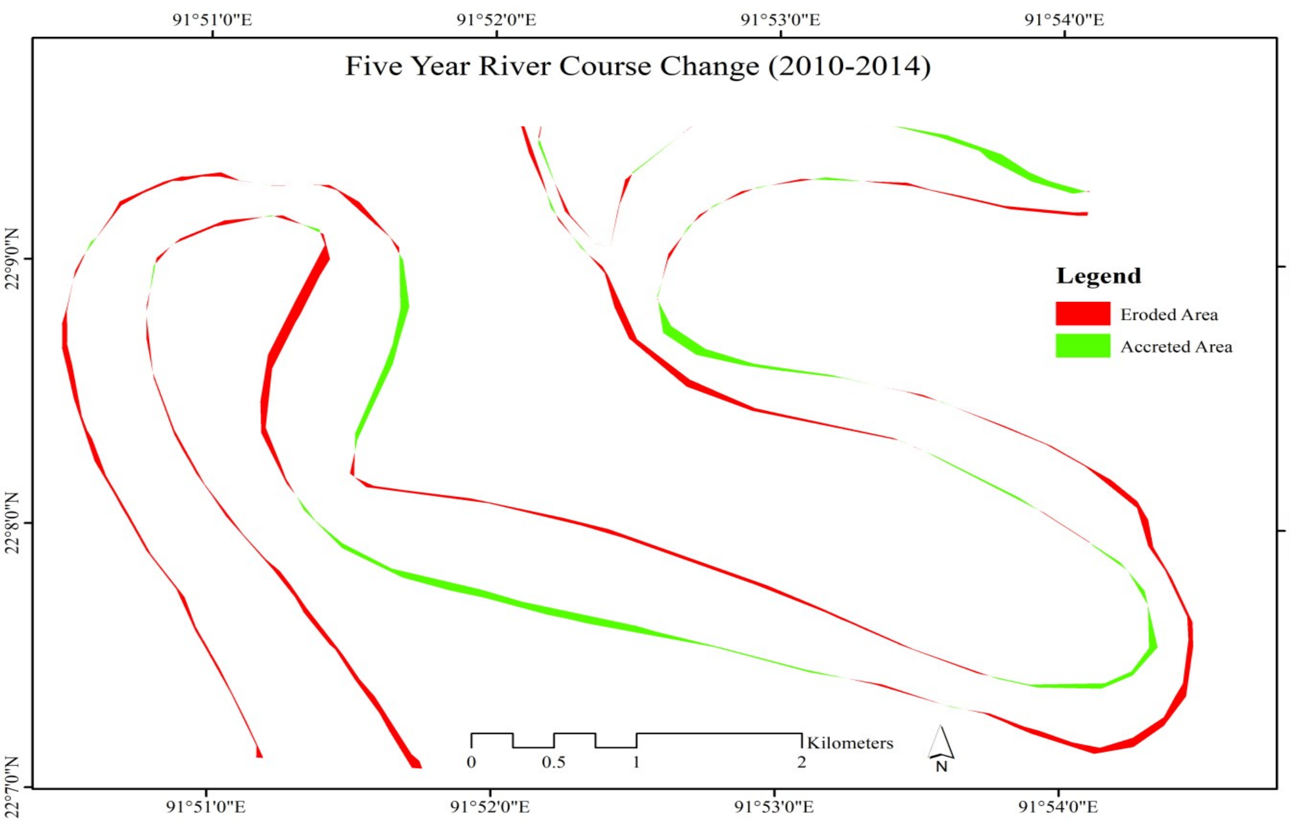

Figure 4.6: River course change in 2010-2014

For example, Fitzpatrick and Knox (2000) found that changes in a runoff after forest clearance caused accelerated stream bank and mainly the channel erosions depend on sources of the sediment lower part of the rivers. In addition, urbanization of watersheds can also result in increased rates of bank erosion and channel degradation. The erosion has mostly occurred in both Upazilas. In Permasia part of the Banshkhali Upazila and char Juidhandi part of Anowara Upazila is deposited (Figure 4.6). Total eroded part of this area is 102.51 Hectare, and the deposited area is 83.18 Hectare (Table 4. 1). Extensive morphological changes resulting in frequent shifts of homes & widespread losses People living in Padma riverbank areas are frustrated by continuous land loss due to bank erosion. Consequences of bank erosion have increased over the year and each year, several districts face riverbank erosion and lost numerous meters of lands and infrastructures. The rate of bank erosion in the older floodplain is less compared to the recent one, but the range varies widely. Along the older floodplain, at Paturia and Dhulsunra to Mawa, the rate of bank erosion varies from 0 to 20 m per year when the main river stream of the Padma river attacks the river bank. Downstream of Mawa, though the floodplain along the left bank is older, the rate of bank erosion is found to be much higher, i.e. also in the scale of a hundred meters per year. (Shajahan and Reja, 2012).

Erosion and Deposition From 2014 - 2018

Typically, free-flowing rivers tend to be at equilibrium during the process of deposition and erosion. The deposition mainly balances the erosion at each location at each other (CRJC, 1996). Between 2014 and 2018, erosion is more predominant in Barunchara and permisa region. While the Ratarkul part of Bashkhali has been eroded. Also, in the guderpar, Kanu majir hat and Anowara Upazila juidhandi region are eroded (Figure 4.7).

The total amount of eroded area is about 99.28, while the total deposited region is 33.71, as shown in table 4.1. The bank disintegration process in numerous areas of the river system depends incredibly on the shape of the channel release and the river quality (Florsheim et al., 2008). Due to this, Riverbank erosion is an ongoing natural process. This was evident from the comparative analysis of Jamuna river siraigonj Upazila, which tends to erode projected increment and riverbank erosion in the past decades, and it was sequentially much more compared to the year 1973.

In the context of upper discussion, kazipur upzila also region demonstrates that since 2000, from 2001-2002 most of the highest erosions in happen in this area and this areas erosions rate is 68 hectares (Rabii et al., 2013). On other side Unnayan Onnesha -2011, made another's research about kazipurs upzila. In this papers they classified this union in three parts depend on the susceptibility of the erosions. In these categories the most eroded area is 47.01 sq km, the second vulnerable area is 206.56 sq km, low vulnerable area is 134.93 sq km. Furthermore, erosions more often than not rely upon the land slope where the raised slope is progressively presented to erosions contrasted with the curved slope.

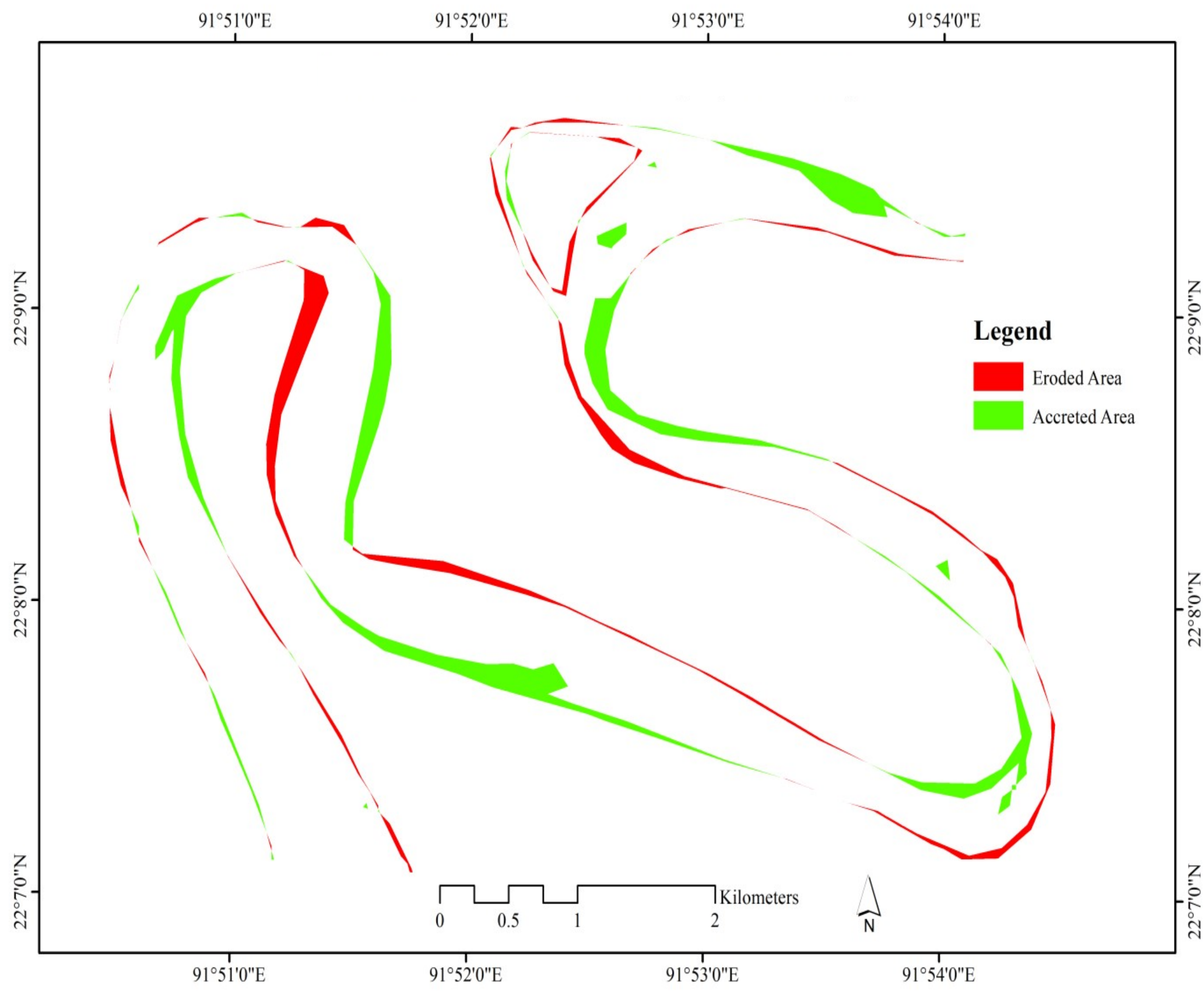

Figure 4.7: River course change in 2014-2018

Total Erosion and Deposition from 1990- 2018

In the last 28 years, the river channel changed notably. Most of the part of the riverside are eroded and Erase forever from the main part. Some parts of the main area are constantly decreased day by day. In the Permesia and Barunchara are mostly deposited and Ratarkul part is mostly eroded. In the Anowara Upazila, Gohira and some part of the Juidhandi and Kuruskhul area are eroded, and some part of the Jiudhandi area are deposited (Figure 4.8). Throughout this 28 years duration, total erosion area is 707.68-hectare area, and the deposited area is 473.85 hectare then per year total eroded area is 25.27 hectare (Table 4. 1). Which is more than statements that occurred in the Sangu Rivers, Such morphological circumstance was also found in the Padma River from 1973 to 2011 years. In these durations about 189.4 Km2 Rivers channel were eroded beginning from the left bank area, and just 23.66 km2 was deposited with a total deficit of around 155 km2.

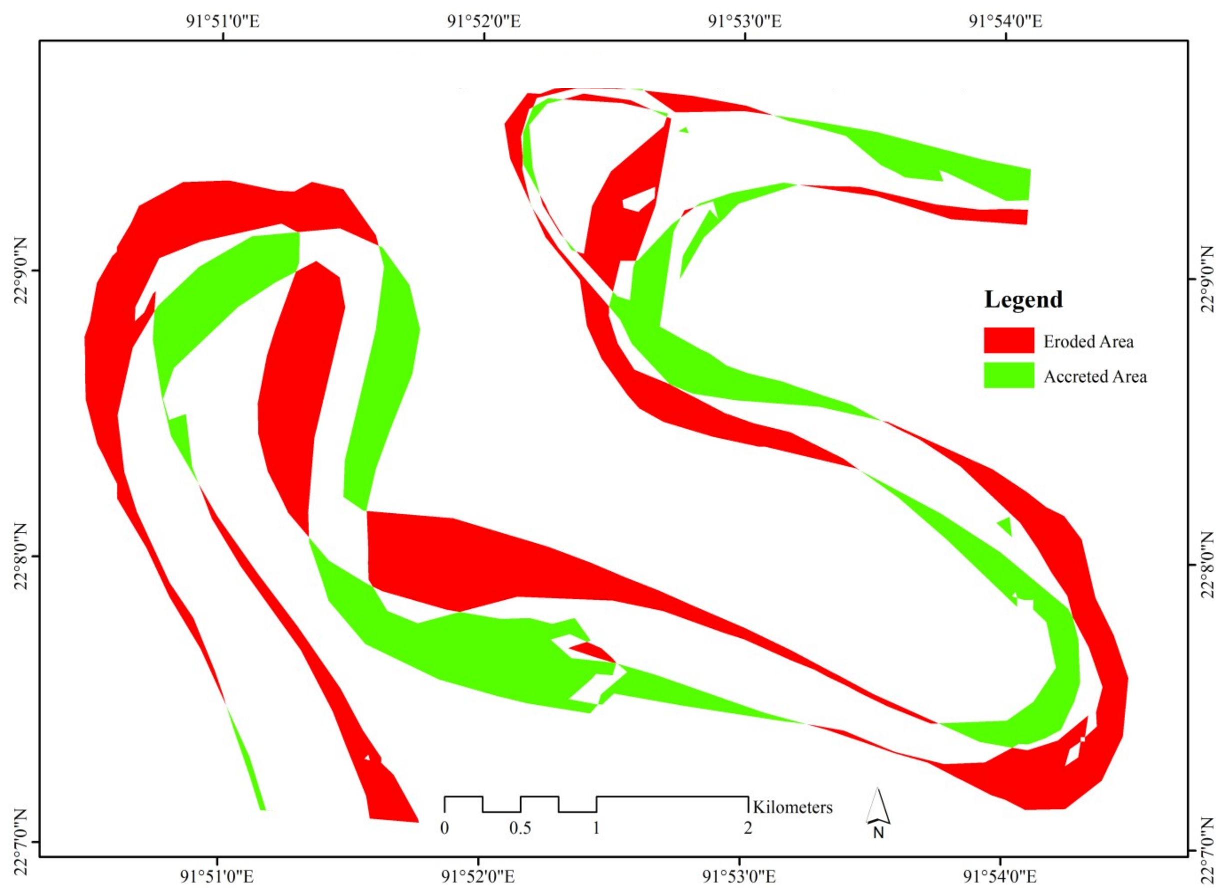

Figure 4.8: Total River channel change in 1990-2018.

In 2017 Bhuiyan descried in his papers, the padma rivers right bank eroded is 166.53 km and 134.45 km2 deposited. In this study area, the vulnerable area is Premasia, gohira , Barunchara some others part of both riversides. Erosions don't just destroy households and land, yet it additionally influences the ecological area for short and long term. The erosions of the river in this areas are severely affects the natural life on fauna, greenery and fisheries area. The farmland tree plantations are normal and customary practice in the study zone.

Table 4.1: Statistical data of yearly erosion and deposition of the Sangu River

Year	Erosion Area (Ha)	Accretion Area (Ha)	Change Area (Ha)
2014-2018	99.28	33.71	-65.56
2010-2014	102.51	83.18	-19.33
2006-2010	45.24	102.60	57.36
2002-2006	76.30	63.27	-13.02
1998-2002	110.31	51.68	-58.63
1994-1998	170.70	19.67	-151.03
1990-1994	103.34	83.74	-19.60

4.3 Graphical Data Analysis (Area) of the River Bank Deposition Side

In the 1990-1998 the accretion rate is decreasing rapidly. From 1998 to 2006 the rate of accretion increased gradually, but in 2006 the rate is highest. From 2010 to 2018 the rate again decreased. If we see the prediction periods 2022, the rate accretion again increased. In the 2002-2006 the highest deposition occurred. In this period, total erosion is 102-hectare area (Figure 4.8). During 1994-1998 this period, the deposition lowest and this period the deposition is the only 19-hectare area. We also studied in secondary data sources other rivers of Bangladesh like the Padma. In the investigation in Jamuna and Padma rivers toward the part of the study time frame (in 2000), remarkable changes from 1977 to 2000 in these regions have disappeared. The evaluated normal erosions from 1977 to 1989 and 1989 to 2000 were 5436 hectares/year and 2954 hectares/year separately. The normal accretions from 1977 to 1989 and 1989 to 2000 were 773 hectares/year and 1954 hectares/year correspondingly (Islam, 2009).

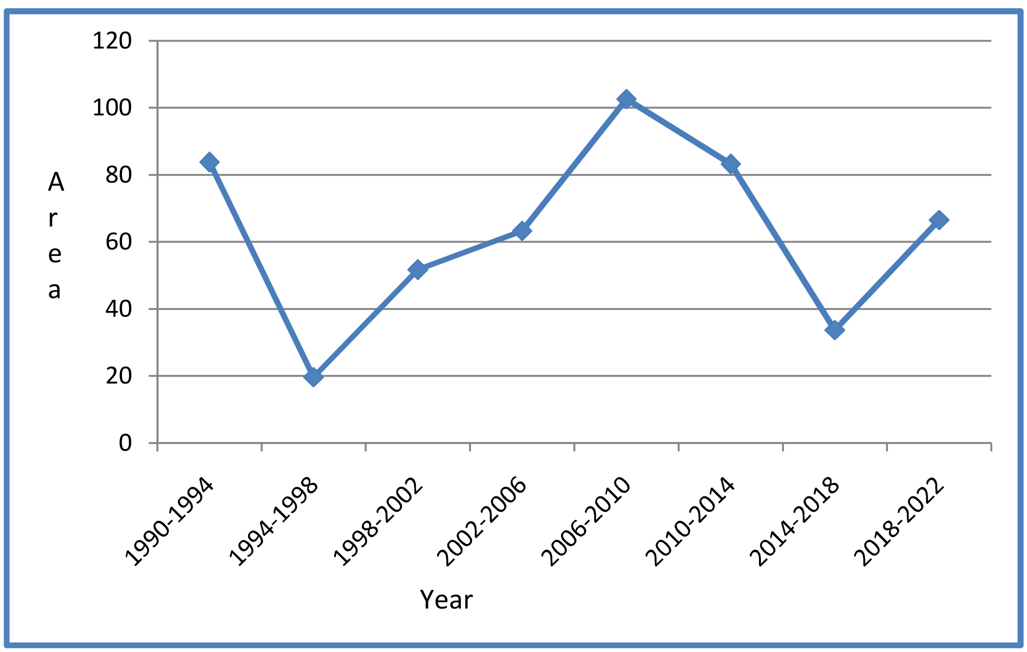

Figure 4.9: Deposition area(Ha.) of the Sangu River

4.4 Graphical Data (Area) Analysis of the River Bank Erosion Side

The total erosion conditions are showed in this graph. In this graph, we show the total opposite conditions from the deposition Figure 4.9.In this figure 4.9, the 1994-1998 the erosion has increased this condition decreased gradually until 2010. But from 2010-2022 this rate increased again. In 1994-1998 the erosion was higher, and in 2006-2010, the erosion rate is lower (Figure: 4.10). In the Jamuna and Padma river, we saw that the total erosion from 1977 to 1989 and from 1989 to 2000 amounted to 65233 and 32491 hectares respectively. The rate of erosion from 1989 to 2000 was slower than that from 1977 to 1989. In these periods, from 1977 to 1989 and1989 to 2000, the erosion was higher for crops/agriculture type land cover. (Islam, 2009).

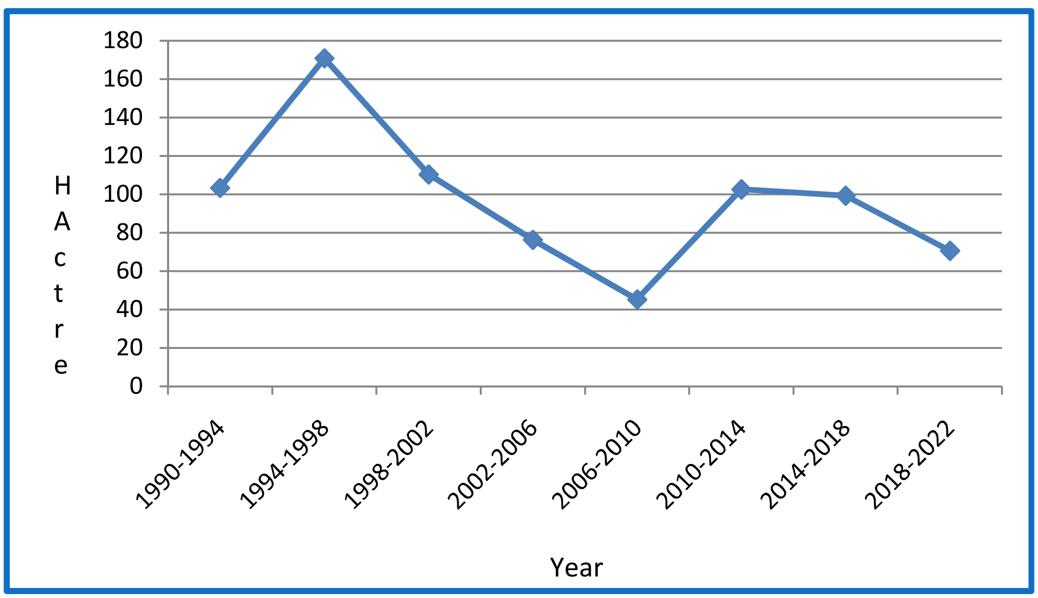

Figure 4.10: Erosion area(Ha.) of the Sangu River

4.5 Total Change and future predictions of the River Bank Erosion

In Figure 4.10, we can see that the total condition are mostly negative conditions that mean in this area, erosion is more than a deposition. Only during the 2006, the condition is positive that's means in time deposition is more than erosion.

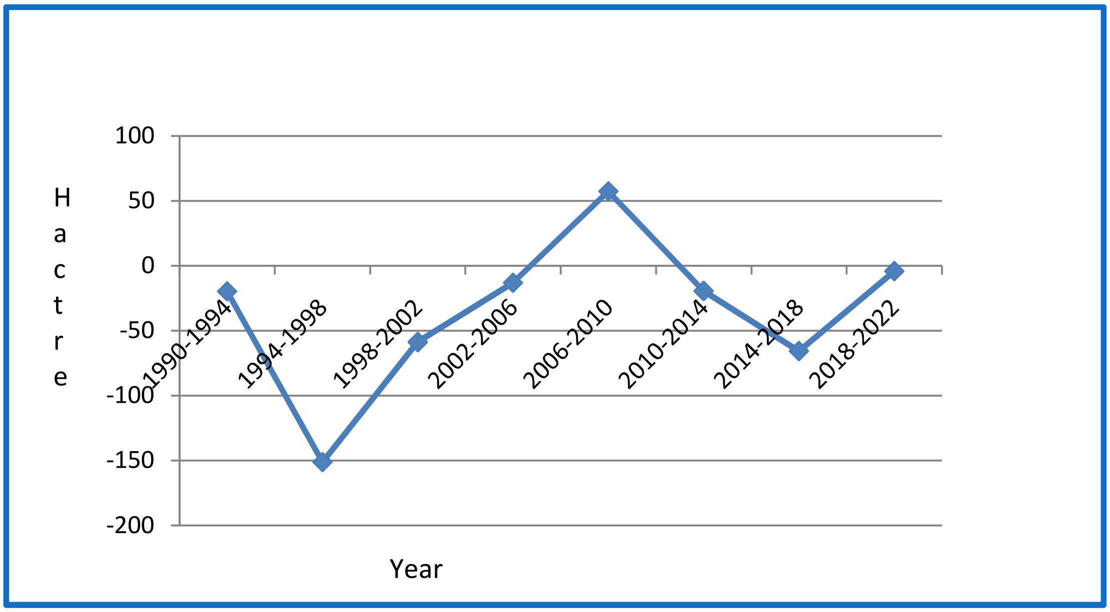

Figure 4.11: Graphical predictions of Erosion & Depositions areas(Ha.) of the Sangu Rivers

In the period of the river, channel change several times. Last 28 years, total erosion is 707.39-hectare area and deposition is 437.85 hectare (Table 4.1). Ahamed (2001) discussed that riverbank erosions are steady and old natural disasters, which increased the development of the disastrous place in Bangladesh. In other hand, Erosions is steady processes this is related to others disastrous in those areas. It's made a huge amounts lose in peoples life's, properties and environments. As indicated from the satellite information the river eroded around 8700 hectors of arable land each year, and around one million peoples groups were influenced. In the year of 1998, 6 millions family units and around 50 million people groups were straightforwardly influenced by the riverbank erosions.

4.6 Yearly Sediment Budget of the River bed Area of Sangu River

The rainwater which flows towards the slopes usually creates a little flow to open lower space. This rain water is flow which narrow space is call channel. Generally, River also a common term utilize for channel, where has water flow. The water flow channel to rivers is called the drainage system. The drainages system is also correlated with pattern of a river system.

In the channel process different land forms are made by rivers. The main processes in channel are erosions, depositions and sediment transportations from one side to others. The fundamental channel procedures are erosions, transportation and sedimentation. The most valuable spatial examination procedure for a specific report relies upon the sort of region to which results are to be connected. The pertinent zone may be a genuine area (for example a particular catchment, channel reach or regulatory area) or a speculative area (for example an 'ordinary' catchment or reach). Although some the conditions of the locations need to described in the budget, but of that side are most of the time often the critical problem. The area of tributary contributions to a channel reach, for instance, may firmly impact the working of the sediment budget, at any short period.

So also, for spending plans created to investigate landform development, data concerning procedure rates must be dispersed over that landform. Geographic data frameworks (GIS) are valuable for building these spatially enlisted sediment budget. In any case, for different applications, this degree of spatial explicitness is pointless, and results can be introduced as averages for specific land types, land utilizes, sub-catchments or whole catchments. Spending plans developed for easygoing settings, which are regularly utilized for looking at results from changed arranging choices, can be either spatially dispersed or arrived at the averaged. In this study zone, the Sangu river is upstream originated from the hilly region. A large portion of the hilly sediments is likewise shipped by this river. Anowara and Bashkhali Upazilas part are for the most eroded part of this river. A few pieces of this stream are changed over to the island. Some sediment is kept to another side. Complete diagram here most recent 28 years we determined by arithmetic mean procedure. In the term absolute, 1415.36m3 sediments is dissolved in the study zone. (Table 4.2)

Generally, the main river channels in the bank line of the collapse process can be attributed both to the liquidation of the bank line and to the flow or the keeping of bank materials. These types of erosions are happened in the low tide and high tide in the river. In the low tide season, the affected side of the river and sediments of the rivers bank expose to others erosions because of collapsing by wave activity and inward water weight. On the others side during the low tide waters, the pressure against the rivers embankments decrease, waters of rivers mover from the formations back into the channel flow, bringing about subsequent erosions..

Table 4.2: Sediment Budget of the Sangu River during the last 28 years.

Year	Erosion Area(m^3)	Accretion Area (m^3)	Change Area (m^3)
2014-2018	198.56	67.42	131.13
2010-2014	205.02	166.36	38.66
2006-2010	90.48	205.21	-114.72
2002-2006	152.60	126.54	26.05
1998-2002	220.63	103.37	117.26
1994-1998	341.41	39.35	302.06
1990-1994	206.68	167.48	39.20

Riverbank and alluvial plain-based sediment plan was set up by the computation of the river bed on the two sides. Mean bank erosions and alluvial accretions information along 11 km of the rivers others some portion of the rivers isn't unequivocally eroded or accreted. Bank erosions rates were changed over to masses by arithmetic mean process. During this study in the field, we calculate 3 meters of bed eroded in the erosion side. On the other hand, 2 meters bed is deposited on the side of the deposition. The focal transect erosions territory (watched rate increased by reviewed bank tallness) for each portion was duplicated by 3 m to deliver a riverbank erosions volume. Bank statures decline from about 3 meters close to the erosions side. In this way, the compelling volume of eroded material declines from upstream to downstream for some random erosions rate. Volumes of sediments expelled from the bank conveyed by water stream and stored others part. For the calculations of deposition sediment to multiple the 2-meter heights of the river bed with the deposited area of the river.

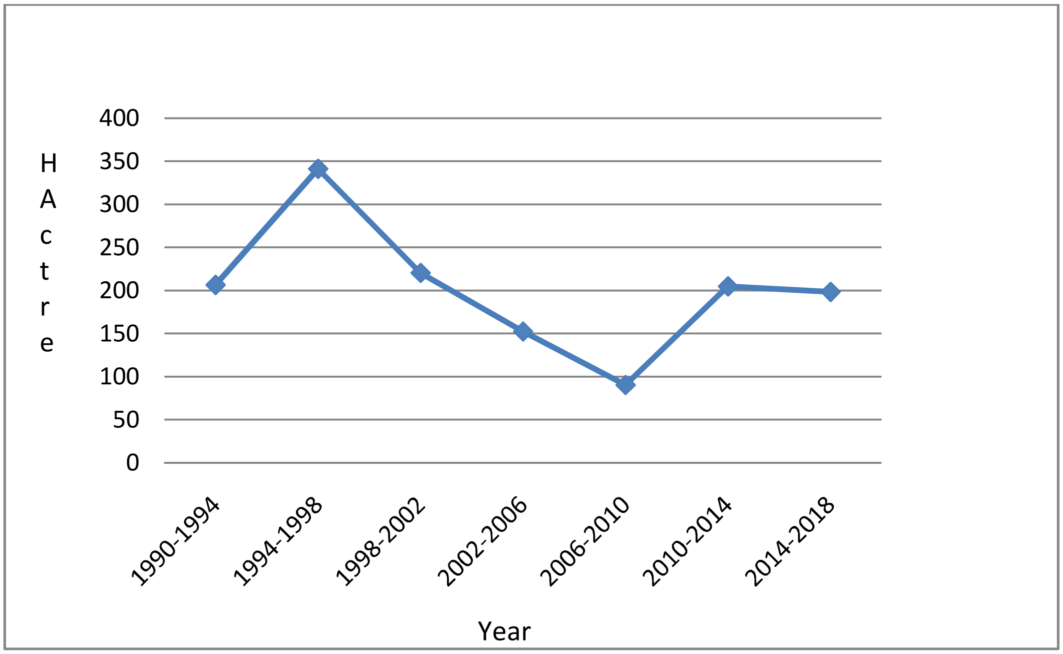

Figure 4.12: Sediment Budget in Erosion Side areas(m^3) of the Sangu River

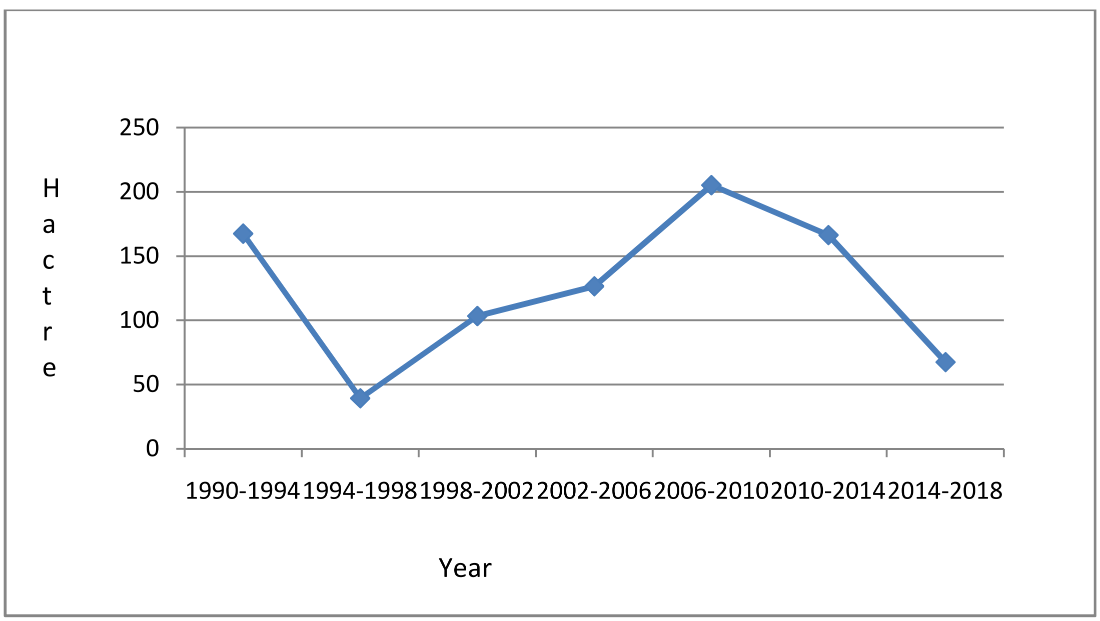

Figure 4.13:Sediment Budget in Depositions Side areas(m^3) of the Sangu River

In the last 28 years, sediment loss in this area 50.54 m^3 per year. This area is flood plain area, and this sediment is clayey types, and this sediment difficult to wash out. In other, the deposition part also deposited sediment is 875.73 m^3. We can use the arithmetic mean equation to find the wash out sediment in this area last 28 years.

4.7 Bank Sediment Erosion Rates

Bank erosion rates were calculated for the entire 11 km segment using time trend analysis for long term (1990-2018) and short term (1990-1994) periods — the average erosion rates for the 50.54m^3 per year period. The more sediment eroded in (1994-1998) year period is the total eroded area is 341.41m^3. we also studied in secondary data the James river bank sediment 56 year period was found to be 0.04 m/yr in the one side bank and 0.01 in the others side bank. The more recent 11-year period average erosion rates were 0 m/yr on the left bank, and 0.07 m/yr on the right bank (Kuehn, July 2015).

Chapter 05: Soil Particle Size Analysis of the Sangu River Bank

5.1 Soil Classification According to USDA

Currently, in the U.S.D.A, there are twelve main soil texture classifications according to USDA. This classifications is really complex , they are classified the soil into: loam, clay, loamy sand, silt clay, sandy loam, sandy clay, silt loam, silt clay loam, silt loam, clay loam sand and sandy clay loam. But on the basis of texture soil are classified into three types such as; clay, silt, sand which is depend on the soil fractions and compositions. Also, some researcher mare specified these classifications of soil mainly constituent particle size such as silt clay and sandy clay. The fourth term is topsoil soil. This has an equivalent extent of silt, sand and clay in a soil structures; it is specified more classifications like as silt loam or clay loam. For example, on the off chance that your soil segment is about 70% sand and 10% clay, at that point your soil is named a sandy soil (Bandyopadhyay, 2012).

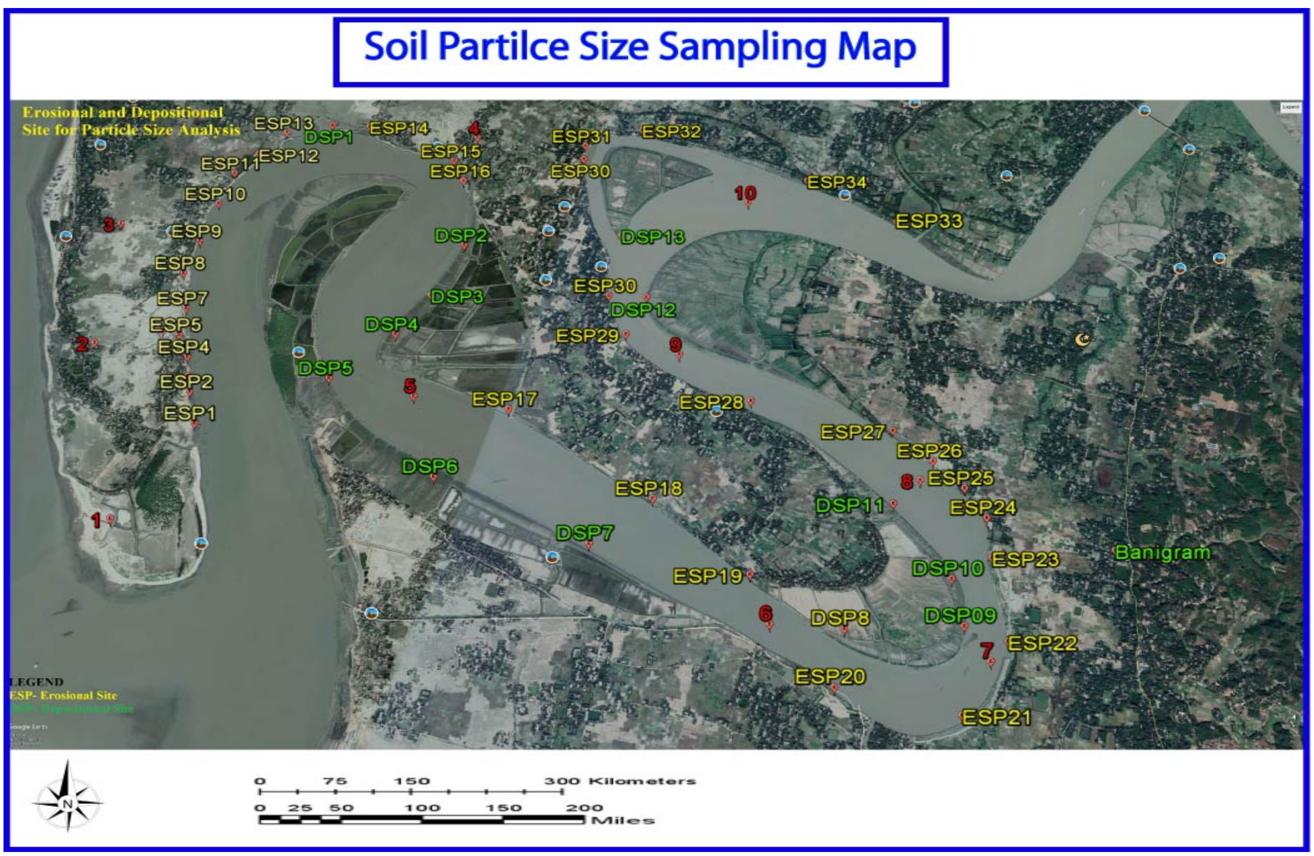

Figure 5.1: Soil Particle Size Analysis Sampling Side.

5.2 Soil Sample Size Selection Area

In this selection process, we take a sample in the selected erosion and deposition side. The sample selection is random. Sample area calculated the midpoint of several time. If we look at the DSP5 and DSP6 in this, both sample areas imagine the same properties of the soil and take the sample last and first point. We see Esp17 and Esp19 also the same condition. In this place, we take another sample middle of this area ESP18. The sample selection area also takes several kilometer inside from the last point of the river because we think the last point of the river joins with the Karnafuli River. So these rivers also influence the soil properties of the Sangu river side.

5.3 Soil Particle Analysis of Erosional Bank of the River

The following diagram is presenting the types of river soil particle of 23 locations in the study area. Some samples sand particle around the same. In sample 4, 5, six, the amount of sand is about the same. But in the sample number 23 has high sand percentages, than others hand, most of the samples contain clay about 70% then we called this is more clay loamy soil. The Silt particle is very high in ESP12 and ESP 21

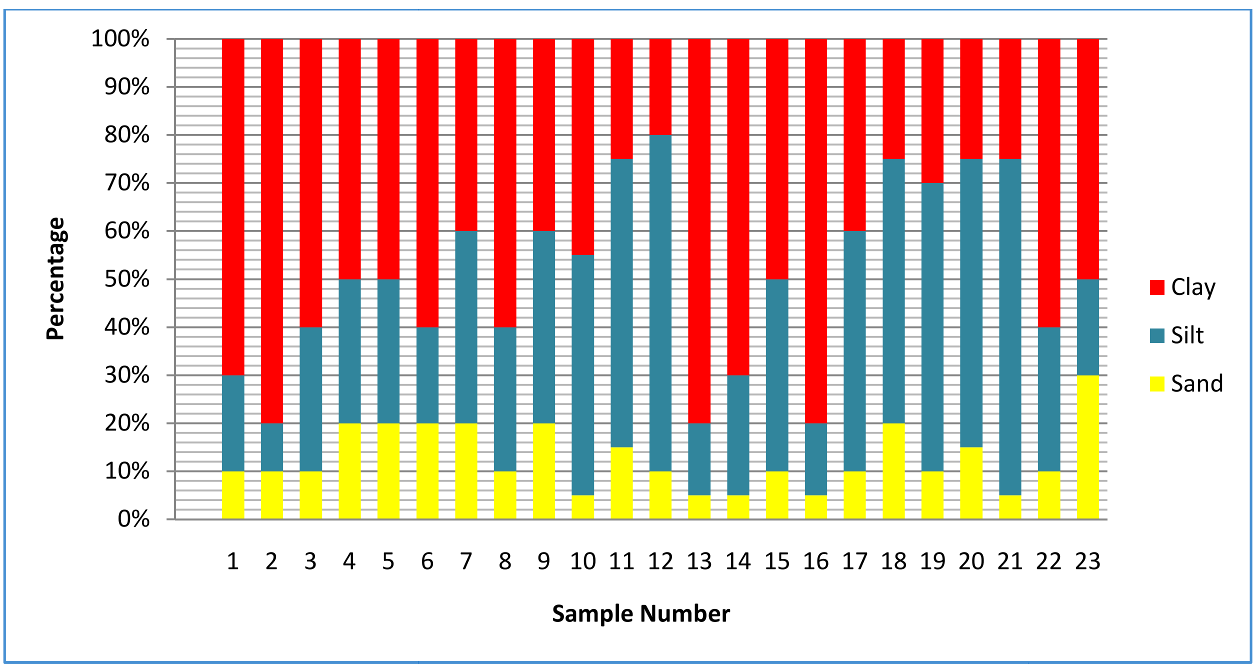

Figure 5.2: Soil Particle Size Analysis in Soil Erosion Side

Again, the Silt particle is increasing ESP 17 to ESP21. The erosional part mostly contains in the clayey particle. Highly clay particle low eroded sample are ESP2, ESP13 and ESP16. (Figure 5.2). Rivers and streams outlet are channels for moving sediment. A stream can move sediments relying upon the speed of the water entering the stream and the size of the silt particles. The moving water at low speed can move modest particles like clay, silt and sand. Water moving at high speed can move both little and huge particles, coarse materials like stones (Malden and Blackwell, 2002).

5.4 Total Soil Particle Size Analysis in the Erosion Site

The noticeable results determine from sediments analysis clayey silt, sandy silt and alluvial sands deposits with sandy silt particles in the flood plain areas. In the river bank clayey silts beds correlated with silt and sandy areas differently, which can be helpful for the aquitards. The clayey silt found on the flood plain, which would be significantly affect the aquifers recharge system. The below diagram is showing the erosion part mostly clay particle about 54% and the amount silt 33% and sand 13% (Figure 5.3).

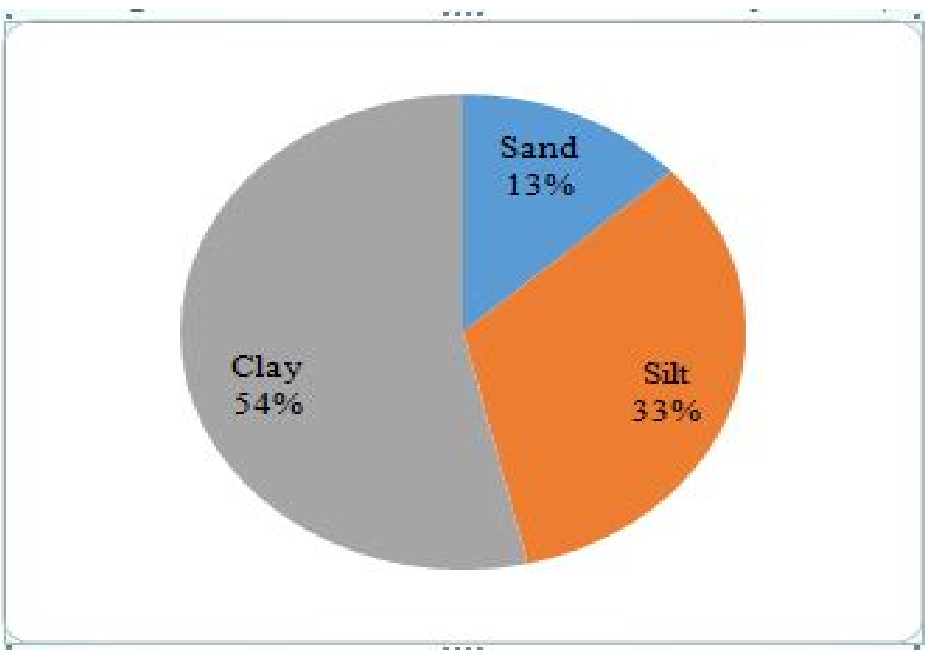

Figure 5.3: Total Soil Particle Size Analysis in Erosion Side

By the quantities analysis of the soil determines to be sandy silt, sand, clayey silt in the soil. Sand types materials is prevailing around the floodplain areas consists of 46% sand and 52% sandy materials separately, and clayey silt particles demonstrate a much lower estimation of just 2% (Ankidawa and Tanko, 2015).

5.5 Soil Particle Analysis of the Accretion part of the river

The following diagram is showing that the depositional part mostly Contains sand. DSP1 and DSP10 sample is mostly sandy while DSP19 is high silt Particle. The moderately increasing and decreasing of the clay particle is deposited in the whole area. Highly clay particle constituents DSP22. Silt and clay kept on a floodplain make the soil there amazingly richness of minerals. Therefore, this flood plain territory is progressively fruitful. In this flood plain region of Sangu river is for the most part overflowed each year. In the dry seasons the flooding mostly changes the soil compositions. In the lower hydro-fluctuations part is normally the silt and clay formations rate is more, then others respectively in centre and upper hydro-fluctuations belt.

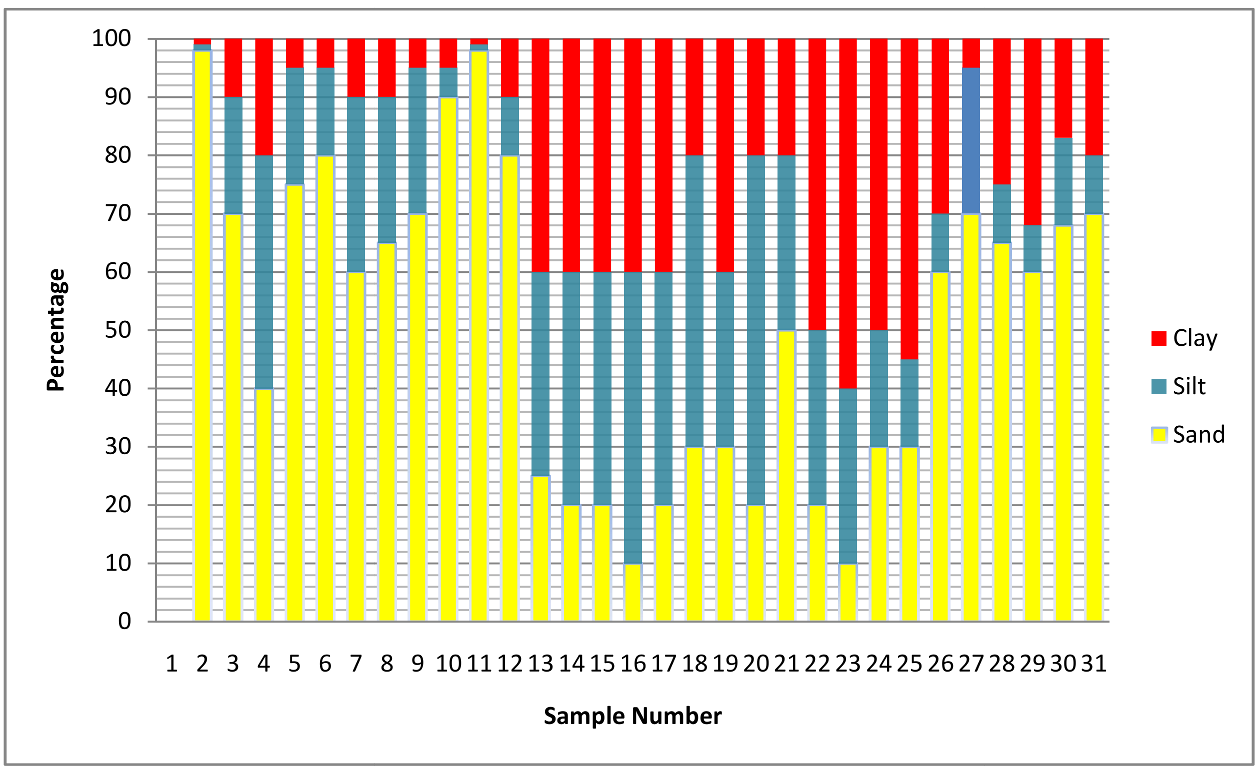

Figure 5.4: Soil Particle Size Analysis in Soil Depositions side

So total amount of sand and silt in 150 gram soil sample more than 180 gram soil sample which amount increased 18.2% .In the context of sand particle in the soil, the more hydro-oscillations areas sand particle is more than others, which follow as centre and low hydro- oscillations areas. As result the sand particle amount at 170 gram soil is more 150 gram soil, which respectively 19.2% percent. The soil segment changed with the expansion in height slope from silt loam to loam and last to sandy loam.

Nevertheless, in the others hand low tide seasons also increase the silt and sand permeations, as well as surface to subsurface area of the soil. So, this process extends the homogeneity of the grain size in the soil layers. The adjustment in soil surface is identified with changes in soil supplements. The proportion of absolute phosphorous, soil natural matters, and all potassium fluctuated incredibly between soil surface sorts, in which loam have the most elevated soil nutrients focus, and sandy loam has the least.

5.6 Total Soil Composition of the Eroded Side of the River

The beneath chart demonstrates the Presence molecule of depositional region Sand 50 %, Silt 26% and Clay 24%. Particle Size distribution is calculated of a developing Sand Bar at Sonadia Island.

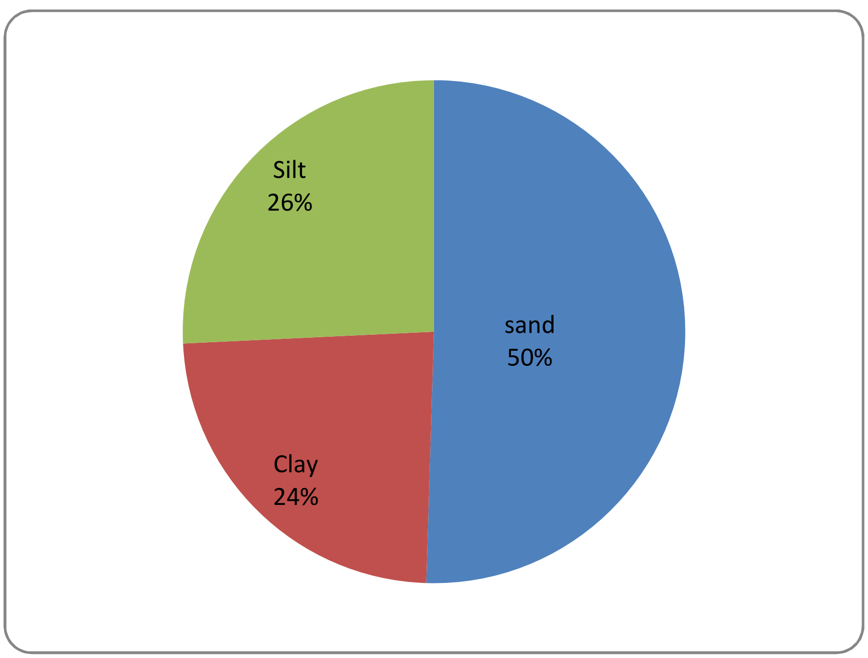

Figure 5.5: Total Soil Particle Size Analysis in Deposition Side

Bangladesh additionally soil molecule investigation in the shore territory 50% of the particles is found sand. This is justifiable on the grounds that the Sand Bar district experiences consistent geo-morphological changes because of dynamic activity of wave and tide and the locale is encompassed by water with a substantial suspended load of sediments. (Hoque, et al.; 2013).

5.7 Soil pH and Soil Electronic Conductivity

In the collected sample, we selected some sample for pH measurement and electronic conductivity test in the laboratory of SRD Bangladesh. From this test, we see that most sample's pH is near the neutral level means till now, the soil pH has not altered. In the study area, the average pH level is found between 6.2 – 8.0. The salt contents increase in the roots zone of the crops is main problem in study zone areas. The process of salt increase in soil in inland through the rivers and channel enter salts water particularly in the dry seasons. The people collects the saline water from the river that additionally causes the increase salinity in ground's water in the study areas and it made the problem into agricultural fields irrigations. However , the shrimp cultivations in the inland areas is mostly responsible for the salinity, particularly the southern part of Bangladesh affected this problem. As a result of salinity increase in the soil increase the aridness of the soil. Appropriate soil pH in the coastal areas of Bangladesh 6.00-8.4 (Rahman, et al.; 2013).

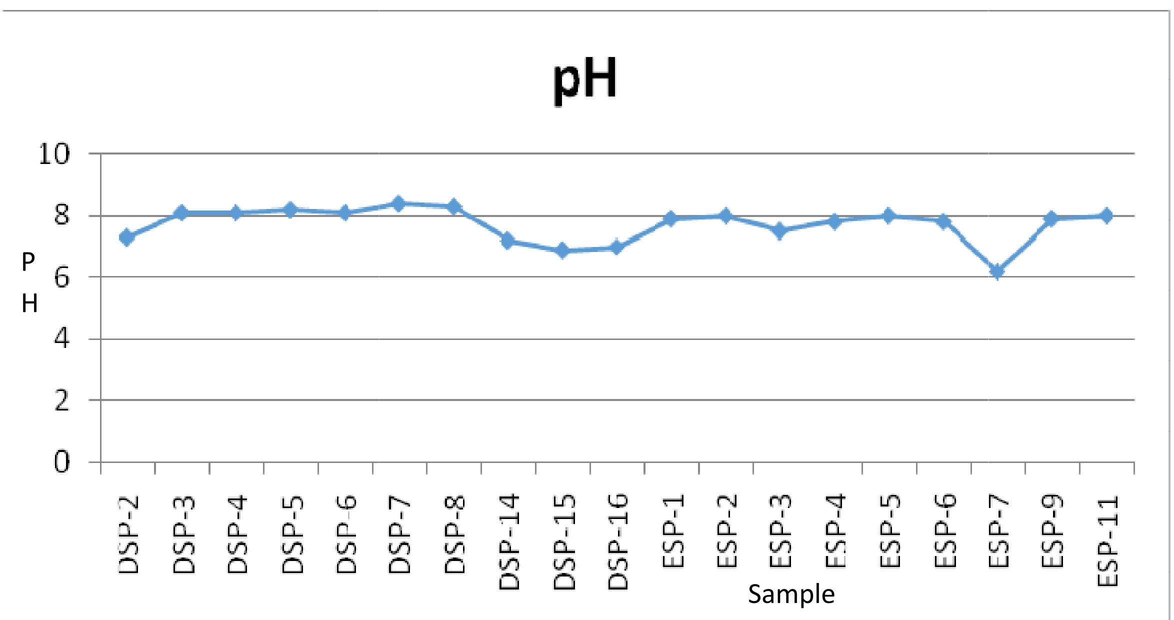

Figure 5.6: Analytical Report of Soil Salinity and Soil pH

Table 5.1: Result of Soil Salinity and Soil pH Measurement in SRD Lab in Bangladesh

Soil Sample	Soil Salinity	pH	Comment
DSP-2	0.1dS/m	7.3	Most of the samples are basic level pH, the salinity level also a minimum level.
DSP-3	0.1dS/m	8.1	
DSP-4	0.5dS/m	8.1	
DSP-5	0.1dS/m	8.2	
DSP-6	0.6dS/m	8.1	
DSP-7	0.1dS/m	8.4	
DSP-8	01.2dS/m	8.3	
DSP-14	0.1dS/m	7.2	
DSP-15	0.1dS/m	6.9	
DSP-16	0.1dS/m	7	
ESP-1	1.8dS/m	7.9	
ESP-2	0.3dS/m	8	
ESP-3	0.6dS/m	7.5	
ESP-4	0.2dS/m	7.8	
ESP-5	0.3dS/m	8	
ESP-6	0.2dS/m	7.8	
ESP-7	0.8dS/m	6.2	
ESP-9	0.8dS/m	7.9	
ESP-11	0.1dS/m	8	
ESP-12	0.3dS/m	7.7	

5.8 Overall Discussion on the collected Soil Sample

The total investigated soil sample result are described in this sections.This area is flood plain areas so in the hand auger meathos shows that maximum area soil are clayey and loamy clayey soil or vary clay which includes the little amount of sand and silt. For this investigations we collect both parts of the soil sample where we saw that, in the erosion side soil mostly clyey and the deposited side sample are mostly sand. In the figure 5.2 and 5.4 we saw that different soil percentage. According to the soil stability mechanisms the sandy soil are less stability and less cohesions facility is more. In the others side, the clayey soil is stability power is more so this part river bank erosion is less. In the erosion side, soil samples show that the study areas of Anowara and Banshkhali Upazilas soil are sandy and silty type and more sand and minimum silt and clay. It is the reason for river bank failure because sandy and silty clay bear low shear strength.

5.9 Cation Exchange Capacity

The measure of particles, in meq/100 g soil, that can be replaced from the soil by particles in solutions. The lower part of the Sangu River is flood plain area. Flood plain areas soil is a different characteristic's. CEC is an implicit soil trademark doesn't change fundamentally. Cation Exchanges capacity control the stability of soil, fertility of soil, soil pH and soil reactions with different types of fertilizers and others activities. The erosion side is mostly clay compositions, so this side area is usually fertile. In this soil more nutrient constituents. But another side of the river is less fertile because this side is fewer clay materials in the soil. These areas are more agricultural and slowly convert to an urban area.

5.10 Soil Fertility Changes

The Soil fertility of a degraded land zone indicates huge changes. Because of siltation, the topsoil layer in the farming fields is secured with a meager sheet of fine sands, which isn't rich. During the way toward losing the topsoil, the potential agrarian terrains become desolate. While the recently accumulated char land comprises of sandy material and dynamic which yield low crop generation and restricted harvest species. Most occasions just kaon, peanuts and pumpkin are collected in the char land.

5.11 Relations between River Bank Erosion & Soil Particle Size

In the previous years, there has been a sensational change in cases identified with soil erosions. In any case, soil erosions are characterized as a naturals procedure which consistently happens with no signs or symptoms. It has been distinguished as a major issue for a long time now. It is attributing to be a major problem because of uncontrolled advancement. In 2012, Julien described that the normal procedures of sedimentation and erosions have been dynamic during the topographical time, and it has formed the present scene of our reality. Therefore, the riverbank erosions would make the riverbed degrade and store sediments to the water body. The bed structure particles, alongside river bank particles, would be disengaged from their interlocking because of the activity of water stream. The transportable particles would begin to move and store at the downstream piece of a river segment. This procedure would cause serious engineering's and natural issues if checking projects are not well-managed and practiced.

5.12 Clayey Soil Sample in the River Side

Soil quality relies upon its compositions of the soil molecule. The compressive quality has expanded in the thickness molecule of the soil. Also, the compressive quality reduce with decrease of the water quality in the materials, which pursues a comparable capacity. On the other hand, the compressive quality reduced with increase in sand content because of the high conents in material heterogeneity and loss of sand grains from the sides during the shearing procedure (Khan et al.; 2014). The clayey soil has more compressive power and possesses low water holding capacity, which results in less erosion of this type of soil. In the erosion sample, 1,2,13,14,16 more contain clay particle as this area are less eroded or need more time for erosion. In the deposition also same the sample number 14, 15, 16, 23, 24, 25 is a less eroded area in the Sangu river area. The soil of this area contains more than 50% clay silt about 20 % and sand is about 10%. The shear quality of soils is exceptionally impacted by dampness conditions, particularly when the soil comprises of clay materials. Commonly, the research facility example which is utilized to evaluate the shear quality of the soil is set up at the dry thickness and water content like the field conditions, regardless of the implications it may cause later on (Bláhová et al.;2013) .

In the soil properties clay fractions determines the soil strength, hydraulic conductivity, ions exchange capacity. In this situations also include the isomorphism. The isomorphism of soil is called isomorphic substitutions, if the octahedral or tetrahedral sites are replaced with different atom are found elsewhere. The surface property of the solids is defined as in per unit how mass solid consist of in the whole area. Separations of hydroxyl ion from the clay surfaces, which results in the lack of crystal on the crystal head, some anions are mixed with surface in this way. Natural atom substance causes electrical burden unevenness (Ural; 2018).

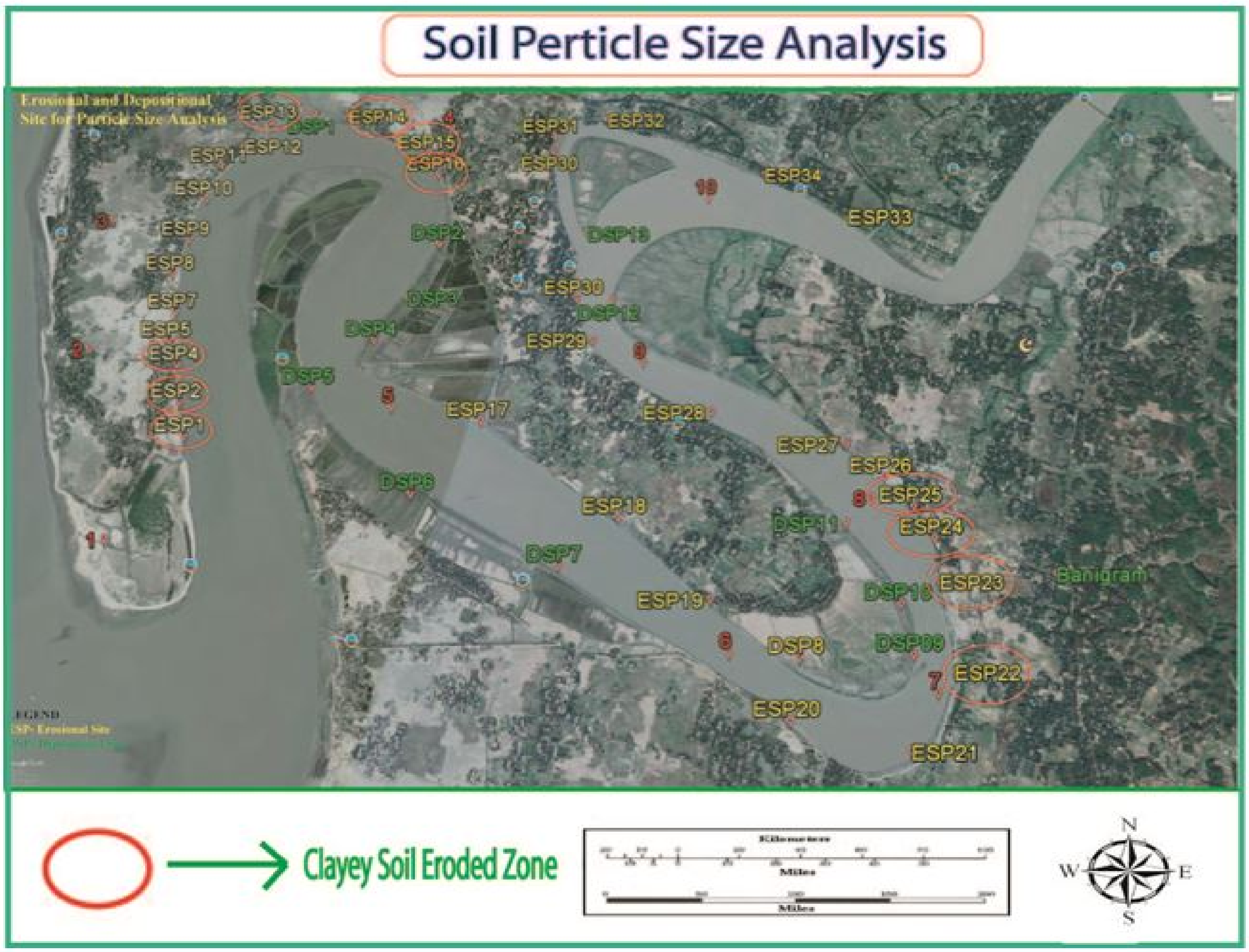

Figure 5.7: Less Eroded Zone in the Sangu River

5.13 Silt Soil sample in the River Side

The greater part of the common soil stores contain a specific measure of silt and clay. In the river bank area various types silt soil are constituents like as silt soil, sandy soil, clay sand, sandy clay and sandy silt etc (Norsyahariati et al., 2016). The surface of soil, the quality of being easily shaped or molded index, compressive quality and are most noteworthy geotechnical parameters of a Riverbank, for its quality, and to potential River bank cracking, which may influenced the flood and erosions. Because of discovering the center topographical factor affecting Riverbank erosions, the study depends on the hand auger methods soil particle size analysis. For all tests, an example was gathered from a few. The majority of the focuses were arranged in the powerless and influenced zone for River Embankment disappointment. The majority of the tests had been done at oneself controlled conditions.

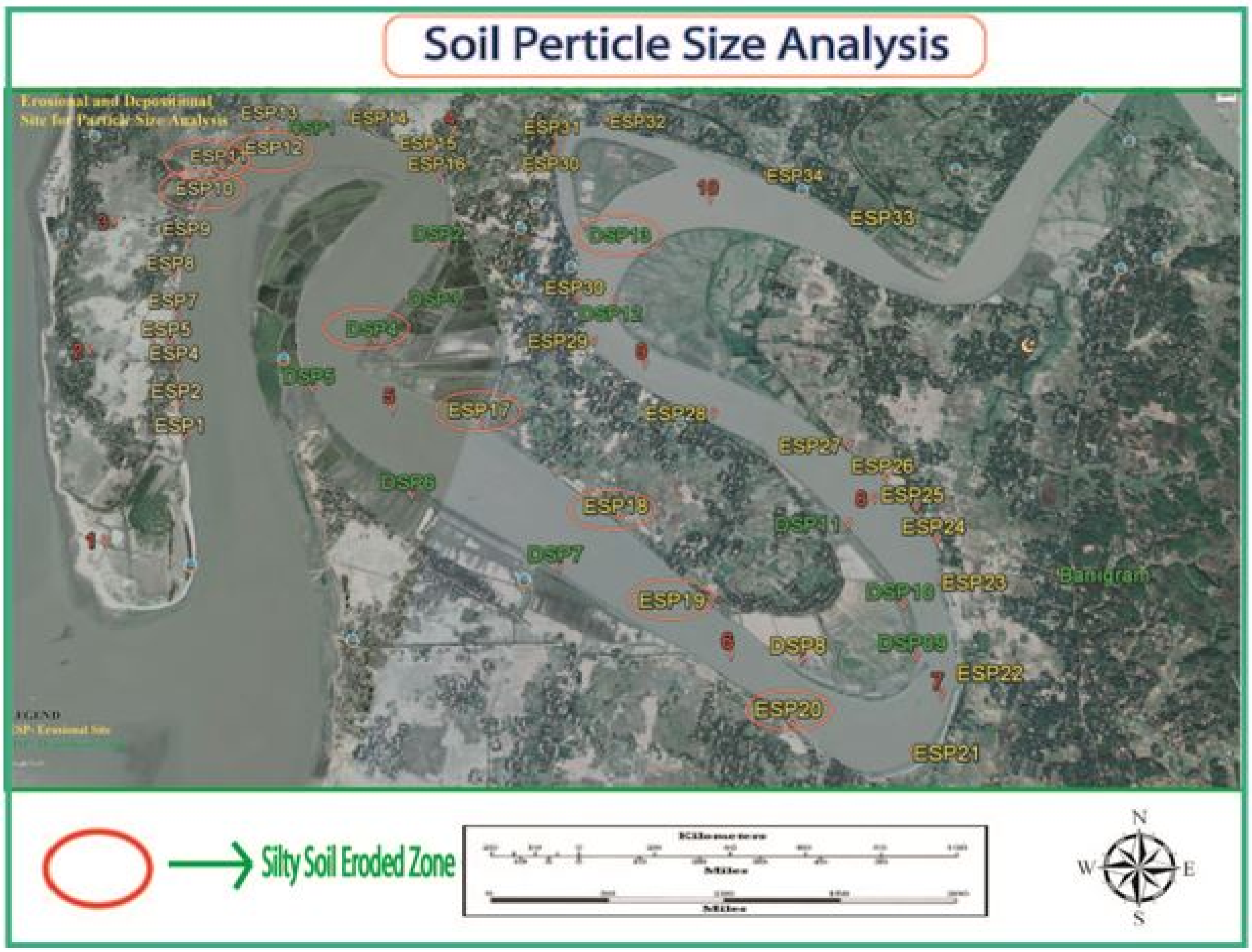

Figure 5.8: Medium Eroded Zone in the Sangu River

For the test of this sample are collected on both sides of the river. In the riverbank erosion side sample 10, 11, 12, 17, 18, 19, 20 and depositions side sample 13 is mostly silt soil point (Figure 5.8). In that point, soil erosion is mostly silt soil (Figure 5.8) those locations soil erosion is medium.

Because of silty soil has medium shear strength and gravity also less from the clay soil. “The soil specific gravity determines which soil are cohesion less, loose, that is the causes of riverbank failure. If the soil specific gravity value show below 2.50, it predicts in general that the area soil is more likely to be eroded though many other factors influence the soil erodibility” (Hasan and Methela; 2018).

5.14 Sandy Soil sample in the River Side

Floodplains are complex and varied according to the sedimentary composition of the environments. Sedimentation includes a variety of factors which include topography and river flow (Long et al., 1996). The sedimentary floodplain arrangements which comprises of a wide scope of molecule size incorporates strong clay and silts related with sands related as rock of channel fills. Soil texture id the most important part of the study areas, previous sediments of the depositional flood plain area, which is identifications of the environments and sub environment conditions in areas. (Dark and Allen, 2005).

In view of the examples gathered from the erosions side of the river as appeared in figure 5.9, sand is low, however as far as depositions, soil test (Figure 5.9) and substance are high. Sandy soil shear quality and gravity are low also. The soil shears strength of the soil is defined the soil resistance of the per unit soil mass, which help the soil to resist failure and slide from the any nearest plane areas. It is imperative to comprehend the idea of shearing obstruction in other to break down the soil dependability issues, which leads to compare with better facilities to interlocking, high frictional limit in the poorly graded soil. .

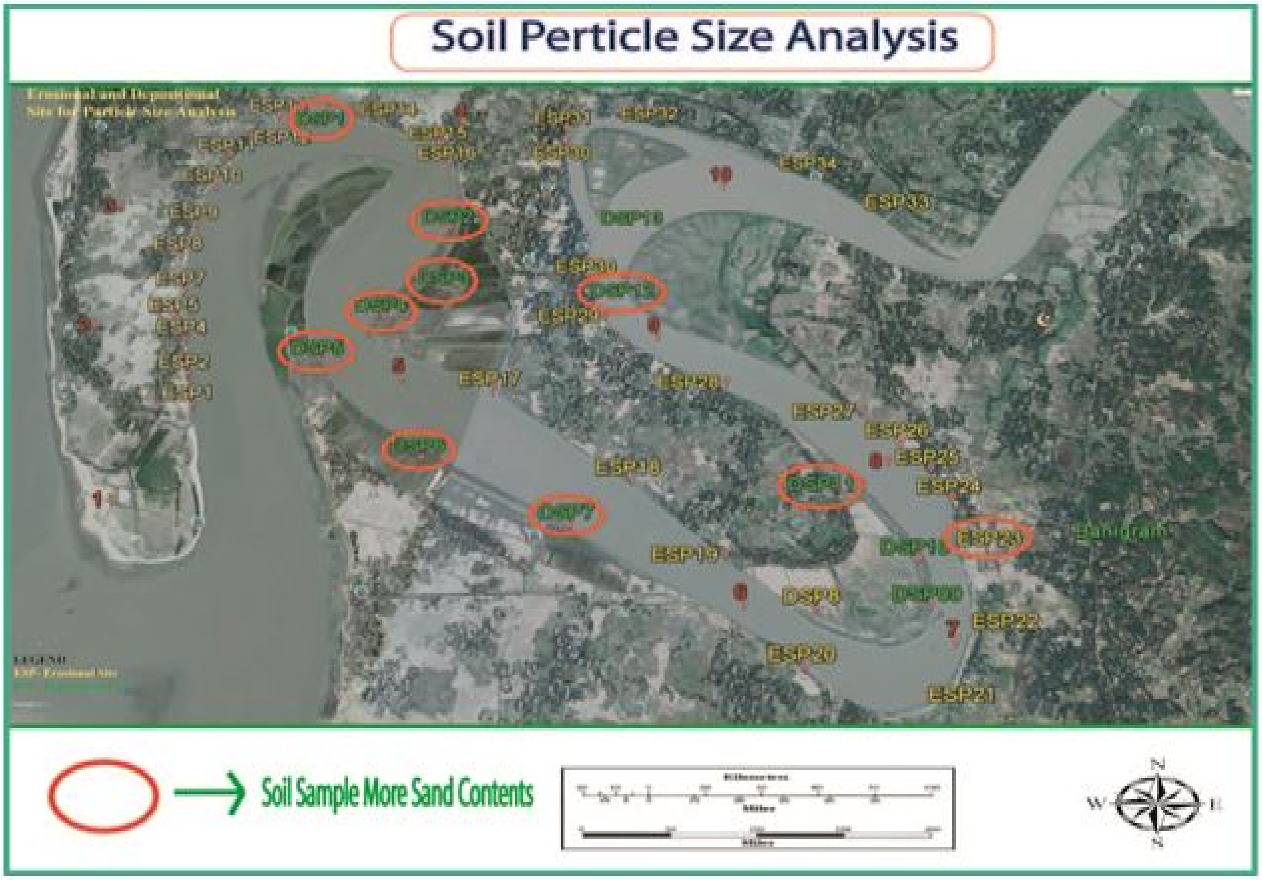

Figure 5.9: More Eroded Zone in the Sangu River

Chapter 06: Land Use Change Due to the River Bank Erosion and Depositions

Bangladesh is developed day by day. The developments are influenced the land use change or land cover changes. The land use change is a common term in present world. Land use changed would be different , some important changes of land use are ; road constructions, change of crops verities, deforestations, embankment buildings, coastal zone weathering, mining, wetland modifications, the extensions of urban areas etc. Kashaigili et al. (2009) described that only the adequate land use and proper water management can be sure sustainability of ecosystem and environments. This study around the advantages of incorporating remote sensing's and traditional information in progressively understanding the catchment assets by illuminating the arrangement and chiefs on the requirement for satisfactory arranging and developments of the agriculture practices for the sustainable management of the study areas properties. On the earth, Bangladesh is the most populated nations of the world. Because of this, there is a highly demand of foods and other developing national financial sectors apply pressure on the water assets accessible in the nation.

Moreover, streams from farming terrains can prompt surface water contamination, which can severe affect aquatics animals (EGIS II, 2001). Ongoing examinations demonstrate that the decrease of aquatics species, biodiversity, land and water proficient assets and wildlife living spaces has prompted the adjustment in wetland-dependent on human exercises and decrease in financial exercises (Islam and Sadque, 1992).

All these issues might be directly, or indirect get affected by the changes of land use in an area; therefore, in this study has analyzed the land-use changes that are due to the morphological works of Sangu River. This chapter will elaborate on the land-use change along the channel of the Sangu river for 28 years' time period.

6.1 Land-use change in the Flood plain area of Sangu River in Bangladesh:

Land Use change Changes in 1989

Land is an important part of the human activities. Everyday human beings made modifications of the land use. Humans has crucial role for shaping ecosystem functions. The meanings of land use changes is the mordanizations and modifications of the land areas such as ; agricultural land forest land and urban land areas. Land use change is the most important elements of the measuring the common ecological and human movements related changes. Generally, Land use changes is the development or degradations land by human beings or others. (Hasan et al., 2017) . For this study, we classify differently of this area like as vegetation, fellow land, char land, Sangu river, settlement, shrimp cultivation. Due to the Sangu riverbank erosion in these areas, the land use pattern has been changing gradually. From the 1989 map, we have a study that the total area was 5178 Hectare. Where fellow land was 1268.61 Hectare (24.5%) Vegetation area 1848.54 hectare (35.5%), Shrimp cultivation 201.94 Hectare (3.9%), settlement 300.32 Hectare (5.8%), Char Island 388.85 hectare (7.5%), Sangu river 1170.22 Hectare (22.6%) (Table 6.1 & Figure 6.2 , 6.3). We studied from the secondary data source, the example of land use change of Rajshahi Dictrict discuss revealed the agricultural field is facing more danger challenges. Despite the fact that the pace of decrease is slower than different kinds of changes, its huge sum is concerning more than different changes. The rural place where there is the Rajshahi region has been diminished by 14.05% during the previous 33 years and at a pace of 0.46% every year (Islam and Hassan, 2011).

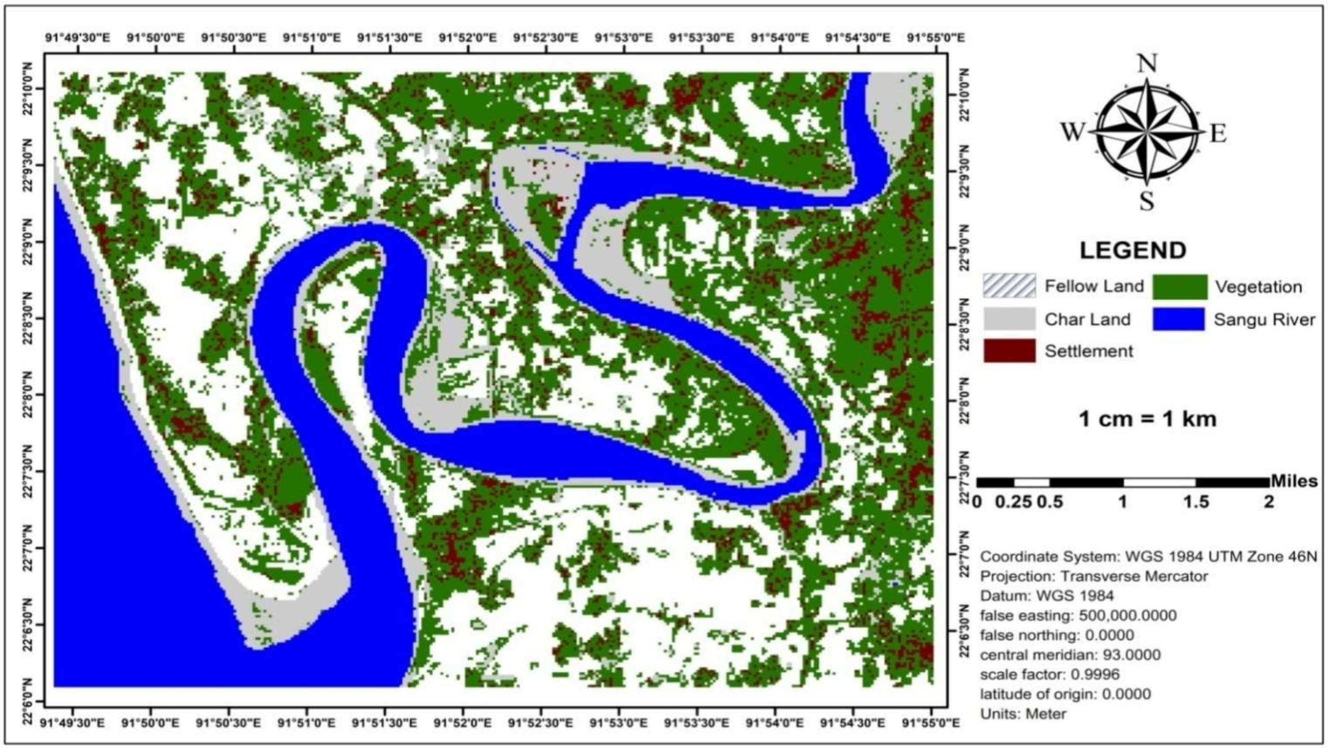

Figure 6.1: Land Use Change Map In 1989

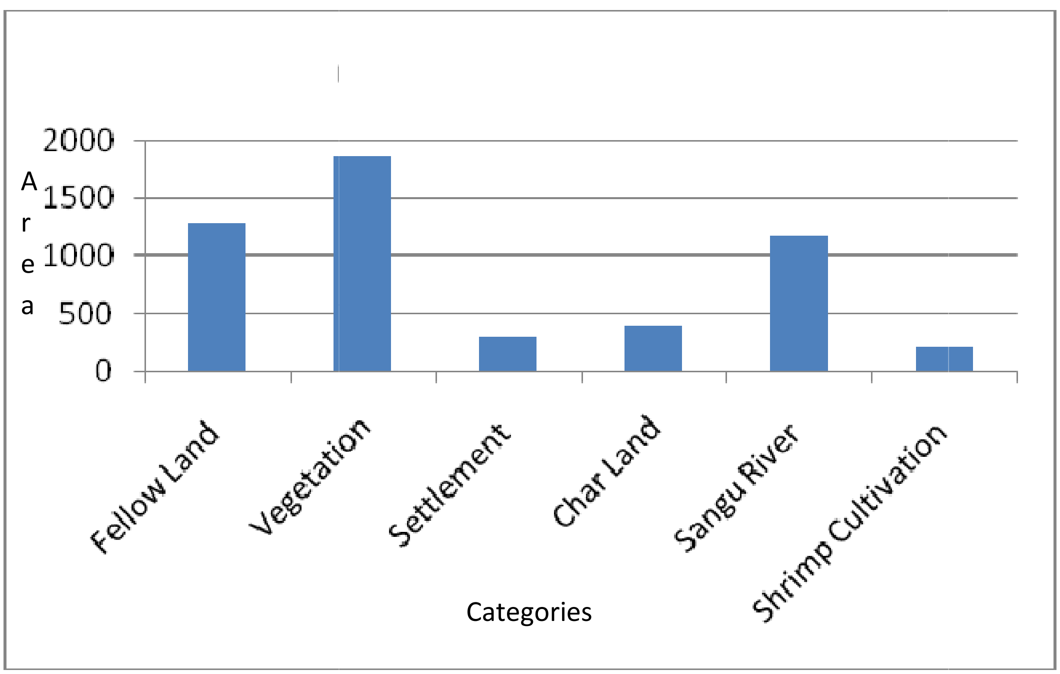

Figure 6.2: Land Use Change Area-1989

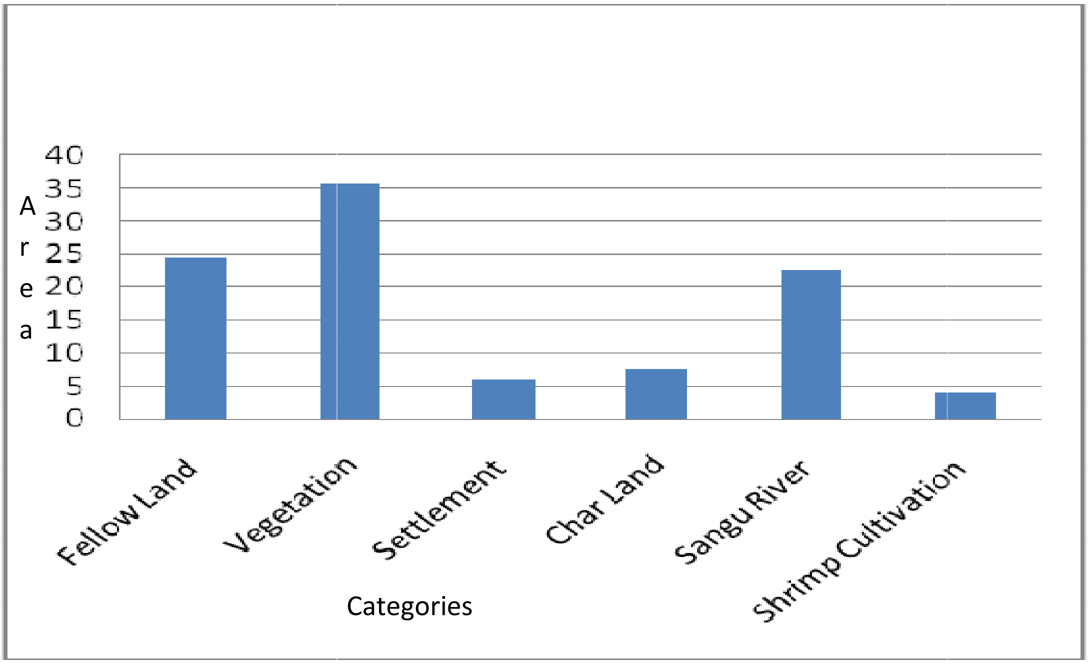

Figure 6.3 : Land Use Change Percentage -1989

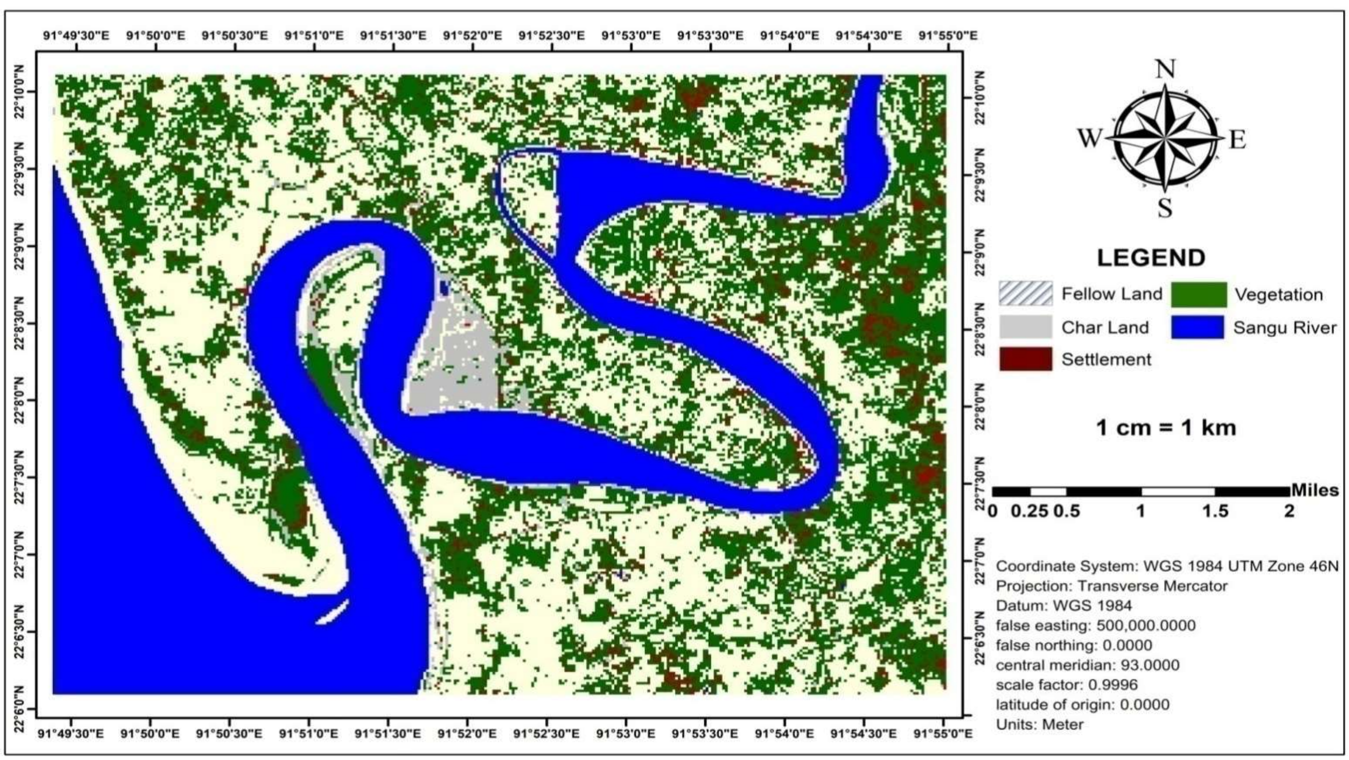

Figure 6.4: Land Use Change Map In 1994

Land Use Changes in 1994

There are different effects of rivers bank erosions, which incorporate wellbeing, social economic, instruction and political variables. As a result of land erosions the peoples are homeless and they migrate to others places, these are social impact of land use changes. After the constrained movement, peoples face economical problems for example, loss of property, loss of employment and they are increasingly inclined to poverty and most occasions' contribution in crimes (Iqbal, 2010). In 1994, the total land area is the same, but presently fallow land is 1310.03 hectare (25.3%), vegetation is about 1744.9 hectares (33.7%), shrimp cultivation has increased with 253.8 hectares (4.9%) while the Sangu river area is 1128.8 hectare (21.7%) decreased as shown in table 5.1 and figure 5.3 & 5.4 respectively. Soil research development Institute (2004) projected 0.1% of agricultural land annually converted to other human activities such as industries, settlements, Brickfields, roads and borrow pits based on the information acquired from an aerial photo in different years.

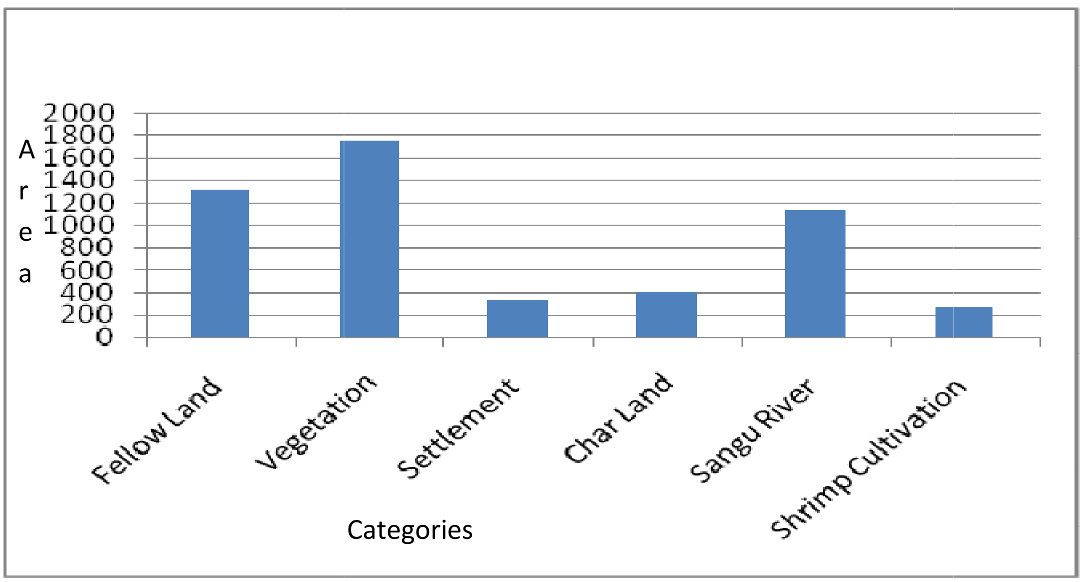

Figure 6.5: Land Use Change Area-1994

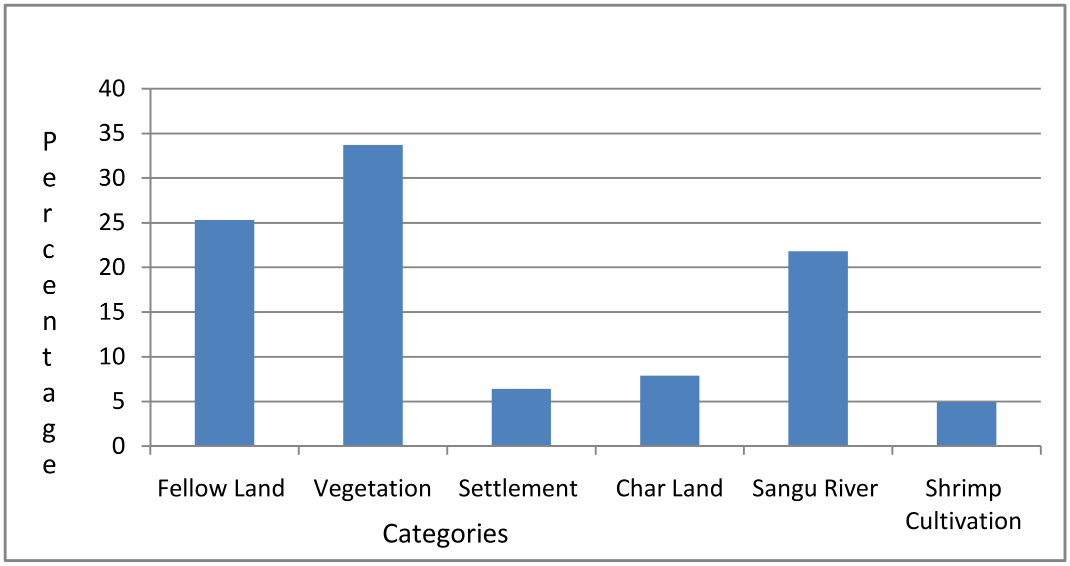

Figure 6.6: Land Use Change Percentage -1994

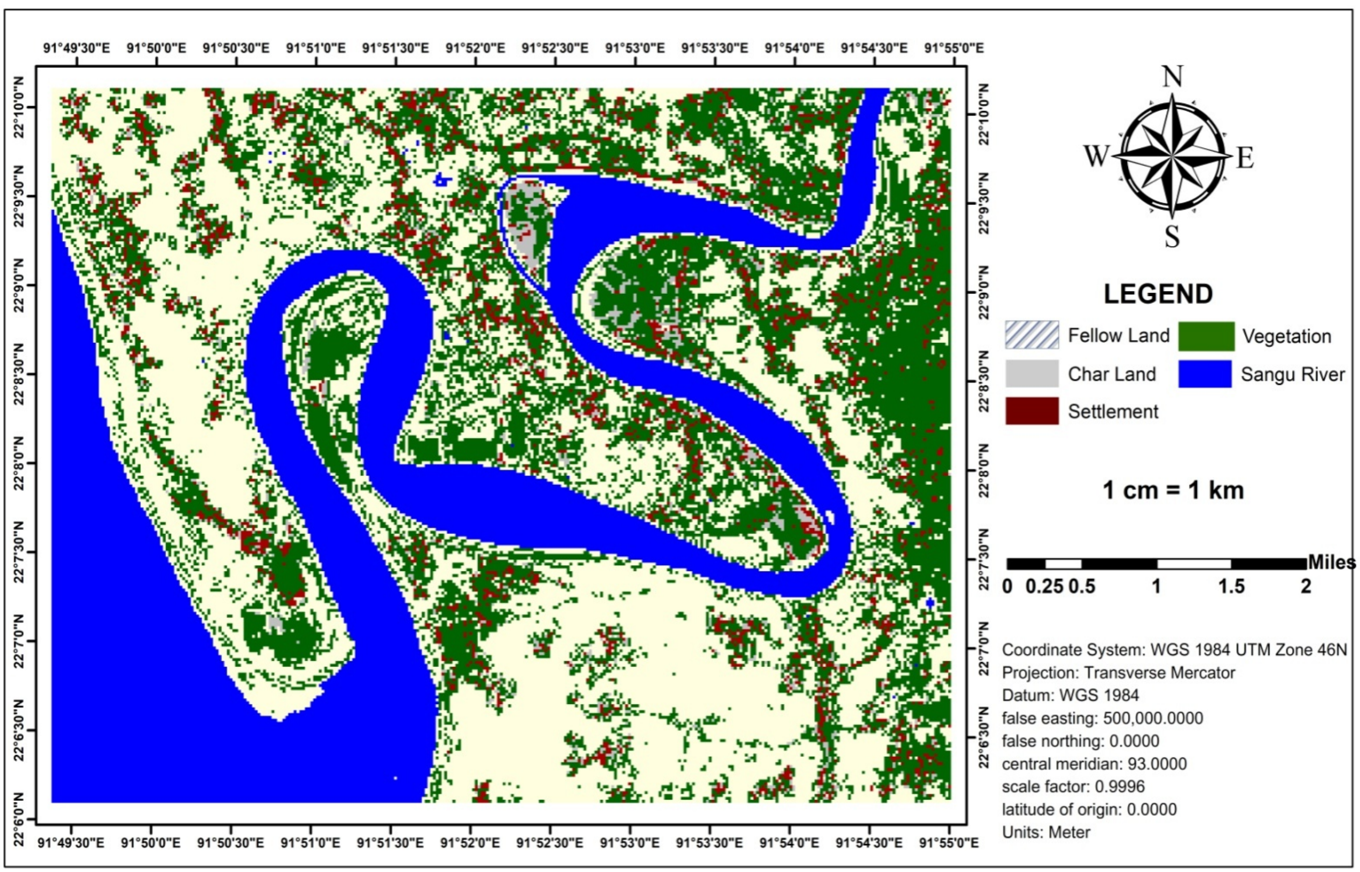

Figure 6.7: Land Use Change Map In 1999

Land Use Changes in 1999

In the recent research by Islam(2000), he was described in his documents the areas of the agricultural land , waters bodies , fallow land, and rivers decrease day by day, particularly the infrastructural urbanizations area and char land increased. From this we determine that the rural land area are converted to infrastructural land areas. In the year of 1999 total vegetation area used to be 1682.85 hectare (30.6%), settlement was 326.21 (6.3%), Shrimp cultivation was 150.16 hectare (2.9%) (Table: 6.1 & Figure: 6.8,6.9).

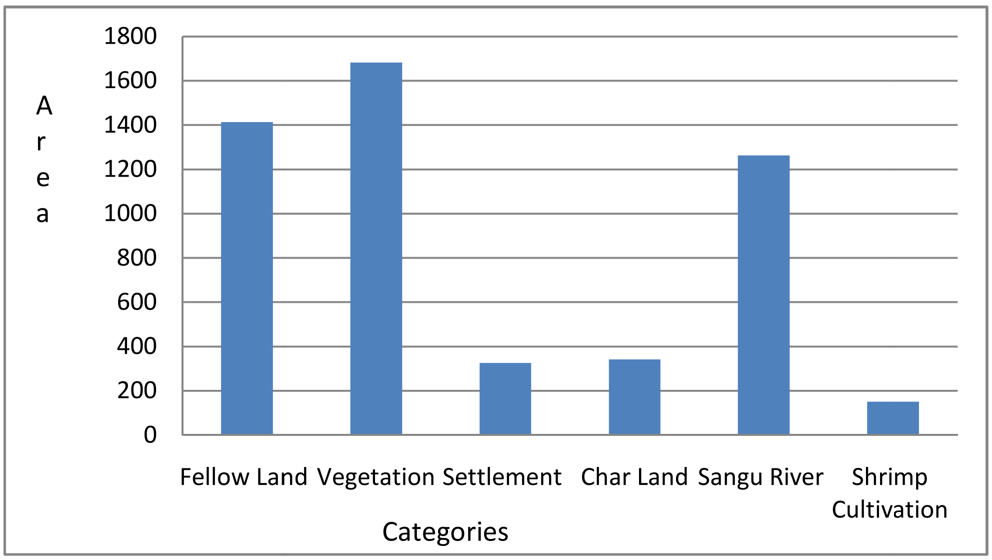

Figure 6.8: Land Use Change Area-1999

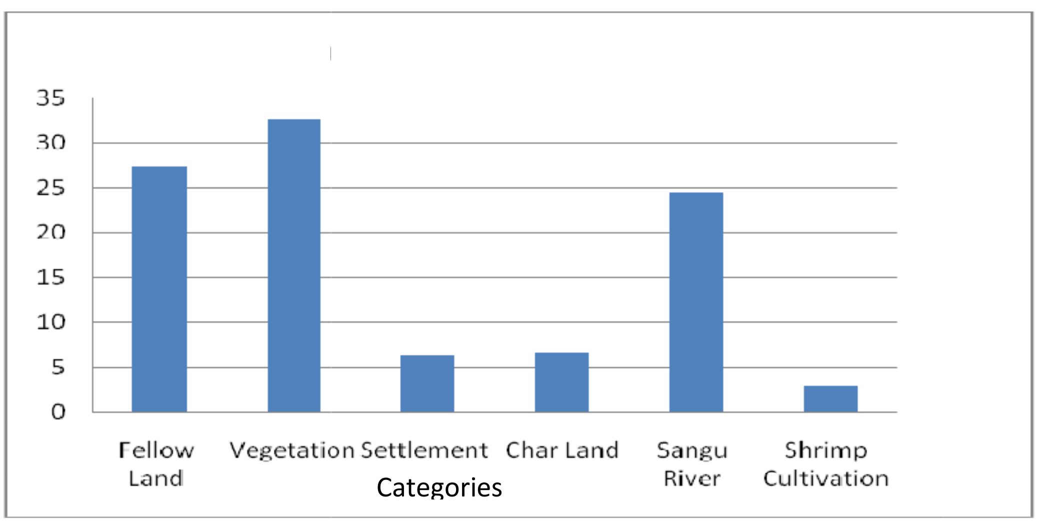

Figure 6.9: Land Use Change Percentage -1999

Above this discussion, we also saw that conditions in the others research of Mandol (2008), he found that about 46.26 % agricultural land changed to shrimp cultivations firm land in coastal areas of Bangladesh. According to the Statistical report of Bangladesh, the per land of peoples in Bangladesh is 0.0526 ha, total agricultural land is not more than 70 cores ha. Despite consistently 1% of agricultural lands are converting to others in Bangladesh. Because of increasing rate of populations will be over around 190 million by 2030. As a result of this 25% extra food crops are badly needed to produce. Yet, the extra collects should be harvested from an a lot littler territory of cropland that is presently accessible (Bhuiyan, 2003).

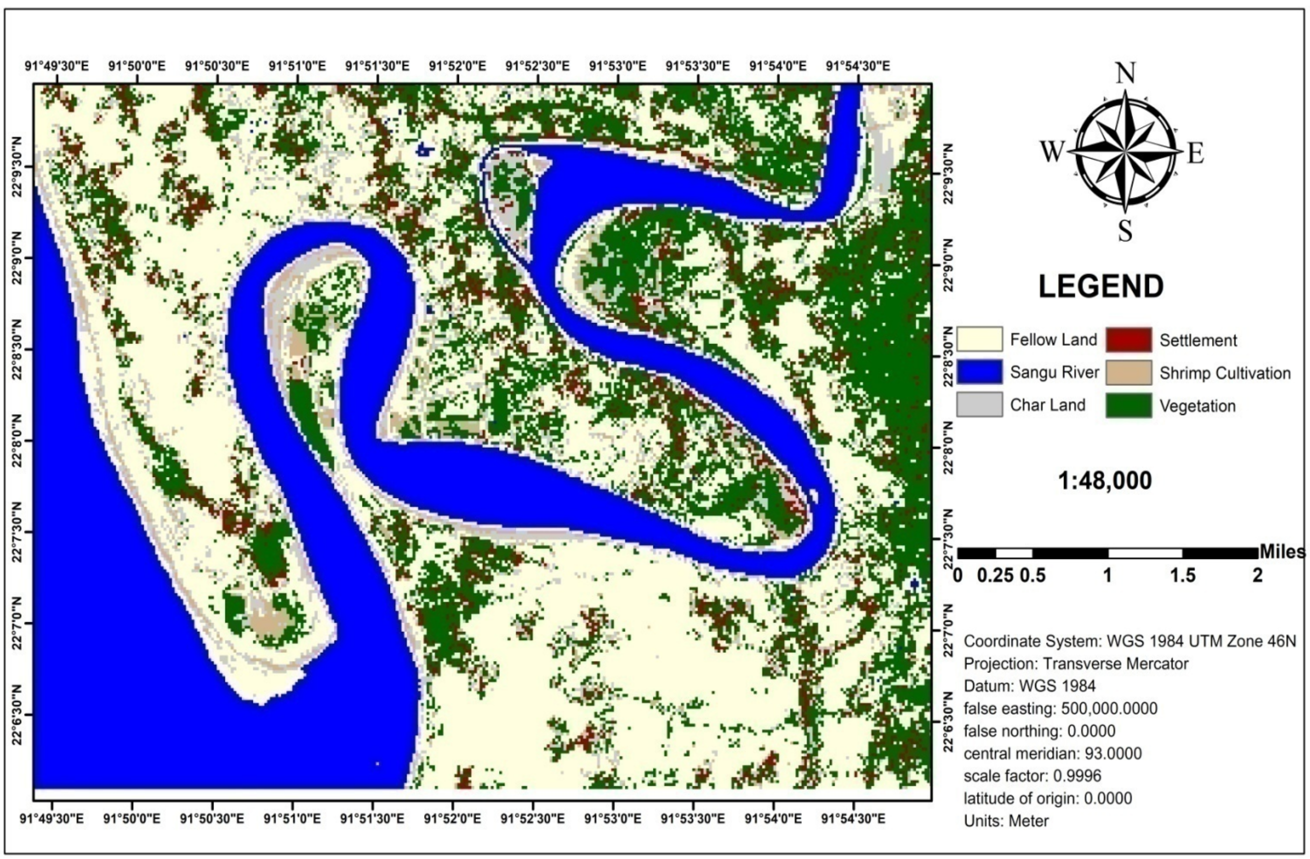

Figure 6.10: Land Use Change Map In 2004

Land Use Changes in 2004

When nations are coping with livelihood and recover their stresses without any worries then this nation's sustainability will achieve (Carney, 1998). In the study area, people change their occupation causes of river bank erosion; most of peoples converted to shrimp cultivation or some move to the city area as daily labors work. In the Sangu river area (Anowara and Bashkhali Upazila) in the duration of 2004 total vegetation area is 1584.46 hectare (30.7%), settlement is 424.59 hectare 8.2%, Shrimp cultivation is 196.8 hectare (3.8%), Sangu river is 1123.6 hectare (21.7%) which is gradually decreased, fallow land is 1496.44 hectare (28.9%) which has gradually increased every season (Table: 6.1 & Figure: 6.11 ,6.12). Every year char-land areas are increasing seasonally in several parts, so fellow land also increases in the study areas.

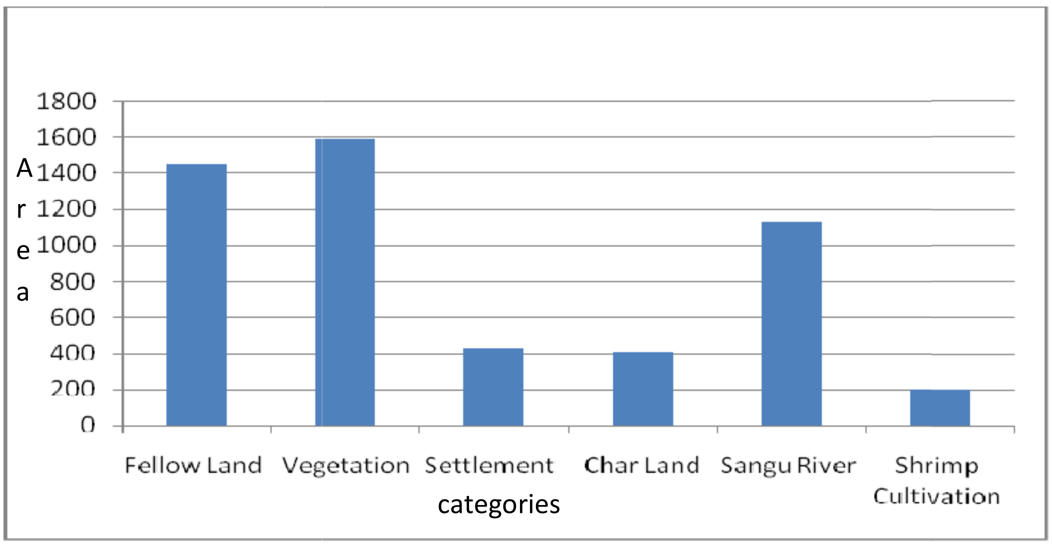

Figure 6.11: Land Use Change Area-2004

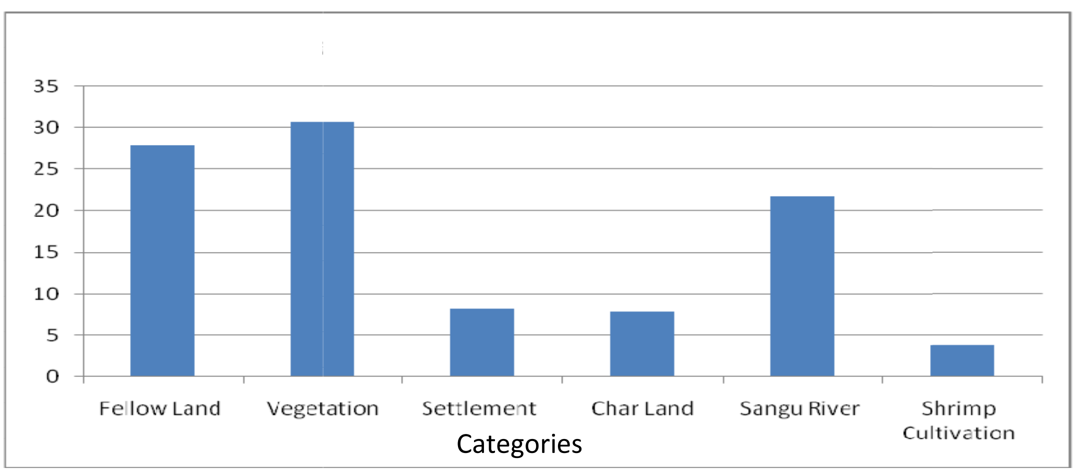

Figure 6.12: Land Use Change Percentage -2004

The deficiency of land is very serious when 50% peoples are landless in a nation and numerous individuals are constrained to settle in the undeveloped char islands when this shows up in the center of riverbeds or in the seashore regions, taking a chance with their lives (Ullah, 1996). A portion of this undeveloped and unstabilized island gets immersed during the elevated tide and dries out during the low tide.

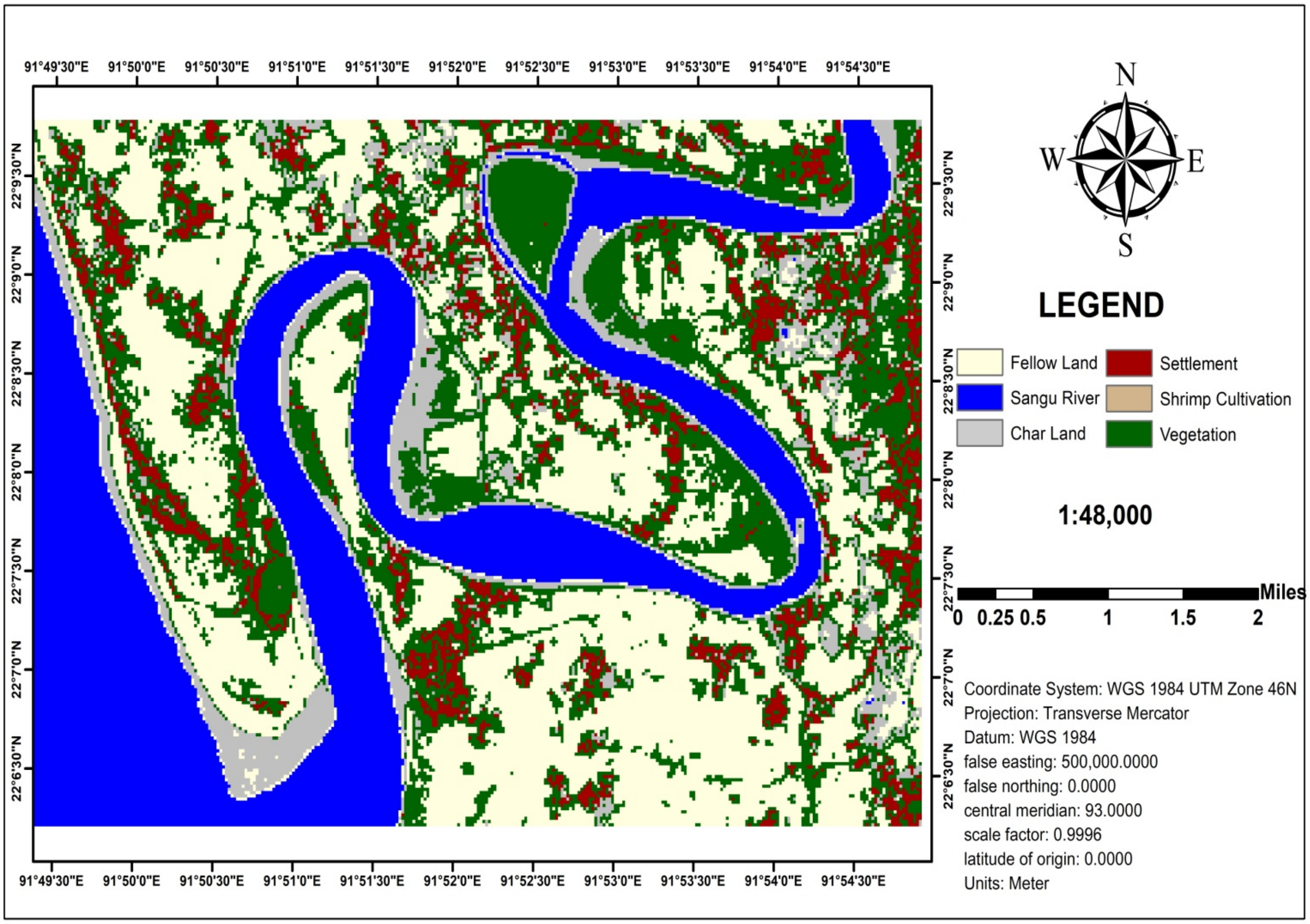

Figure 6.13: Land Use Change Map In 2009

Land Use change Changes in 2009

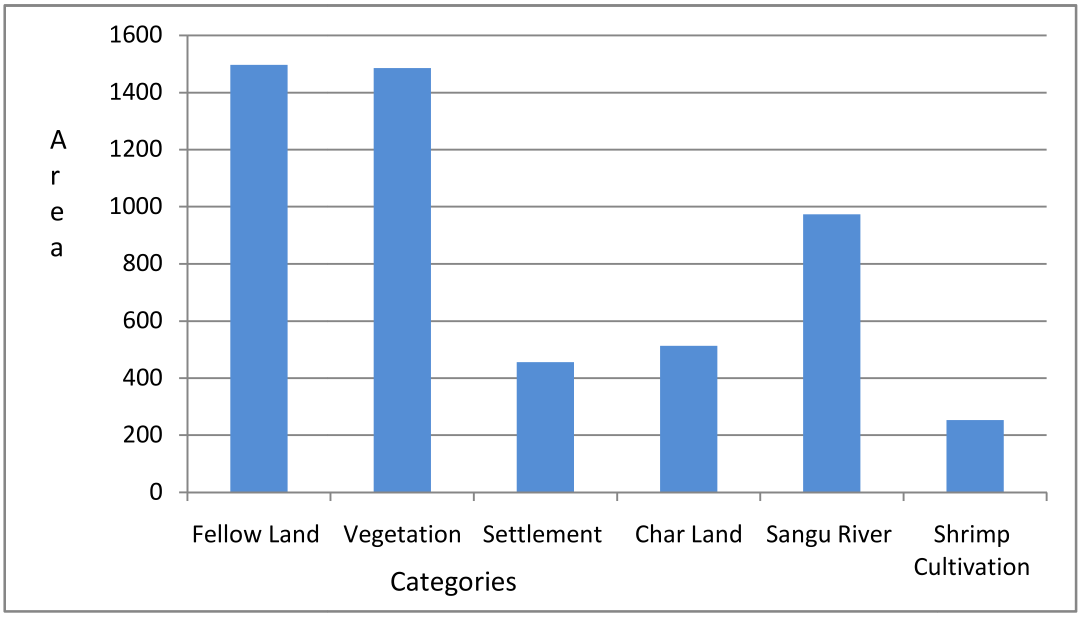

Figure 6.14: Land Use Change Area-2009

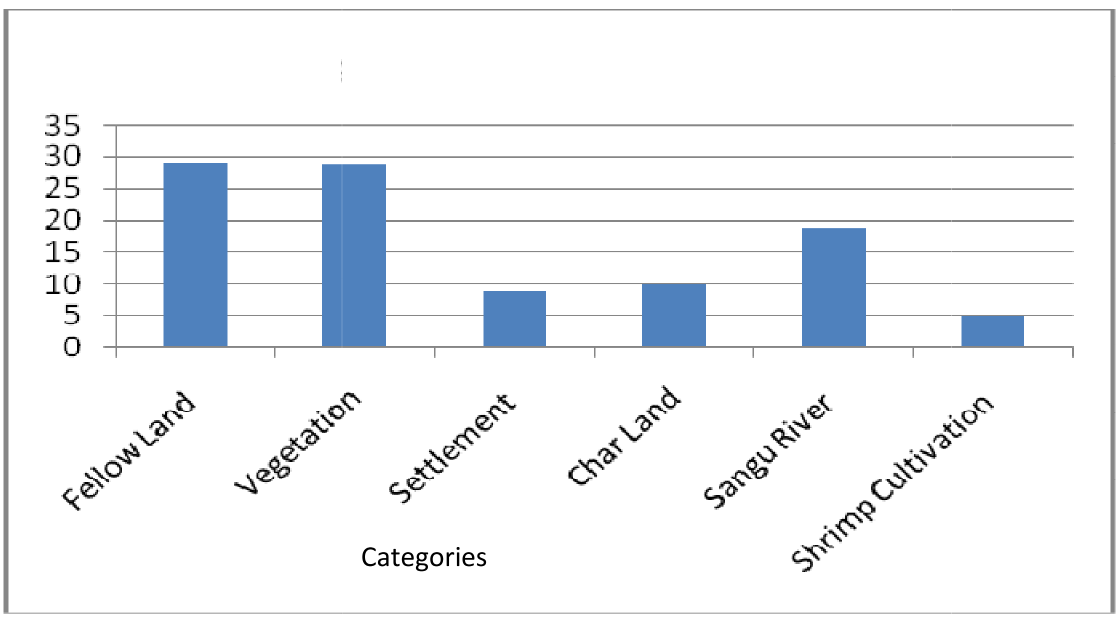

Figure 6.15: Land Use Change Percentage -2009

In the durations of 1973 to 2004, total 877.90 km2 of landmass had been degraded including the jamuna and padma rivers , where only 23.90 km2 degraded in the padma described by CEGIS-2009.In this study area duration of 2009 total vegetation area is also decreased by 28.4%, settlement 8.8%, Shrimp cultivation is also increased by 4.9%(Table: 6.1 & Figure: 6.14,6.15). Aside from the floodplain and settlement, Bangladesh has lost numerous kilometers of streets, railroads just as flood control embankments yearly. There are no different shocking, for example, riverbank erosions with respect to long term impact on individuals and the general public (Elahi, 1991).

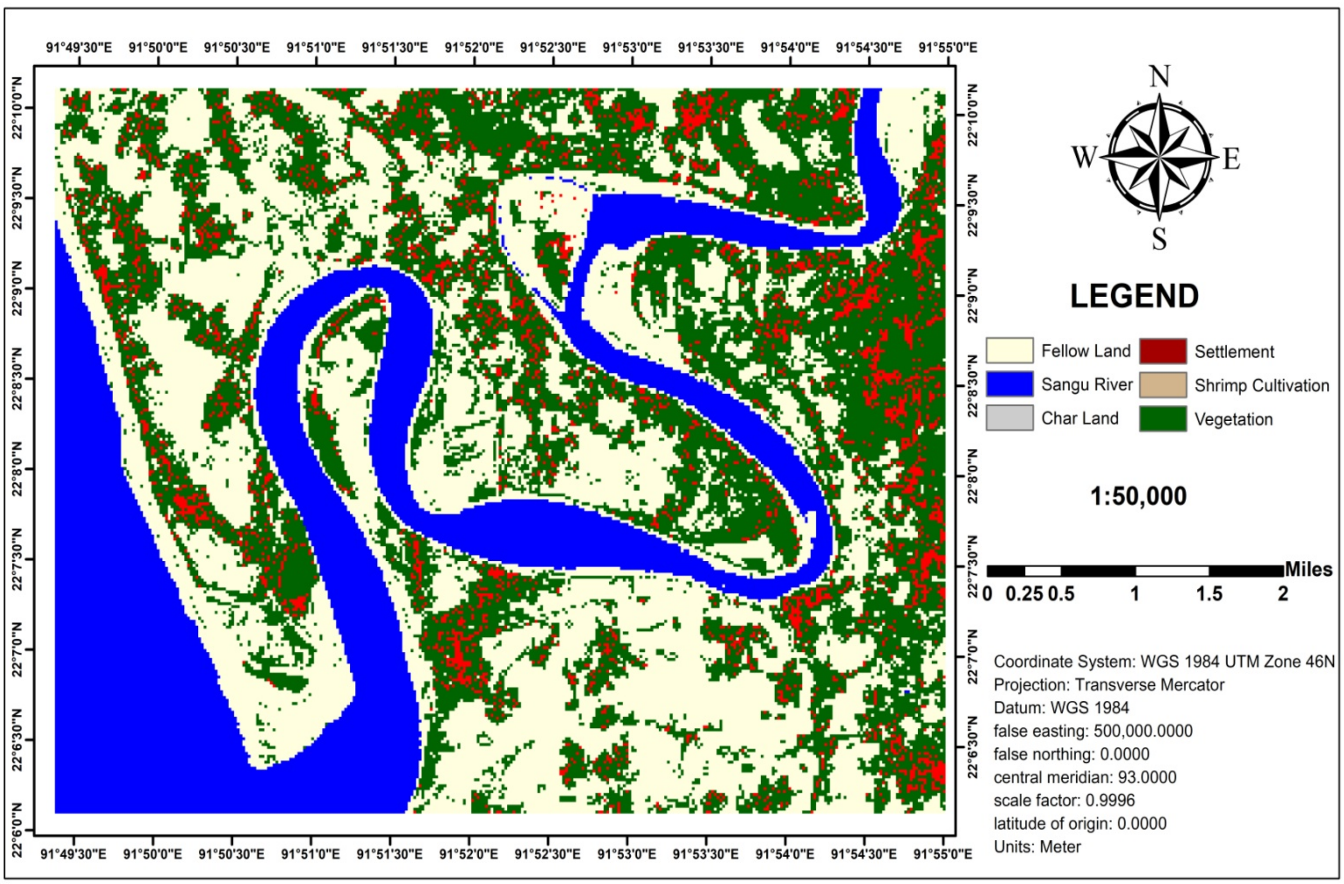

Figure 6.16: Land Use Change Map in 2014

Land Use change Changes in 2014

The erosional procedures of land greatly affect agribusiness. Agriculture practice and yield generation are diverse between singe land and the terrain. The misfortunes of farming area bring about the decrease of all out harvest productions. In 2014 total vegetation area is 26.4%, settlement 9.2%, Shrimp cultivation 5.3%. (Table: 6.1 & Figure : 6.17,6.18). These occasions were dangerous and made much harm individuals, agrarian exercises and street frameworks, particularly in the lower segment of the flood plain area. Especially, two extreme floods happened inside the bowl in 1991 and 2007, individually, with high peak discharge. In the recent research also analysis the land use changes due to land erosions and floods, which is mainly contradicted to the results of same changes. Nevertheless, the outcomes from individual investigations are real, yet it is hard to assess the effects of problems because each examination requires a particular and research-situated point of view. In late distributions which incorporate the paper of Gupta et al. (2015) center around the total impact of land use and environmental changes on river flow. Additionally, Alila et al. (2009) give more understanding into the impacts of forestations practice on floods, which have prompted a logical contention with the outcomes being censured by numerous specialists.

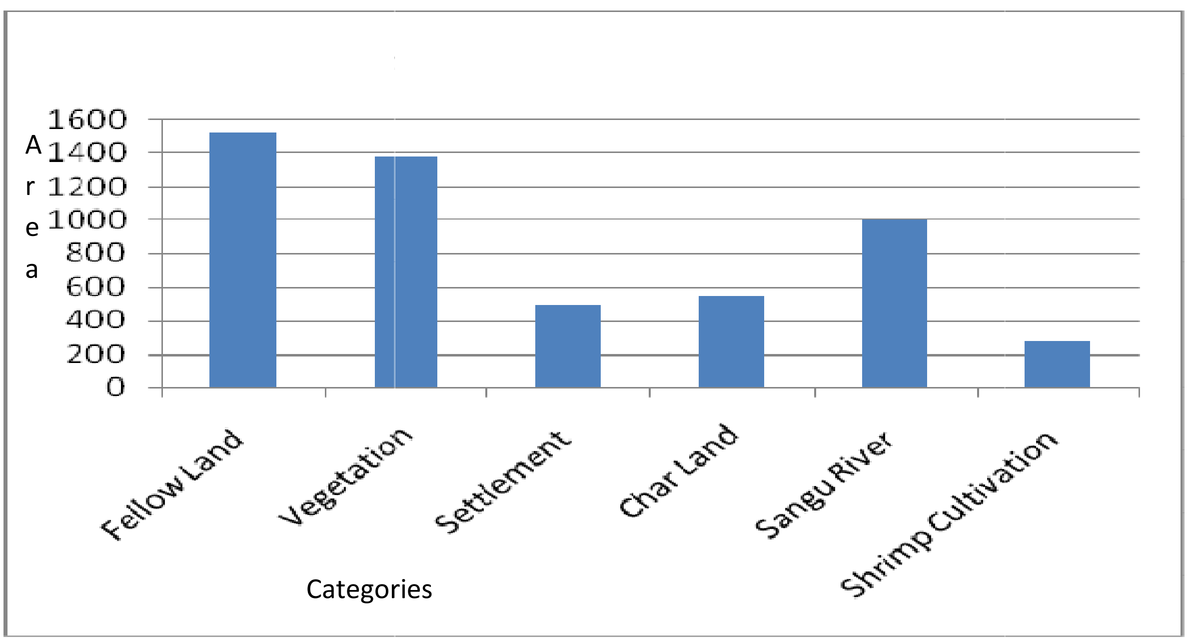

Figure 6.17: Land Use Change Area-2014

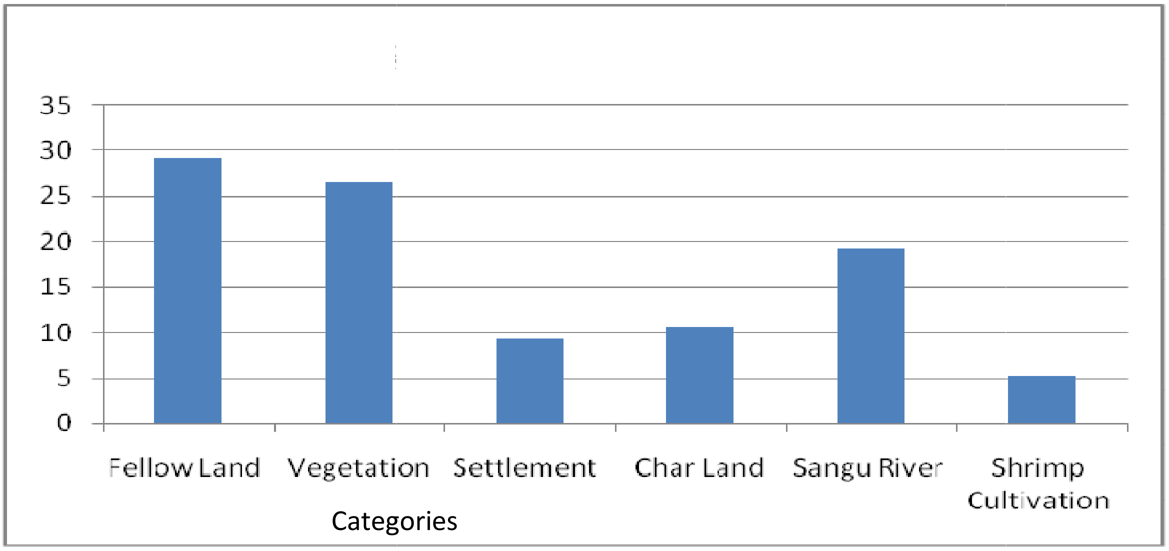

Figure 6.18: Land Use Change Percentage -2014

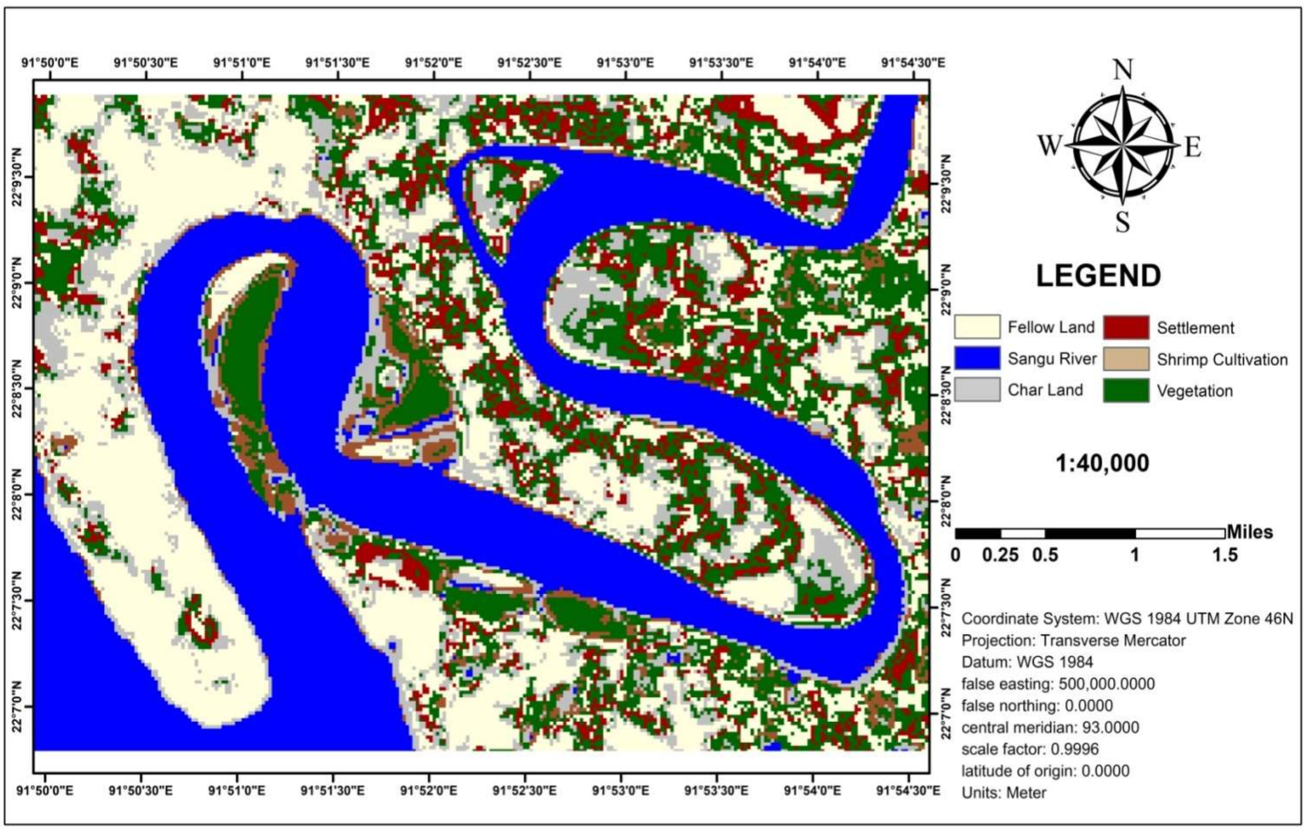

Figure 6.19: Land Use Change Map In 2018

Land Use change Changes in 2018

Normally, floodplains area is not static or stable. A flood plain comprises of unconsolidated particles, which are eroded quickly during floods and high progressions of water, or they might be found on new layers of clay, silt and sand deposited. Because of this, the stream may change its channel and move from one side of the floodplain to the opposite side. One of the primary floods in the moist area is less inclined to cause channel spreading and floodplain devastation because of the vegetation which obstructs erosions exercises. Likewise, the flood can make optional channels through a floodplain and store rock and sand over the enormous territories, particularly those regions used to for agricultural purposes. The terrace through the channel can also be confused with a floodplain. Most occasions, the terrace is normally recognized from dynamic floodplain through the vegetation type and the surface material accessible. Agricultural land is a profitable asset for individuals living in Bangladesh, above all, the individuals who live in rustic locales and bank line. Around 48 percent of the all out populace depends enormously on agribusiness (BBS, 2011).In 2018, the total vegetation area is 26.9%, shrimp cultivation 9.2%and settlement 9.2% as shown in table 6.1 and figure 6.20 & 6.21 respectively. The size of the Manas River in China has increased cultivated land with about 130% from 3231 km^2 in 1976 to a massive increase of 7438 km^2 in 2015.

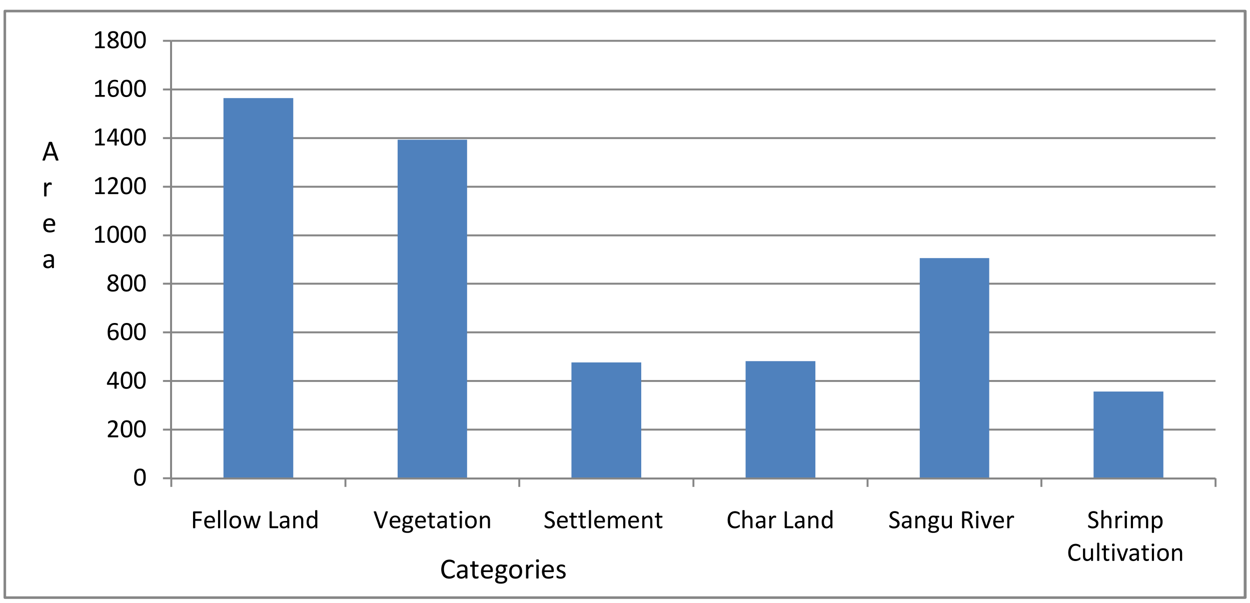

Figure 6.20: Land Use Change Area-2018

The land region has definitely expanded by 118% from 1976 to 2015. A large portion of the zone which comprises of grassland has decreased roughly in last 30 years. In 1976 the grass land of this areas is 22% or 15, 763 km2, which decreased in 2015 only 12, 064 km2. In the mean time the fellow land areas and the forest areas also decreased considerably, 7% and 8% individually. On the others some amount of forest land, grass land and water region were altered to a cultivated land causes of increasing populations, with regions of 3744 km2, 580 km2 and 29 km2, separately over the most recent four decades (Yang et al., 2017).

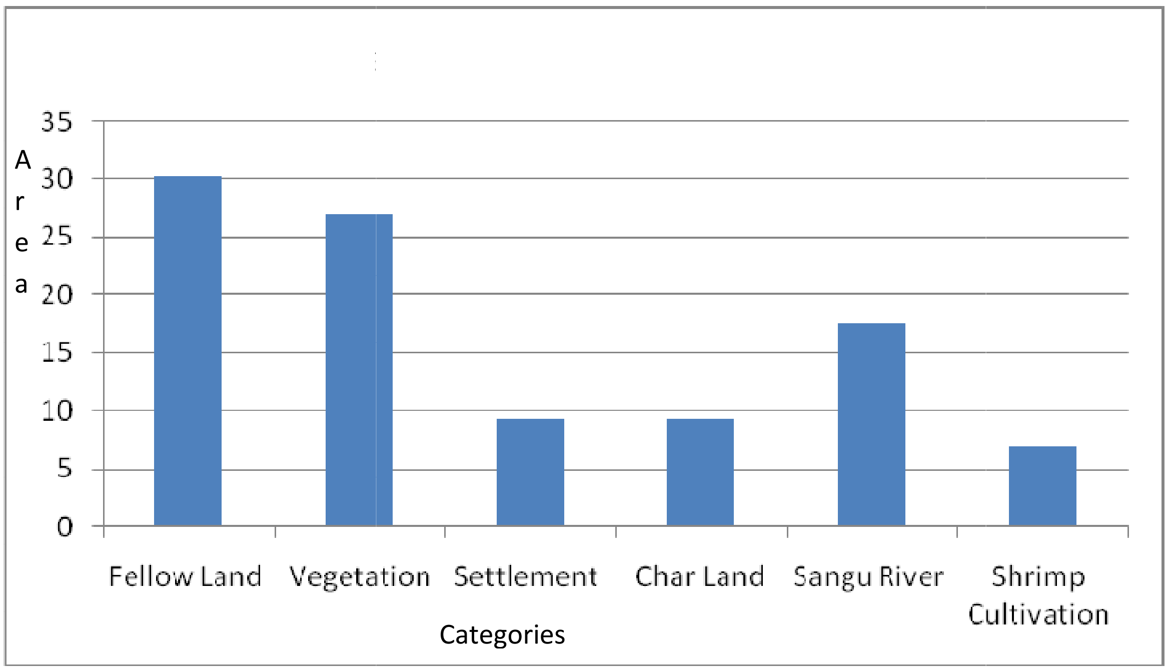

Figure 6.21: Land Use Change Percentage -2018

Table 6.1: Different Years Land Use Change in Sangu River Flood Plain Areas.

Land Classes	1989		1994		1999		2004		2009		2014		2018	
	Area (in hectare)	(%)	Area(in hectare)	(%)	Area(in hectare)	(%)	Area(in hectare)	(%)	Area(in hectare)	(%)	Area (in hectare)	(%)	Area (in hectare)	(%)
Fellow Land	1268.61	24.50	1310.03	25.30	1413.59	27.30	1445.00	27.90	1496.44	28.90	1512.00	29.20	1563.75	30.20
Vegetation	1848.54	35.70	1744.9	33.70	1682.85	32.50	1584.46	30.60	1486.08	28.70	1367.00	26.40	1392.88	26.90
Settlement	300.32	5.80	331.4	6.40	326.21	6.30	424.59	8.20	455.66	8.80	481.60	9.30	476.37	9.20
Char Land	388.35	7.50	409.06	7.90	341.74	6.60	403.90	7.80	512.62	9.90	548.90	10.60	481.55	9.30
Sangu River	1170.22	22.60	1128.8	21.80	1263.43	24.40	1123.60	21.70	973.46	18.80	994.20	19.20	906.15	17.50
Shrimp Cultivation	201.94	3.90	253.8	4.90	150.16	2.90	196.80	3.80	253.72	4.90	274.43	5.30	357.28	6.90

6.8 Scenarios of Future Land Use

As opposed to concentrating and generalizing on noteworthy patterns, the future land use settings were produced for the investigation region as per the rational analysis on of past information in the zone. The depictions are evaluated by a procedure quantitative and qualitative interpretation by experts. At the point when a farmer changed over the business agriculture, the capabilities were proposed until 2050 with the utilization of concurred percent diversions from the 1989 land-use baseline. Nevertheless, the investigation doesn't stretch out past 2050, because of the huge vulnerabilities in both political and social patterns in over two decades into the future. (Anirban Mukhopadhyay, Duncan D. Hornby, Craig W. Hutton, Attila N. Lázár, Fiifi Amoako Johnson, Tuhin Ghosh).

The land-use settings were connected to expert socio-economic and demographic improvement. The proper land use change used to be for development of socio economic and biophysical improvement, which play important role to drive a modeling between for demonstrating the connection among individuals and biological system administrations. It is imperative to encourage farmer to anticipate the future dependent on their experience; land use is a perspective which includes day by day exercises of the nearby populations and choice makers. Based on our investigation, the maps that are created demonstrate a picture of fast variations in the course of the last long decades along the delta. Normally, there are a combination of polders and agriculture among them, just as a huge increment in the rule saline shrimp cultivations just as agriculture which has supplanted rice fields. This procedure may be imperative to improve farming later on and principally inside the setting of the advancement policy of Bangladesh Delta Plan 2100 (BDP2100 - 2015).

6.9 Saline Water in the Sangu River Flood Plain Area

The saline waters are influenced the river bank line to 185 km width along the river bank area. The saline waters flow from the upper shore and silting up the feeder river reduces the soil salinity in the coastal areas. In 1983, the extension of the saline area was increased to be 830000 ha, but currently, it is studied to be 10200000 ha (SRDI, 2000). The country water development board and SRDI are maintaining and collecting both soil and water saline, which FAO has offered their support to the CEGIS for updating, compiling and interpretation of the salinity data. Water salinity level increased drastically in 2008 compared to the reference salinity data of the 1980s, which was developed by MP0.In the investigation region, the saltiness level is restricted separated from the regions where individuals have shrimp development. The saltiness trial of this districts soil test saltiness level is 0.001ds/m. Only one example in disintegration side saltiness level is 1.8ds/m. The SRDI delivered soil saltiness data with the utilization of accessible data in 1973. The huge relative region has turned out to be salty and influenced in the course of recent years. What's more, in excess of 170,000 hectares have been influenced by 11 areas; the issue has additionally escalated in the year 2009.

This is an adverse condition which contrarily influences efficiency and employments of the area (Karim et al., 1990). Shrimp development and salt-beds have prompted coastal soil degradations and landscape changes. The production of salt has been profitable and has improved the odds of farming grounds to salt-beds, which harms the soil and utilizes the land for harvest generation pointless. In 2007, Bangladesh experienced one of the extreme violent cyclone cum floods, which has additionally affected the decrease of land assets in the south-western zones of the country.

6.10 Environmental Losses Cause of Land Use Change:

Erosions in a specific district don’t just destroy its foundation and land, yet it additionally influences the environment over the long term. The disintegration of the stream Sangu situated at Anowara and Banshkhali Upazilas has some extreme ecological effect on both fauna, vegetation and fisheries area.

The farmstead tree plantations are a typical practice in the study regions. Each home has enormous neighborhood trees in the open air condition. Because of unfavorable erosions, the trees vanished after certain occasions. The greater part of the indigenous individuals sold their juvenile trees in view of the degradations of the land. Increment in the impact of disintegration can prompt loss of land mass just as the loss of forestry and agricultural products. The cutting edge char land ordinarily sets aside more effort to create adequate soil layers for plantations. Likewise, the most influenced division of nature is basically the fisheries region. The populations of fish reaped are diminishing gradually. Nevertheless, the River bank erosions and increase the char land in the midpoint of the stream decreased the waterway depth, due to the fish item decrease. The siltation procedure likewise influences the route of the waterway and the profundity of the stream decline definitely while the fish populations lessen.

6.11 Land Use Change Impact on Soil and Agriculture

In this analysis, we see that some rural land has been changed over into shrimp developments. Due to shrimp cultivations in the soil increase the salinity. Salinity increase about (500%) causes of shrimp cultivations, its hampers the non saline land crop productions also in the study areas. Generally the farmers of the study areas lose their income due to low rice productivity, loss of poultry and livestock, erosions of residence vegetation and social forestry service. A logical report supported by Nijera Kori (1996), he found that salinity also control the soil degradations and loss of agricultural crops in the coastal regions. For shrimp cultivations need to saline water storage in whole year. Many shrimp cultivated areas where previously used to as an agricultural land; due to its paid instantly. But after ten years farming shrimp cultivations this land would be crashed because of pathogens affect. This pathogens shelters the muck of shrimp waste and fodder unconsumed, made poisoning this area for furthers use. It's also general that when the water release from those areas by evaporations the salt are consist there, which are unfit for agriculture.

Figure 6.22: Saline water collection from the Sangu river for shrimp cultivations.

As well as the shrimp farmer are not uses their same land over and over years. They changed their land nearest others side, so ultimate whole areas are affected by with saline. An image of Figure 6.22 demonstrates the procedure how saline water put into the shrimp firm of this territory. In figure 6.19 demonstrates the procedure of how shrimp culture involves the agriculture land quickly.Due to the variations of the agricultural practiced, the salinity of the soil retained long time durations, which helps salt percolations in the nearest whole fields and changes soil chemistry in this areas. On others side, in the rainy season due to rain water the farmers add more solid salt in the shrimp project which are deposited into lower part of the pond which affect significantly. This salt directly affects this area ecosystem and soil fertility. Generally, the soil salt is reversed or decreases the plant osmosis process, creates humidity shortages, eventually this soil are moist and create physiologically drought conditions and consequently goes died (Rahman, 2013).

Figure 6.23: The process of agricultural land converts into fellow land due to shrimp cultivations.

Chapter 07: Findings, Recommendations & Conclusions

7.1 Findings

Banshkhali and Anowara are a portion of the outstanding Upazilas (sub-locale) in Bangladesh. As per the assessment of the older people of the region, they are battling against riverbank riverbank for a couple of decades. The waterway Sangu has devoured a huge zone between Anowara to Banshkhali. A great many individuals and families are influenced and have experienced untold tragedies. To know about the local peoples miseries suffering and social and changes need to long term and insight research. It is so difficult to made somethings meaningful in this short term study. From lots of limitations of this study some important limitations discoveries of riverbank erosions at Anowara and Banshkhali Upazilas are distinguished.

7.2 River Bank Erosion and Deposition

River is frameworks in dynamic balance. It adjusts water stream and sediment transport. At the point when waterway channels are changed under normally powerful hydrologic conditions, the stream readjusts itself concerning measurement, profile, and example to arrive at its previous equalization or balance (Couture, 2008).In this examination measure a sum of 28 years waterway bank disintegration and statement. We see that consistently, erosions is more than the depositions. In the year 1989, the erosions are 99.28 hectare. In the multi year is a less eroded yet more deposited year around there. In a year ago 28 all out dissolved regions is 7070.70 Hectare, and the normal is 25.752 Hectare every year. Similarly, total depositions are 437.87 Hectare over the most recent 28 years, and the normal is 15.68 Hectare.

7.3 Sediment Budget

Soils is a natural common variable engineering properties and along these naturally, in the soil properties showed some engineering characteristics which related to geotechnical properties of the soil. In this characteristics try to out some geotechnical properties of the Sangu Rivers.

This stream flood plain zone eroded or deposited each year. The erosions is in excess of depositions. In this study discover that how much sediments is eroded and deposited in consistently interim. In the length all out, 1415.36m3 sediments is eroded in the study zone, and normal erosions is 50.54 m3 per year. On the opposite side, total depositions 875.75 m3, and the normal is 31.27m3 in per year. In this investigation, we comprehended that a lot of sediments is washed out by water stream in this waterway.

7.4 Particle size Analysis

In the riverbank region, the eroded part and deposited part soil particle are extraordinary. In this study, we have found that the eroded molecule is progressively clayey, around 54 %. This part of soil is progressively clayey. In any case, in the deposited territory soil are progressively sandy. The sand partition in this soil is about half. The mud soils are more grounded than sandy soil.

7.5 Land Use Changes

For this study, Land use change Sangu Riverbank is subdivided to 6 classes. We won't perceive how much territory is changed because of the riverbank erosions. This region is a town region. The greater part of the people are depend upon farming. Be that as it may, because of the riverbank erosions agricultural land are reduced day by day. In 1989 the total 1854.68 Hectare area was vegetation, yet in 2018 this sum is 1392.88 Hectare. Then again, the fellow land, settlement, and shrimp development are increased day by day. Most noticeable, the shrimp cultivations are increased are influenced the soil fertility and crops productions. In 1980 just 3.8% shrimp development around there however in 2018 this one 6.9%. This is likewise a noteworthy biodiversity loss around there.

7.6 Recommendations:

Riverbank erosions are dangerous hazards in Bangladesh that all time miseries for the people. The study area of sangu river are situated most important southern part of the Bangldesh. High flow sangu rivers flow have been made discontinuous and indiscreetly made this river meanders. The rivers flow erode the land, degrade the large land areas and deposited the sediments elsewhere. From Investigations, it's find out that Banshkhali and Anowara Upazilas till do not take any major structural or non structural step take by authority to ensure the decrease river bank erosions and solve the environmental and socio-economic conditions to improve this local peoples. For the long term development of this areas need to be achieving sustainability. Some important might be moderate bank erosions, its influence the people successfully. The geotechnical properties of bank material should be improved by utilizing added substances or strengthening materials like soil-concrete, natural or geo-synthetic fiber, and so forth. It is additionally important to secure the incline by confronting materials utilizing geo-packs, concrete composites with support, and so forth. It is additionally prescribed to find the free surface inside the dike by leading drainage examination before direct slant dependability investigation to acquire a progressively solid factor of wellbeing in structuring stable sediments.

We can fight against erosions somewhat if a managements plan is progressively improved by-

• Construction of cement bolder jacketing as opposed to utilizing sandbags to spare the profoundly populated right bank;

• To battle against erosions just as to ensure the Bed Bars which are developed to constructed to save the populated Western bank, the consideration should pay for their maintenance purposes right away;

• Plantation of trees should to do along the river bank by considering about the dynamic role of trees in the protections of erosions;

• In the Sangu river, we see that this river as of now make sense of the circular shape. So in the event that we made a cannel from Barunchara, Bashkhali Upozila to Juidhondi north, Anowara Upazila then the momentum stream of this waterway are change, and riverbank erosions of the Raterkul part of Banshkhali Upazila decline adequately.

• River bank erosions and depositions is one of the common phenomena of our country. Gradually some areas of our 700 rivers anywhere ids affected this problem. So exhaustive riverbank erosions the board management might be made for Bangladesh;

• No improvement plan that hampers the natural flow of the river ought to be taken. Proper and effective erosions control measures ought to be a significant thought while making an arrangement;

• And it is imperative to find a way to ensure the issue regions before the rainstorm season; and so forth.

Despite the fact that it is likewise insufficient in light of the fact that erosions is a natural and inevitable of the stream, concrete bolder jacketing is more erosions opposition than others. And furthermore give greater life span. .

7.7 Perspective of Future Research:

Bangladesh is developing country, research facility is not available widely till now. Although, I am eagerly interested my future research area. In this study also need more research for gaining sustainability in these regions. It is necessary to find out total fluvial process of river for proper's implementations of my recommendations. We need more precisely analysis the river flow rate and source of water flow in these rivers. The sediment load of this river and sediment transpirations process also needs to be analysis. Because Anowara and Banshkhali are located at the area which is Flood plain for the expansion of KEPZ(Karnafully Export and Import Processing Zone) area, it can be an important factor for the future development of fluvial and Industrial landscape uses.

7.8 Conclusion:

The study investigates an itemized examination of riverbank erosions, depositions, and land-use changes in Bangladesh. Due to the river bank erosions peoples and their properties are under risk in these regions. River bank erosion also depends on the geographic and geological settings and consistently several peoples relocated from the erosions zone with no wellspring of food and safe shelter. On account of its moderate procedure and dispersed occurrences, transients of riverbank erosions neglect to draw consideration effectively of the responsible authorities. The riverbank erosions and victimes don't approach media inclusion as the casualties of different fiascos approach. Because of this, consistently a quiet threat is going on to a unfortunate gathering of individuals. As of now, there is no particular program or approach for the riverbank erosions migrants either in non-governmental or governmental divisions. As a result of bank erosions the environmental refuges are increased day by day and they cope their live extreme poverty line. Additionally, a few changes are required dependent on existing activities and strategies of foundations to help casualties of the riverbank erosions. It is important to consider riverbank erosions as a flat out ecological calamity.

Insight of these effects is fundamental in arranging sustainable land-use change of this region with due thought for bio-diversity variety and socioeconomic characteristics of the wetland. Total Erosion of this region over the last 28 years 7070.70 Hectare. A large portion of the erosions soil is comprised of clayey particles. Around there, individual's change their occupation because of riverbank erosions the vast majority are occupied with shrimp development, which is hurtful to the environment. Finally, this examination prescribes that progressively itemized and careful investigation ought to be led in the coming days to discover the instruments and issues related with waterway bank erosions. In the southern piece of Chittagong just as the mindful experts should take extreme measures to anticipate the erosions in both the banks of Sangu river to secure the biodiversity, environment and in the long run the human properties.

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Appendix:

Particle Size Analysis in the Deposition Part:

Particle Size Percentage					
Sample Number	GPS Value		Sand	Silt	Clay
	Latitude	Longititude			
1	221224503	918613517	98	1	1
2	2212332893	918611991	70	20	10
3	221237023	918609492	40	40	20
4	221241421	918606031	75	15	5
5	221252928	918598918	80	15	5
6	221264142	918592096	60	30	10
7	221264794	918585681	65	25	10
8	221290031	918571294	70	25	5
9	221298644	91856872	90	5	5
10	221301948	918566603	98	1	1
11	229165	9153200	80	10	10
12	2209169	9153176	25	35	40
13	2209169	9153164	20	40	40
14	2209170	9153149	20	40	40
15	2209169	9153134	10	50	40
16	2209166	9153113	20	40	40
17	2209162	9153097	30	50	20
18	2209161	9153091	30	30	40
19	2209158	9153080	20	60	20
20	2209151	9153063	50	30	20
21	2209142	9153040	20	30	50
22	229147	9153050	10	30	60
23	2209190	915883	30	20	50
24	229198	915158	30	15	55
25	228990	915251	60	10	30
26	228960	915255	70	15	5
27	228915	915150	65	10	25
26	228911	915101	60	8	32
27	227858	915022	68	15	27
29	227855	915010	70	10	20
			51.8	24.167	24.533

Particle Size analysis in the Erosion Part

Particle Size Percentage					
Sample Number	GPS Value		Sand	Silt	Clay
	Latitude	Longititude			
ESP1	228244	9150272	10	20	70
ESP 2	2208256	9150265	10	10	80
ESP 3	2208185	9150291	10	30	60
ESP 4	228139	9150258	20	30	50
ESP 5	228129	9150239	20	30	50
ESP 6	2209115	9150322	20	20	60
ESP 7	2209152	9150333	20	40	40
ESP 8	2209185	9150322	10	30	60
ESP 9	2209203	9150312	20	40	40
ESP 10	2209275	9150330	05	50	45
ESP 11	2209236	9150402	15	60	25
ESP 12	2209277	9150389	10	70	20
ESP 13	2209169	9151294	05	15	80
ESP 14	2209196	9151198	05	25	70
ESP 15	2209183	9151161	10	40	50
ESP 16	2209198	9151071	05	15	80
ESP 17	22305054	91854335	10	50	40
ESP 18	22154495	918548945	20	55	25
ESP 19	221336336	918555304	10	60	30
ESP 20	221309811	918586525	15	60	25
ESP 21	2213418	918598523	05	70	25
ESP 22	2209132	9150341	10	30	60
ESP 23	2209170	9150392	30	20	50
ESP 24	2209258	9150438	10	20	70
ESP 25	2209260	9150447	10	20	70
ESP 26	2209282	9150415	25	15	60
ESP 27	229276	9150384	10	20	70
ESP 28	2209168	9151296	10	15	75
ESP 29	2209183	9151143	15	25	60
ESP 30	2210184	915543	20	10	70
			13.17	33.17	53.67

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
কৃষি মন্ত্রণালয়

মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট

জেলা কার্যালয়, চট্টগ্রাম

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Date: 16.09.2018

The analytical report of your supplied soil samples are given below-

Sample No.	Soil Salinity (EC)	P^H	Comment
DSP-2	0.1 dS/m	7.3	Most of the samples are basic. Salinity is also present in minimum level.
DSP-3	0.1 dS/m	8.1	
DSP-4	0.5 dS/m	8.1	
DSP-5	0.1 dS/m	8.2	
DSP-6	0.6 dS/m	8.1	
DSP-7	0.1 dS/m	8.4	
DSP-8	1.2 dS/m	8.3	
DSP-14	0.0 dS/m	7.2	
DSP-15	0.0 dS/m	6.9	
DSP-16	0.0 dS/m	7.0	
ESP-1	1.8 dS/m	7.9	
ESP-2	0.3 dS/m	8.0	
ESP-3	0.6 dS/m	7.5	
ESP-4	0.2 dS/m	7.8	
ESP-5	0.3 dS/m	8.0	
ESP-6	0.2 dS/m	7.8	
ESP-7	0.8 dS/m	6.2	
ESP-9	0.8 dS/m	7.9	
ESP-11	0.1 dS/m	8.0	
ESP-12	0.3 dS/m	7.7	

Photographs:

Figure: Soil Sampling in the Field

Figure: Soil Handdrilling in the Field

Figure: Geo-Textile bags for reduce River bank erosion in the Study area

Figure: Erosion Scenario in the Study area

Figure: Bank Revetment process to reduce Erosion in the Study area