STUDY OF IMPACT ON SURROUNDING LIVELIHOODS DUE TO RIVERBANK EROSION: A CASE ON SHIBALAYA'S JAMUNA BANK OF MANIKGANJ

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A Dissertation

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July, 2015

DECLARATION

I do hereby declare that this dissertation titled **"Study of Impact on Surrounding Livelihoods due to Riverbank Erosion: A case on Shibalaya's Jamuna Bank of Manikganj"** is the output of my own research, under the supervision of Dr. Md. Shahedur Rashid, Professor, Department of Geography and Environment, Jahangirnagar University, Savar, Dhaka, Bangladesh. The entire dissertation is prepared for academic pursuit and solely aimed at the partial fulfillment for the Degree of Masters of Arts in Governance and Development.

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July, 2015

CERTIFICATE

I hereby recommend and certify that this dissertation entitled “Study of Impact on Surrounding Livelihoods due to Riverbank Erosion: a case on Shibalaya’s Jamuna bank of Manikganj” is a research work conducted by Mr. Prem Gopal Halder, MAGD-6, ID-14272013, under my supervision for partial fulfillment of the requirements for the Degree of MA in Governance and Development (MAGD), BIGD, BRAC University, Dhaka, Bangladesh.

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THIS RESEARCH TESTIMONY IS DEDICATED TO

THE MEMORY OF MY HEAVENLY

MOTHER AND FATHER

MOTHER CHARULATA HALDER

LEFT HER EETERNAL LIFE ON DECEMBER 13, 2012

AND

FATHER HARIPADA HALDER

LEFT THE EARTH ON JANUARY 11, 2015 DURING MY COURSE WORK

ACKNOWLEDGEMENTS

First of all I would like to express my greatest appreciation and thanks to my Lord who has given me the opportunity for higher study at a very recognized institute likes BRAC Institute of Governance and Development (BIGD), BRAC University. Then I would express my heartfelt love, honor and gratitude to my parents who dedicated their lives for the betterment of my life. For successful completion of my research, I am indebted to many persons and agencies.

I would also like to express my deepest gratitude and sincerest appreciation to my thesis Supervisor Dr. Md. Shahedur Rashid, Professor, Jahangirnagar University, Savar, Dhaka for his immense support, supervision, invaluable guidance, advice and continuous encouragement which helped me to accomplish this over many difficulties related to my dissertation.

My Profound gratitude and heartfelt thanks to Professor Dr. Rashed Uz Zaman, Academic Coordinator BIGD, BRAC University; Dr. Sultan Hafeez Rahman, Executive Director BIGD, BRAC University and Dr. Md. Zohurul Islam, Former Academic Coordinator, MAGD-6 for their valuable suggestions and comments which have helped me to develop the quality of the research.

The BRAC Institute of Governance and Development (BIGD), BRAC University also deserves lots of gratitude and thanks for granting me the fund for my study. I would like to take the opportunity to extend my especial thanks to the respondents of Char Ganga Prasad, Char Shibalaya and Kanaidia mauza for their kind cooperation and help in the field during data collection. I am lucky enough that I have got nice cooperation from the local people. My sincere thanks are also due to Director, Administration, Directorate of Land Survey and Record Tejgaon, District Statistical Office, Manikganj and Upazila Statistical Office, Shibalaya, Nayeb, Union land office Shibalaya and Teota Union for providing important data related to my dissertation.

I am grateful to all the participants of MAGD-6 and officials of the BRAC Institute of Governance and Development (BIGD) for their constant support and encouragement. Special thanks to Regional Office, BRAC, Shibalaya, Manikganj for their co-operation in field data collection. I am also grateful to some young teachers and students of Jahangirnagar for co-operation while conducting field survey. Finally I am deeply indebted to my family members for their immense moral supports and sacrifice.

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EXECUTIVE SUMMARY

The Jamuna is the lowest part of the Brahmaputra River. It enters into Bangladesh at Nageshwari Upazila of Kurigram district and ends at Aricha while confluenceing with the Ganges. It is the most dynamic among the rivers of Bangladesh and considered as the largest sand-bed braided rivers in the world which is complex and chaotic by nature. The annual erosion along the banks of this river is the highest among all the rivers in Bangladesh having a profound impact on the livelihoods of the riverine community of our country.

Riverbank erosion is one of the most unpredictable, critical and complex type of disaster, that takes tolls less in lives but more in livelihood as agricultural land and homesteads along with other livelihood options that are evacuated. The study was conducted in three mauzas namely Char Ganga Prasad, Char Shibalaya and Kanaidia covering an area of 7.2 square kilometers of Shibalaya upazila of Manikganj district which is the most severe erosion phone area of Bangladesh. In this study an attempt was taken to find out the trends of riverbank erosion, its impact on major physical and cultural features of the study area and livelihoods of the people living along the banks of the river in association with difficulties arises from Riverbank Erosion (RBE). The study employed massive primary and secondary data sources to find out the impact of river erosion on livelihoods of the community people of this vulnerable char region. Primary data were collected through structured and semi-structured questionnaire from focal group discussion, key informant information and informal discussion with the local people of the study area to understand the adverse effects of bank erosion on the livelihoods of the surrounding peoples. On the other hand, tracking through Global Positioning System (GPS) along with mauza maps give the current bank line and image analysis from Google Earth gives the amount of area eroded for different time periods. A series of maps on RBE and land use pattern have been determined using GPS and GIS techniques. Google Earth Pro, ArcView GIS 3.3, ArcGIS 10.2.1, Excel and Microsoft word have been widely used for development of maps and data base on erosion and land use.

Findings of the study indicates that from 1980 to 2015 almost 4.48 square kilometers i.e., 62.30% of 7.2 kilometers study area have been devoured by the Jamuna riverbank erosion which have profound impact on the livelihoods of the people living in this Char lands. Analysis of the percentage value of river erosion of my study area indicates that for the period of 1980 to 2006 average rate of erosion of this study area was less than1% of total study area per year. From January 2007 to January 2013 average rate of erosion was more than three percent per year. Drastic rate of erosion occurs for the last two and half year, from January 2013 to July 2015 when average rate of erosion was about 9% of my study area per year.

Riverbank erosion contributes immensely to the marginalization process of a large number of people of my study area by loss of agricultural lands and homestead lands and adversely affecting their social and economic circumstances and affecting livelihood of the people of surrounding areas.

Respondents living in my study area have experienced riverbank erosion 1-20 times in their lives. 96% of the respondents have lost their agriculture lands, 92% of the respondents have experienced homestead loss and 62% of the respondents have experienced loss of vegetable garden in their life. 90% have losses their households and 20% have lost their cattle. Due to these losses income level of the river eroded people has decreased drastically leaving the people of this study area in a miserable condition.

Respondent's monthly income is within the range of Tk.5000-Tk.10000. Due to low income their standards of living including expenditure on food, clothing, healthy life style, safe drinking water and education is minimal.

The marginalized and poor people not only lost property but also experienced socioeconomic deprivation through frequent homestead loss and involuntary displacement. Because of the dynamic character of the braided channeled river and the failure of structural measures, the sufferings of the people continue. Although Government has taken some initiatives to lessen their resettlement problem by constructing "Ashrayan Project" (Rehabilitation Project for the vulnerable people) and some relief items for their livelihood improvement, it is very limited in comparison with needs. So, long-term policies and strategies are very much essential to cope up with bank erosion taking into account the social and institutional adjustment measures. Land relocation assurance is one of the appropriate strategies to cope up with this disaster. In addition, honest political and administrative culture is very much essential to lessen the vulnerability of riverbank erosion.

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List of Abbreviations

AC (Land)	Assistant Commissioner (Land)
BB	Bangladesh Bank
BBS	Bangladesh Bureau of Statistics
BIGD	BRAC Institute of Governance and Development
BIWTA	Bangladesh Inland Water Transport Authority
BRAC	Bangladesh Rural Advancement Committee
BRRI	Bangladesh Rice Research Institute
BWDB	Bangladesh Water Development Board
CEGIS	Center for Environmental and Geographic Information Services
COAST	Coastal Association for Social Transformation Trust
CRs	Community Radios
CS	Cadastral Survey
DGI	Digital Globe Image
DLSR	Directorate of Land Survey and Records
DPI	Department of primary Industries
EMIN	Environmental Monitoring Information Network
FAO	Food and Agriculture Organization
GBM	Ganges-Brahmaputra-Meghna
GIS	Geographical Information System
GPS	Geographical Positioning System
GO	Government Organization
ISPAN	Irrigation Support Project for Asia and the Near East
IUCN	International Union for Conservation of Nature
JL	List of Jurisdiction
LGED	Local Government Engineering Department
LGI	Local Government Institutions
MAGD	Masters of Arts in Governance and Development
MOA	Ministry of Agriculture
MODMR	Ministry of Disaster Management and Relief
MOE	Ministry of Education
MOFL	Ministry of Fisheries and Livestock
MOEF	Ministry of Forest and Environment
MOFDM	Ministry of Food and Disaster Management
MOHFW	Ministry of Health and Family Welfare

MOHPW	Ministry of Housing and Public Works
MOI	Ministry of Information/ Industries
MOL	Ministry of Land
MOLE	Ministry of Labor and Employment
MOPA	Ministry of Public Administration
MOPME	Ministry of Primary and Mass Education
MOT	Ministry of Telecommunication
MOWCA	Ministry of Woman and Child Affairs
MSW	Ministry of Social Welfare
MWR	Ministry of Water Resources
NGO	Non-Government Organization
NSW	New South Wales
NWMP	National Water Management Plan
PHED	Public Health Engineering Department
PO	President Order
RBE	Riverbank Erosion
RMMRU	Refugee and Migratory Movements Research Unit
RRI	River Research Institute
RS	Revisional Settlement Survey
SA	State Acquisition Operation
SRDI	Soil Resources Development Institution
TV	Television
UK	United Kingdom
VGD	Vulnerable Group Development
V GF	Vulnerable Group Feeding
VP	Vested Property

Glossary

Aman	A variety of Paddy which can tolerate high water level
Ashrayan Project	Governmental Residential Scheme for the poor and destitute
Bata dag	Number that is placed instead of missing number while preparing the map
Beels	In Bangladesh, the world 'Beel′ means a lake with static water.
EID	The national religious festival in Bangladesh
Halot	Wide path between plots of land for movement of farmers and bullocks
Jula	Submerged Area
Kamranga	A special fruit containing enough Vitamin C
Khals	Canals
Khas Lands	A land that’s ownership belong to the State
Khesari	A type of Pulse
Mattobbor	Village Head
Morol	Village Head
Pakka Paikhana	Sanitary Latrine
Sofeda	A sweet fruit
Suta Dag	Sequential plot number of land which has been missed while preparing mauza map.

Chapter 1
INTRODUCTION

1.1 Background

Bangladesh is the biggest deltaic floodplain and the lowest riparian of three major river systems of the Himalayan Range-the Ganges, the Brahmaputra and the Meghna. She drains a huge volume of water generated in the Ganges, the Brahmaputra and the Meghna regions and pass though Bangladesh on to the Bay of Bengal. About 92% of the water received by the country comes from upstream annually outside of the country. But Bangladesh occupies only 7% of the Ganges, the Brahmaputra and the Meghna catchment area with a network of 405 rivers crisscrossing the country. Due to the climatic conditions and geographical position, riverbank erosion is a common phenomenon every year in our country.

Although the problems of bank erosion are widely distributed along the bank line of all the rivers of the country, the most severe erosion phone areas have been observed along the Jamuna the Padma, and the Meghna riverbanks. The catchment area of the three major rivers is about 1.7213 million square km. Total catchment areas of major rivers flowing through Bangladesh are shown in table1.1.

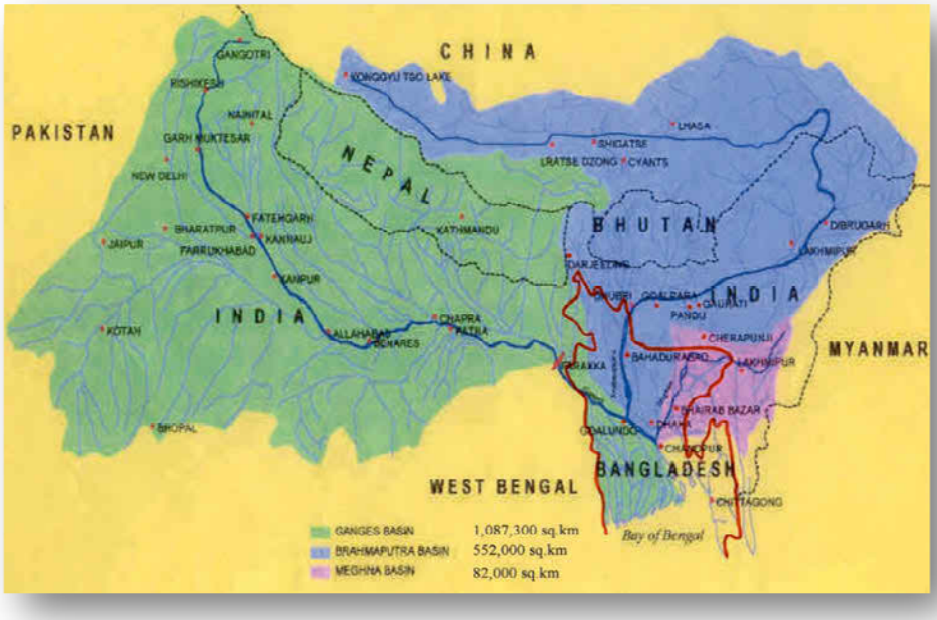
Table-1.1: Catchment Area of Major Trans-Boundary River

Rivers	Total catchment area (sq.km.)	Countrywide catchment area (sq. km.)				
		India	Nepal	Bhutan	China	Bangladesh
Brahmaputra	552,000	195,000	-	47,000	270,900	39,100
Ganges	1087300	860000	147480	-	33520	46300
Meghna	82,000	47,000	-	-	-	35,000
Total	1721300	1102000	147480	47000	304420	120400
	(100%)	(64.02%)	(8.57%)	(2.73%)	(17.69%)	(7%)

(Source: Joint River Commission of Bangladesh, 2015)

The sediment discharge of the Ganga-Brahmaputra-Meghna river system is the highest of the world (Kuehl, Hariu and Moore, 1989). It has been estimated to be about 1050 million tons annually in the Bengal basin (Milliman et al., 1995). About 600 million tons of which are deposited in the Bengal delta itself (Meade, 1996). As a result the river bed is getting silted and losing its depth. Also the sediments are washed down from highlands on three sides of the GBM basin. The sediment discharge of the river bed configuration is being adjusted frequently and consequently the river channel is shifting. These all are responsible for flooding and riverbank erosion (Elahi et al., 1991).

Riverbank erosion plays an important role in the siltation process and reducing water-holding capacity of rivers. The river sediments are subjected to coastal dynamic processes generated mainly by river flow, tide, and wind actions resulting additional new land in some places due to accretion, and loss of land in some other places due to erosion. Through the processes of sedimentation, the formation of chars (islands) through accretion takes place. These undesirable chars in the river system hinder inland water navigation, cause erosion in the riverbanks, and create other socioeconomic problems for people due to land loss and displacement (Ali, 2000).



(Source: Joint River Commission of Bangladesh, 2015)

MAP 1.1: Basin map of the Ganges, the Brahmaputra and the Meghna River

Ganga-Brahmaputra-Meghna Rivers have eroded several thousand hectares of floodplain, several Kilometers of roads and railways and have displaced people. The Ganges-Padma River in Bangladesh is a meandering river. But lately, the Ganges-Padma becomes a braided river because of high sediment transportation by Jamuna and deposition of Ganges-Padma river bed (Yeasmin and Islam, 2011).

During 1970–2000, two major rivers of Bangladesh, Padma and the Jamuna eroded 180000 hectares of land and about 200000 people were displaced (Islam and Rashid, 2011).

Riverbank erosion is a regular phenomenon in Bangladesh, which is considered as the largest delta of three mighty rivers -- Ganges, Brahmaputra and Meghna. According to CEGIS, 88780 hectares of land had been eroded along the Brahmaputra, 27,990 hectares along the Padma and

38,510 hectares along their distributaries between 1973 and 2007 (IRIN, 2010 cited by Raju Md. N.A.et al., 2015).

About 15 to 20 million people are at risk from the effects of erosion in the country and about 1 million people living in 94 upazilas are directly affected by riverbank erosion every year. As per different sources, 500 kilometers of riverbank face severe problems related to erosion. The northwest part of the country is particularly prone to riverbank erosion, which has turned the region into an economically depressed area. About 1 million people are directly affected by river erosion every year and landlessness could be up to 70% (RMMRU, 2007 cited by Raju Md. N.A.et al., 2015).

Displaced people experienced substantial socio-economic impoverishment and marginalization because of forced migration and inequitable access to land and other resources (Mutton and Haque, 2004).

Satellite image on the three major (GBM) rivers gives information that about 106,300 ha of land was lost in ten years from 1982 to 1992. Conversely the amount of accreted land was only 19,300 ha. So the net annual loss was 8,700 ha during this span of time. It is estimated that about one million people become directly or indirectly affected by riverbank erosion every year (Islam et al., 2011)

From ISPAN, 1993 (cited by T.K Das et al., 2014) made study, it was found that a total of 728,439 people were displaced from their original homesteads by riverbank erosion during 1981-1993. It was also estimated that annually the number of displaces to be 63,722. Four million of such homeless people are compelled to lead a suspended life in Bangladesh (Islam et al., 2011).

In Bangladesh, the poor, small and marginalized landowners who live near the riverbank are the most affected victims of bank erosion. Bank erosion affects their well-being in terms of safety and shelter, as well as their sources of livelihood (Brouwer et al., 2007).

Riverbank erosion is bringing about unemployment, landlessness and poverty in every year, and is increasing over time. It is supposed to be responsible for the unstable condition in the country (Rahman, 2013).

A report prepared by Geography and Environment Science Department of Jahangirnagar University on the losses of riverbank erosion from 1996 to 2000 (COAST Trust, 2007), gives the following picture (Table-1.2);

Table 1.2: The Losses of riverbank erosion from 1996 to 2000

Year	Financial loss (In Millions)	Affected area (In Acres)	Affected Population
1996	5809	71680.4	10103635
1997	33012	7756	173090
1998	2201	41519	321000
1999	10535	227755	899275
2000	3286	219310	416870

(Source: Costal Association for Social Transformation Trust, 2007)

From table 1.2, it is obvious that financial loss due to riverbank erosion is remarkable. Affected areas and affected people are also large. Therefore, it is one of the most dominant calamities that Bangladesh is facing every year and livelihoods impact of this calamity on people is also massive.

The Brahmaputra-Jamuna is the second largest river in Bangladesh and one of the largest in the world, with its basin covering areas in Tibet, China, India and Bangladesh. Among the major rivers, Brahmaputra-Jamuna is the most energetic and has the highest stream power. Although, this river has a smaller drainage basin than the Ganges, it has a steeper slope, larger discharge, higher sediment transport and higher sediment content. Jamuna is the downstream course of the Brahmaputra which took place after the earthquake and catastrophic flood in 1787. Presently the Brahmaputra continues southeast from Bahadurabad as the Old Brahmaputra and the river between Bahadurabad and Aricha is the Jamuna.

The Jamuna, which is braided in nature, is on a regular basis, susceptible and vulnerable to riverbank erosion has lots of chars of different sizes within the braided belt. According to an assessment of the 1992 dry season Landsat image, the Jamuna contained a total of 56 large island chars, each longer than 3.5 km. There were also 226 small island chars, with a length of 0.35 to 3.5 km. This includes sandy areas as well as vegetated chars.

Riverbank erosion has become a common phenomenon along with the major and minor rivers of Bangladesh and forcing people to migrate or resettle in areas which is more vulnerable (i.e. mid-channel or chars). This displacement exacerbates the livelihoods of the people of riverine community. In entire Bangladesh during 1981 to 1993, a total of about 729,000 people were displaced by riverbank erosion. Of them more than half of the displacement was along the Jamuna. A recent study of CEGIS (2014) shows that bank erosion along Padma River during 1973–2013 was 29,842 hectares and along Jamuna River during that period, it was 90,567 hectares.

The current study area (Char Ganga Prasad, Char Shibalaya and Kanaidia mauza of Shibalaya Upazila) is extremely vulnerable to riverbank erosion due to its remote geographic position. The area is in between two main channels of the Jamuna. Due to its adverse communication local administration preserves little information about this area. Even the local union parishad and UNO Office could not provide reliable information about riverbank erosion on this area. There is no accurate data base on eroded land, number of households and vulnerable population of this area. Within about 7.2 square kilometers of the study area there is only one primary school. There is no high school, hospital, community clinics, Pacca and Kacca road. Three thousand people of these three mauza are living in extreme poverty level. Vulnerable and pro-poor people of this area need special attention and measures from both Government and Non-government organizations.

Considering the intensity of vulnerability of livelihoods of all the river eroded people of the country this research has been conducted on the Jamuna Char land people of Shibalaya Upazila. This research will be an eye opener for the academicians, national planners, development workers and the policy implementers of Bangladesh.

1.2 Problem Statement

Rivers in Bangladesh are morphologically highly dynamic. The main rivers are braided and form islands or chars between the braiding channels many of which are inhabited, "move with the flow" and are extremely sensitive to changes in the river conditions. The processes of erosion are highly unpredictable and not compensated by accretion which has dramatic consequences in the lives of people living in those areas.

During the process of erosion and sedimentation, new fragile lands emerge in between the flow channels of some rivers. These lands are called mid-channel bars or braid bars. Most braid bars do not remain stable and have a longitudinal migration. They emerge, submerge and re-emerge continuously.

Bangladesh is suffering from acquit riverbank erosion. It has been estimated that between 2,000 to 3,000 kilometers of river-bank line experience major erosion annually (Islam and Islam, 1985).

Erosion compels millions of people to be displaced from their place of origin. More or less all the rivers of the country, whether big or small, are responsible for erosion at various points on their bank lines. According to a study report prepared in 1991 that 100 administrative units out of 462 were subject to some form of riverbank erosion of which 35 were serious, and affected about 1 million people on a yearly basis (Department of Disaster Management, 2012).

Annually rivers erode 10,000 ha of land in our country (NWMP, 2001 cited by Islam M. S. 2011) and make thousands of people landless and homeless. Along with floodplain, the country also loses several kilometers of roads, railways, and riverbank erosion in terms of long term effect on people.

Riverbank erosion is one of the natural disasters that caused displacement of inhabitants who previously lived near riverbanks. Many of those erosion-distressed people loose not only their homes, means of livelihood and assets but also their previous identity and they therefore, often try hard for recognition of an identity (Das, 2010).

Riverbank erosion in certain places along the Jamuna frequently occurs at a rate of more than half a mile and occasionally over one mile per year. The Jamuna has been continuously changing its morphology and bank erosion has been the common phenomenon for the riparian community. It should be mentioned that two principal resources of our country are its land and people. Maximum of the people of the bank area are farmers and are solely dependent upon small holdings as owners, occupiers, tenants, share croppers, or as landless laborers. The loss of land due to riverbank erosion is permanent and has a long term impact on the livelihoods of the people in the riverine areas. Once residential and productive land is lost due to riverbank erosion, it can hardly be replaced. Moreover, due to erosion not only the resources are lost but also additional resources are required to manage erosion.

Livelihoods impact on people due to riverbank erosion is heavy but institutional compensation mechanisms are either limited or not available for erosion distressed people of our country. This undesirable circumstances demand extra attention and appropriate measures at the time of policy making, so that the conflict between river dynamics and human settlement could be minimized. Moreover, quantitative information on livelihood consequences of riverbank erosion is not available unlike at other natural disasters. Attempts are highly needed to quantify the human vulnerability due to riverbank erosion, and to formulate appropriate public policy.

Keeping the above things in consideration, this study will try to identify the nature of livelihood impacts on the people caused by riverbank erosion on Shibalaya of Manikganj.

1.3 Aim and Objectives

Aim of this study is to analyze the impact on surrounding livelihoods due to riverbank erosion on Shibalaya's Jamuna bank of Manikganj. To fulfill this aim the author has targeted the following objectives

1. To collect and scan relevant mauza maps.
2. To develop and interpret database on riverbank erosion using GPS and GIS techniques.
3. To analyze the key issues selected form overall field context.
4. To discuss and highlights the livelihood scenario in the context of riverbank erosion.

1.4 Research Questions

To execute my aim and objectives of the study the following research questions are important-

1. How much erosion has been occurred?
2. What type of physical, cultural and livelihood change has been occurred and their magnitude?

1.5 Rationale of the Study

Since Bangladesh is a riverine country so almost every year it has to face area based river erosion resulting the destitution of the river levee people. Manikganj is a small district of Bangladesh which is more vulnerable for various natural disasters, especially river erosion. It is surrounded by the mighty river Padma, the Jamuna, the Dholeshwri, the Kaliganga and the Ichamoti. Riverbank erosion is a common phenomenon of this district.

Upazila Shibalaya of Manikganj district is more erosion prone due to its location. The study area (Shibalaya upazila) is situated in low lands and is bounded by the Jamuna, the Padma, and the Ichamoti rivers and transacted by the numerous khals. For this reason most of the area of this upazila is highly vulnerable to riverbank erosion. Almost every year this upazila is affected by riverbank erosion that causes serious hamper to the livelihood activities and to their lives and assets.

Shibalaya upazila is formed by old Ganges alluvial land, new Brahmaputra alluvial land and active Brahmaputra alluvial land. The entire region is almost plain to little wavy terrestrial lands along with some depressions (beels). Higher terrestrial lands (settlements) of the area do not inundate during the usual monsoon. In rainy season, some of the medium height terrestrial lands inundate by little depth to medium depth and the depressions inundate by medium depth to high depth. This area is the newly formed sandbar, which is mostly transient. This land is under the flood and river erosion prone area (SRDI, 2000).

Severe river erosion caused by the river Padma and the Brahmaputra have created enormous impact on livelihoods of common people's of this upazila which has got special attention from both the policy makers and the researchers & academicians and media personnel.

(Source: Daily Star Bangladesh, 2015)

Figure 1.1: Jafarganj Primary School (has gone under water in 2013).

(Source: Field Survey, 2015)

Figure 1.2: Char Ganga Prasad Ashrayan Project (under threat due to bank erosion).

During the last couple of years a vast area of lands of Shibalaya, Harirampur and Daulatpur along with many government offices, schools and homesteads have gone under water due to

river erosion. Many people have been displaced. Little initiatives had been taken by the government for the resettlement of the displacees. Even they failed to have attention from the NGOs. This study is carried out to know the livelihood change the displacees have gone through and still the problems they are facing.

(Source: Panoramio.com, uploaded by Kazi Rajib, 2015)

Figure 1.3: Jafarganj Bazar (already eroded due to river erosion).

(Source: Daily Star, Bangladesh 2015)

Figure 1.4: Jafarganj High School in Teota union under Shibalaya upazila of Manikganj district is on the verge of collapse into the Jamuna.

(Source: The Daily Star, Bangladesh, 2015)

Figure 1.5: Jamuna River continues to devour homesteads and farmland at Goshpara village in Daulatpur upazila of Manikganj district.

(Source: The Daily Star Bangladesh, 2015)

Figure 1.6: River erosion on Charkatari village in Daulatpur upazila, Manikganj.

This study can help the development organizers to take new initiatives for the economic development of the victims. It can also help the policymakers to understand the nature of livelihood problems of the erosion phone areas of the country and to take pro-people policy for development of the locality.

1.6. Scope and Limitation of the Study

Every research work has some scope and limitations. This study is not different from that. The scope and limitations of this study are given below.

1.6.1. Scope of the Study

Riverbank erosion displacees face many unavoidable problems in different times of displacement, i.e. before displacement, during shifting household materials and after displacement at new settlement area. Displacees live in an area for long time - from generation to generation. Due to riverbank erosion, they are forced to migrate from their places of origin to other places. Displacement due to riverbank erosion marginalizes them in respect of livelihood patterns and psycho-physical troubles (Islam et al, 2011).

The troubles, problems and losses the displacers face are losses of land and changes in land holding capacity, changes in economic activities and loss of income, loss of house structure, loss of crops, loss of security and so on (Islam et al, 2011).

According to the reflection of distributional and density pattern of population in Bangladesh, most of the people living along the riverbanks sharing their lives with erosion phenomenon and erosion has been a long interest and topic for researchers. In this study social component like population has been included as a prime aspect of the study. However, little works have been done based on mauza maps and Geographical Information System.

Micro level area study where details map is not available for example few mauza or word level remote areas study, mauza map along with GPS machine and GIS techniques could be a better way of socio-economic and geo-graphical and environment related research like river erosion and its consequences on livelihoods of the people living in the study area and its overall impacts on the society.

With the change of river courses a remarkable modifications occurs both in the population distribution and in the dimensions and direction of the riverbank erosion. Therefore, often areas of over population are to be found mainly in the active zones of Bangladesh and out-weighted population pressure is observed in the neighboring areas and villages. Practically, most of the affected people generally have moved a little distance keeping a hope and belief in mind that they would get back what the river has taken away.

This study will try to find out the nature of livelihoods impact due to the riverbank erosion of Shibalaya upazila based on selected mauza maps, GPS and GIS techniques. The findings can help the policy makers to make proper strategy to address riverbank erosion-induced problems in Shibalaya as well as in other erosion- prone areas of the country which is very much

necessary for development of the pro-poor areas of the country. Other young researcher who have limited budget, time could be able to apply this techniques and reference materials for their studies.

1. 6.2 Limitation of the Study

This research is an academic one with limited time, money constraint and small study area. So, it is probable to have some error. During field work some odds had to face in collecting data and documents. These are –

Time constraint: Time provided for the research is very limited. Less than two months is not sufficient time to conduct a quality research. Time for collecting data is not enough. Also qualitative study requires more time to analyze the collected data. At the same time extra time is required to design the research in the light of new developments and insights. In addition to this, for collecting reliable data a good understanding between the interviewer and informants is required. If the informants cannot take the interviewer with confidence they may be conservative in providing proper information. For that interviewer has to give enough time to make good rapport with key informants. With limited time it is difficult to ensure it.

Financial constraint: River erosion needs sufficient money. Limited budget hinders the researcher extensive field survey.

Non-availability of data and documents: Another challenge is the difficulty in having documented information from officials. Sometimes documents may not be found readily available and considered confidential. Sometimes the public offices simply refuse to provide any data. In case of this study it is found that getting data from the public office is quite tough. The AC (Land) office is responsible for maintaining all types of land related records in the upazila. But irony is that AC (Land) office, Shibalaya hasn't provided any data on eroded lands. The situation of BWDB and BIWTA Manikganj office is more than worse. They have not provided any information. The act of DLRS was also questionable. There were anomalies with in this directorate in providing services to the clients.

Selected study area: The study area was small and selected. There may be some variation as sample was taken from a particular geographical location for time and budget constraint.

Determination of various losses: Losses for homesteads, cultivable lands and kitchen garden/home yard land are calculated on the basis of Google Earth Imageries, ArcGIS 10.2.1 ArcView 3.3 and excel software. Due to lack of essential skills remarkable variation may be observed.

Remote study area: The study area was very remote, risky and insecure. There is no easy communication network.

1.7 Conceptual Framework

Bangladesh is the sixth largest populous country in the world. Due to climate change and geographical position rainfall pattern has changed. Uneven distribution of rainfall pattern in unusual time and abnormal flooding has become a regular phenomenon in our country which has ameliorated riverbank erosion for the last couple of years. Riverbank erosion creates enormous sufferings to the people of the surrounding areas as they lost their homestead, agriculture lands, agricultural productions, everything. Combine effects of this loss is income reduction which force them to displace from their origin and poor expenditure in food consumption, education and health care sectors. River erosion victims become isolated from their family ties. These make their life vulnerable.

Conceptual Framework

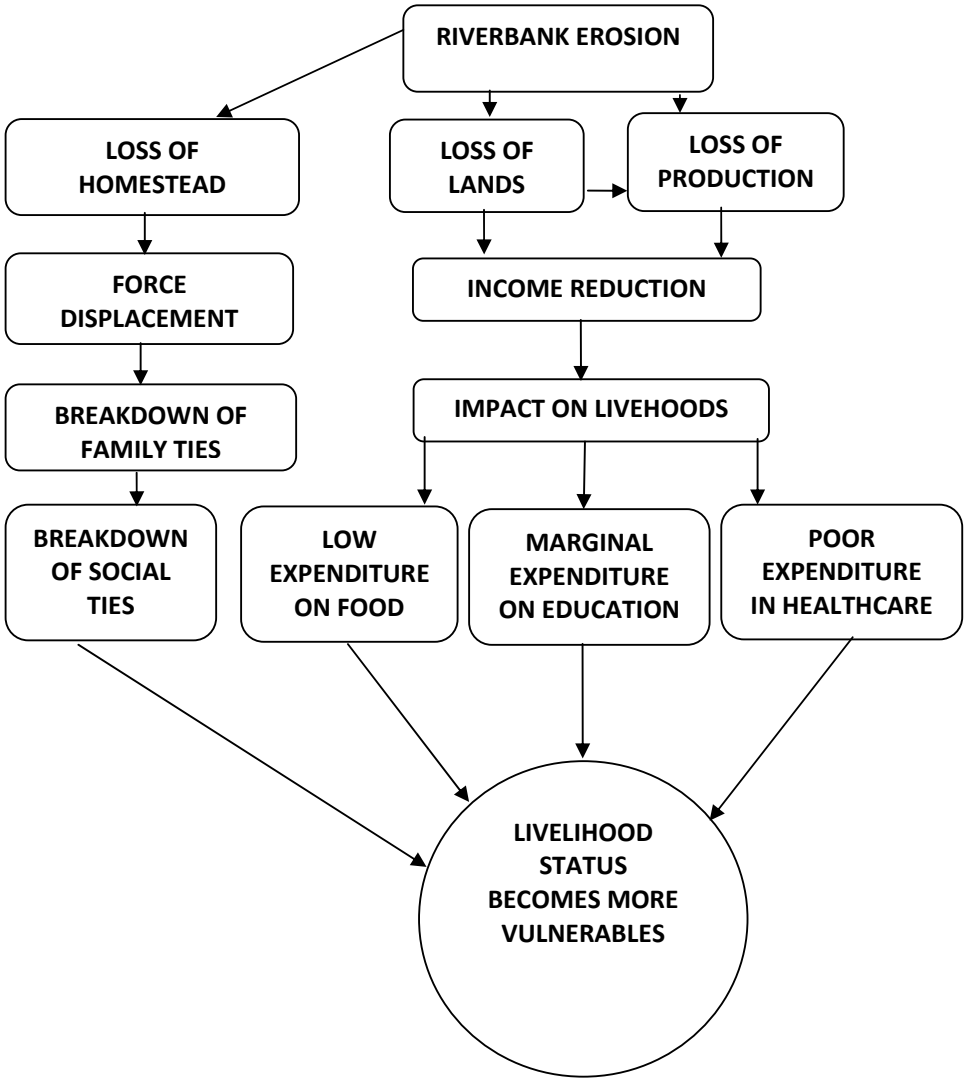


Figure 1.7: Conceptual Framework of the thesis

Chapter 2

LITERATURE REVIEW

To develop a clear conception on impact of livelihoods and to avoid duplicity of the research, different works on impact of river erosion on livelihoods of the riverine community and relevant difficulties are reviewed thoroughly. Further, planning, policies and strategies taken by different government and non-government organization and donor agency in different plan period are reviewed to investigate the lapse and gaps of study which are important for improvement of livelihood of the riverine area. Concepts of erosion, river erosion, impact of erosion on livelihoods and related study materials have also been included in literature review of this study.

2.1 Review of the Past work

Siddiki (September 2002) studied riverbank erosion, population displacement and its impact on socio-economic condition. He used base map, satellite image, historical map, mauza map and conducted some field survey from general affected people, chief of the village or village heads and surveyed Shibalaya and Teota of Shibalaya and Bachamara, Bagutia and Charkatari union of Daulatpur upazila of Manikganj district. He studied on the damages of this area from 1990 to 2001 and explained some mechanisms which are responsible for riverbank erosion and bank line shifting tendency of the Jamuna River at Manikganj district. He observed eastward shifting of the Jamuna River.

Elahi (1991) discussed on the impact of riverbank erosion and flood in Bangladesh in his book riverbank erosion, flood and population displacement in Bangladesh by using some maps, published and unpublished data and remote sensing information. According to his observation, 50% of rural people of Bangladesh are functionally landless. The consequences of riverbank erosion and flood hazard on population displacement, resettlement and socio-economic condition are also discussed in his paper. His study was on some selected erosion phone areas like Chilmari, Kurigram, Gaibandha, Saraikandi, Kazipur, Sirajganj, Jamalpur, Chandpur, Manikganj and some other coastal areas. He estimated that every year one million people are affected by riverbank erosion in our country.

Burger et al., (1991) discussed about the bank erosion and channel possesses in the Jamuna River. He used some map, satellite image and land sat image. This study was done within the framework of the Jamuna bridge appraisal study. He found that Jamuna River is the lowest reach of the Brahmaputra and it is the largest braided sand bed river of Bangladesh. Morgan and Melntire (1959) and Coleman (1969) said that about two centuries ago the Brahmaputra

shifted from the original course to its present course. According to their study, the Jamuna River has increased its total width and has gradually shifted in western direction and reaches up to 10 kilometers. They also discussed about the cross sectional characteristics of the Jamuna.

Mafizuddin (1991) investigated the characteristics of riverbank erosion in Kazipur upazila using the topographic maps, Ariel photos and questionnaire survey. From his investigation, he identified that Kazipur upazila has been totally eroded in between 1980-1984. 80% of the displaced do not want to move from the Kazipur upazila.

Chawdhury et al., (1991) studied about socio-economic and demographic characteristics of displaces in Bhola and Kazipur. He selected the study area from the Brahmaputra-Jamuna and Meghna floodplain on the basis of intensity of erosion, demographic condition, location etc. All upazilas were stratified into three categories mainland mauzas with bank lines, mainline mauzas without backlines and char mauzas. He found that literacy rate is high in Bhola than in Kazipur, maximum household members were illiterate in both the study areas and one third of the population was unemployed. Finally he concluded that there is no significant difference in the socio-economic status of both the study area.

Halli (1991) identified the economic impact of riverbank erosion in Kazipur upazila by using questionnaire survey, mauza map and some related data. He selected eight mauzas depending upon their geographic location. His analysis was based on six steps. Halli found the unequivocal support for the hypothesis that the displaced are economically disadvantaged.

Haque (1986) found that the erosion hazards accounted for a loss of one-thirds of displaces. He studied about human resource to riverbank erosion hazard in Bangladesh. He selected eleven unions of Kazipur upazila and nine hazard concepts. This survey was completed in 1985. He found a threat of erosion hazard among the respondents. He also observed the causes of riverbank erosion and the relationship between human response and selected explanatory variables.

Weist (1991) identified the domestic group dynamics of the resettlement process. His paper is related to riverbank erosion in Bangladesh. He collected primary data on household size, sex ratio, mean age, marital status, etc from Kazipur upazila. He also identified household resource access, labor, time and implications of the occupational distribution.

Hossain carried out some information about displaces of riverbank erosion in urban quarter settlement in Sirajganj. In 1984 he said that during the last few decades more than 100 villages has been affected by riverbank erosion. He found that some respondents want to rebuild their houses and some respondent do not want to rebuild their houses or move other places. He

identified that due to change of working environment, their income has reduced and their social status and livelihood condition such as education, medical facilities etc deteriorated.

In 1987 Islam and Rahman showed that about one million people were directly or indirectly affected every year due to riverbank erosion. They collected data from Dhaka city during March to June. In 1980 they selected two areas. One was Demra Bastuhara Camp near Dhaka city and Dattapara Bastuhara camp near Tongi town. Data was collected based on questionnaire survey and census report. The study found that the total of 2271 household head migrated due to riverbank erosion. For this study100 households were selected randomly for an in depth survey. From this survey he found that most of the migrants had originated from Faridpur, Barisal, Comilla and Dhaka district. They also found that young adults were migrating more. Education level of the migrants was low and one-third of them were illiterate. From that study they also found that the socio-economic conditions of the migrants were very poor.

Ahmed et al., (October 1990) studied impact of bank erosion of Jamuna river in Kurigram, Gaibandha, Sirajganj, Jamalpur and Tangail and conducted some survey on land use based on questionnaire among some population from administrator and residence. From the study he also found some social and economic dimensions of the displacees and their interactions with overall urban situation. He also found the pressure of displaces on urban facilities. Here he also explained selected displacement issues and adjustment of displaces with urban living and the planning policies for the development of Kurigram, Gaibandha, Sirajganj, Jamalpur, Tangail and few other alone the bank of the Jamuna River.

Haggart Kelly (1994), in his famous book “Rivers of Life”, he mentioned river erosion as one of the major hazard in Bangladesh. He remarked that river not only breaks the banks of the river but also breaks the heart of the people displacing every year at least one million people in Bangladesh. He also observed that 19% slum dwellers of the capital were victim of river erosion. In a report in 1986, the water development board identified 600 places around the country which are most vulnerable to erosion. In this paper, BWDB also mentioned some hydrological and geological reasons such as the depth and width of river, the variation of river flow in different seasons, the accretion of new lands due to heavy siltation and the instability of the soil for river erosion in Bangladesh.

2.2 Erosion

The word erosion has come from the Latin term “rodere” meaning ‘gradually reduce’, the same origin that gives us the word ‘rodent’. Simply erosion means soil removal from the earth’s surface.

According to Dictionary.com, it is process by which the surface of the earth is worn out by various agents like water, winds, waves etc. From different point of views the conception of erosion may vary.

According to the Wiktionary Website, from biological point of view, “Erosion is the changing of a surface by mechanical action, friction, thermal expansion contraction, or impact.”

The Connotation sounds a little bit different in agriculture. In agriculture, soil erosion refers to the degradation of a field's topsoil by the natural physical forces of water and wind or through forces associated with farming activities such as tillage (Ritter, 2012).

In Geology, “erosion is the process of the movement of loosened or weathered materials from one place to another, and occurs due to the agents of erosion -wind, moving water, moving ice, and gravity.” So erosion is the process by which soil and rock from the earth's surface are removed by exogenic processes such as wind or water flow or by any other natural or human activities, and then transported and deposited in other locations. It is a soil degradation process by wind forces or water forces (Oldeman, 1991-92).

Though erosion is a natural process, excessive erosion causes desertification, decreases in agricultural productivity due to land degradation, sedimentation of waterways, and ecological imbalance.

2.3 Riverbank Erosion

Riverbank erosion is a “geo-morphological process of alluvial floodplain rivers”. Simply it is defined as the process of wearing of the banks of a river. It occurs due to bank adjustment, bank trampling, and changes in bed elevation and topography in reaction to modified flow conditions or bank resistance. Bank erosion is a natural process; without it rivers would not meander and change occurs. Severe riverbank erosion causes heavy displacements along the bank line of the rivers, which has profound impact on the livelihoods of the community people.

2.4 Impacts of Riverbank Erosion

Impacts of riverbank erosion on people, society, culture, environment and ecology are very high. Increment of it leads to decreased water quality negatively impacting on aqua environment and leading to the loss of native species. Plants growing on the bank reinforce the soil and provides over hanging trees, bushes, grasses and reeds which provide shelter for fish and other aquatic organisms. Tree roots growing along the bank also provide habitat for fish and other animals. When riparian vegetation is removed habitat for aquatic animals declines. Erosion can produce wider, shallower streams with uniformly sandy beds-uncomfortable habitat for many aquatic organisms.

Erosion of riverbanks creates bare, disturbed surfaces which can be a focal point for wild plans colonization and penetration into river landscapes. When sediment settles to the bottom it covers the living space for many bottom-dwelling plants and animals. Sediment can block sunlight for aquatic plants, can clog the gills of fish, and reduces the amount of dissolved oxygen in the water, which is necessary for aquatic organisms to survive. Many riparian areas are valued as sites of cultural and spiritual significance. Accelerated erosion of riverbanks can directly undermine cultural artifacts such as wharfs, bridges, buildings and monuments. Erosion of riverbanks can negatively impact on the cultural links people have to the special parts of the landscape.

Riverbank erosion plays a major role in socio-economic changes too. The displaced people experience substantial socioeconomic impoverishment and marginalization as a result of compelled-displacement from the original residence (Islam et. al., 2011). Due to erosion the displacers suffer from poverty, income reduction, occupation change, displacement, social destruction, degradation of quality of life and many others.

Riverbank erosion is one of the natural disasters that cause displacement of inhabitants who previously lived near riverbanks. Many of those erosion-distressed people loose not only their homes, means of livelihood and assets but also their previous identity, and they, therefore, often try hard for recognition of an identity (Das, 2010).

2.5 Livelihood

A person's livelihood refers to their "means of securing the basic necessities-food, water, shelter and clothing- of life". Livelihood is defined as a set of activities, involving securing water, food, fodder, medicine, shelter, clothing and the capacity to acquire above necessities working either individually or as a group by using endowments (both human and material) for meeting the requirements of the self and his/her household on a sustainable basis with dignity. The activities are usually carried out repeatedly. For instance, a fisherman's livelihood depends on the availability and accessibility of fish.

The concept of **Sustainable Livelihood (SL**) is an attempt to go beyond the conventional definitions and approaches to poverty eradication. These had been found to be too narrow because they focused only on certain aspects or manifestations of poverty, such as low income, or did not consider other vital aspects of poverty such as vulnerability and social exclusion. It is now recognized that more attention must be paid to the various factors and processes which either constrain or enhance poor people’s ability to make a living in an economically, ecologically, and socially sustainable manner.

The SL concept offers a more coherent and integrated approach to poverty. This idea was first introduced by the Brundtland Commission on Environment and Development, and the 1992 United Nations Conference on Environment and Development expanded the concept, advocating for the achievement of sustainable livelihoods as a broad goal for poverty eradication.

In 1992 Robert Chambers and Gordon Conway proposed the following composite definition of a sustainable rural livelihood, "A livelihood comprises the capabilities, assets and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term.

2.6 Socio-Economic Impacts

For better understanding the livelihood impacts of river erosion understanding of socio-economic impacts is very much essential. The word 'socio-economic' is used to describe something that relates to or is concerned with the interaction of social and economic factors. It is basically, income and social position that is used to measure the status of a family or an individual in a community (Ask.com). According to businessdictionary.com 'socio-economic' refers to things that involve economic and social factors. Socio-economic factors include income, education, occupation, and involvement in the community.

A socio-economic impact assessment examines how an incident changes the lives of residents of a community (Edwards, 2000) - the change of lives of the residents in terms of income, education, occupation, involvement or belongingness, standard of life. According to Mary Edwards (2000) the indicators usually used to measure the potential socio-economic impacts are-

- Changes in community demographics
- Demand for housing
- Changes in employment and income level
- Changes in the standard of life of the community Demography: Demographic impacts include the density and distribution of the people and any change in the composition of the population (age, gender, ethnicity, income, occupation, education level, or health status).

Housing

It is strongly related to a community's land use, social bond and security. Displacements due to disaster break the community's land use pattern, social bond and security.

Income and Employment

Riverbank erosion has negative externalities on income and employment generation.

Standard of community life

When the people are obliged to compromise with their basic and fundamental needs, the standard of life deteriorates. Standard of life falls with the loss of people's income sources or reduction of their incomes.

2.6.1 Socio-Economic Impacts of Riverbank Erosion

Riverbank erosion has appalling socio-economic impacts on people in our country creating adverse effects on people, damaging standing crops and infrastructure, destroying settlements and disrupting communications. The degree of economic loss and sufferings of people has increased in recent years and the total monetary loss is estimated to be approximately USD 500 million a year (Hasan, 2011).

Riverbank erosion displacees' losses knew no bounds. Besides the loss of land, they also lose other things, and being homeless, they become asset less too. Erosion victims lose their agricultural and homestead lands in one hand and on the other hand they become rootless, ousted from their community, breaks down their family ties and social bondage. The effect is enormous and the loss is quite impossible to regain.

2.6.2 Demographic Change

Riverbank erosion displacees frequently move to other places for shelter. Thus they get separated from their well-known society. They lose their social bond. Also their family ties breakdown. The joint family system is one of the most ancient customs of our country. The joint family culture also gets hampered due to riverbank erosion.

2.6.3 Resettlement Issues

Due to riverbank erosion many people lose their homestead and houses. When erosion is slow they can shift their household materials. But when erosion takes place rapidly and comes towards their houses, they all together dismantle their houses themselves pursuing to shift household materials. But all of them do not get enough time to take house materials. Many of them become victims of such incidents several times. Smaller owners of lands suffer a lot. After getting uprooted from the living place, searching for homestead land becomes the main priority and a few of them can manage to become landowner. Sometimes they become destitute and live in Khas land or Vested Properties.

2.6.4 Income Reduction

Any kind of displacement has direct impact on regular sources of income and income generating activities of the displacee households. Loss of income compelled them to live a sub-standard life and they could not continue their way of living even parallel to the way before displacement. They face difficulties to find new sources of income in new settlement areas. Riverbank erosion displacees take shelter in distant places or migrate to urban slum areas. The landless and jobless heads of the households under financial constraint often leave their families. Left alone, women of those households has to struggle hard to maintain their family.

Bank erosion causes dislocation of huge people - many of them permanently. Besides, the demographic and socio-economic consequences of riverbank erosion are far reaching and often enormous in our country (Islam et al, 2011). Estimation shows that 50 percent of the total homeless people are victims of riverbank erosion and they cannot rebuild their home due to poverty and scarcity of resources (Islam et al, 2011).

Erosion induced displacees go through various problems- personal, familial and social. One major personal problem is related to income reduction that leads them to live a substandard life. As displacees' incomes are reduced it influences their amount of food- intake, health care, education of the children.

2.6.5 Loss of Cultivable Lands

Due to riverbank erosion many farmers become poor overnight. As agriculture is the main livelihood for maximum people, losing cultivable lands economically they become vulnerable. Finding no other alternatives most of them become day- laborer. Sometimes they fail to cope with changed situation.

2.6.6 Loss of Industry/Grocery shops/Business centre

Some sort of loss of Industry/grocery shops/ business centre is found in every situation faced by the erosion affected people. Many people losing all these types of livelihoods become from poor to poorer.

2.6.7 Loss of Kitchen Garden/Homestead

Trees and plants sometimes become the alternative source of money to the rural people. Mango, jackfruit, coconut, Papaya trees are available in many houses. They eat these fruits and sometimes earn money selling the fruits in local market. The trees also provide wood. Meeting their household demands they sell trees for money. In rural area of Bangladesh bamboo trees are very common in almost every house. The bamboo not only meets their domestic needs but also helps to earn some money. But due to erosion the victims lose all these scope.

2.6.8 Degradation in Quality of Life

River erosion induced displacees very often go through heavy social changes. The impacts on the displacees may be positive or negative. But In most of the cases the impacts are negative. Due to riverbank erosion the victims lose their homesteads, cultivable lands, crops, livestock, plants and trees, business centers etc. Losing all these they suffer from income erosion and are compelled to lead poor quality lives. They cannot spend more money for food, heath care, education and other necessary things of life.

2.7 Importance of Governance

For proper implementation of any development policy, inclusiveness and participation of the community people, who are directly or indirectly related to this, is badly important. People who would enjoy the benefit of this development should own it. Otherwise it may not serve the purpose effectively. But like most of the developing countries, in our country the participation of people in development is not well accepted. Development work is very often not need- based rather political will and personal interest-driven. So it fails to ensure transparency and accountability. It is because of lack of good governance. In the following context the limitations in terms of governance issue are very often observed in our country.

Interest driven and political motivated policy

Because of the lack of commitment from the political leaders and policy makers very often interest driven and political motivated projects are taken.

Community Participation

In our country development is a top-down approach. People have rarely any participation. As a result they do not own development and frequently it fails to serve the purpose. As a result sufferings of the people remains as it are and development is very often wastage of national assets.

Proper and Timely Policy

Government often takes various measures to control erosion. But in most of the cases the initiatives are visionless, unplanned, non-inclusive and politically motivated seasonal activities. So these have less positive impacts on socio-economic vulnerabilities. Therefore, sufferings and degradation of standard of life of the people continue.

Chapter 3
STUDY AREA

My study area covers only three mauzas of Shibalaya union of Shibalaya upazila, Manikganj. Before describing the selected mauzas some facts and figures of Manikganj district and Shibalaya upazila have been cited from Community Report Manikganj (2015).

3.1 Manikganj District

Manikganj district is one of the low-lying area of the country and it is adjacent to two big rivers the Padma and the Jamuna. There are also some prominent rivers such as the Dholeshwri, the Kantaboti, the Ichamoti and the Gazikhali. Severe riverbank erosion is one of the main hazards of the people of Manikganj. Nearly 1.4 million people living in this district directly or indirectly face this challenge every year.

3.1.1 Location and area

Manikganj district is bounded by Sirajganj and Tangail districts on the north, Dhaka district on the east, Faridpur, Rajbari and Dhaka districts on the south and Pabna and Rajbari districts on the west. It lies between 23°38' and 24°03' north latitudes and between 89°41' and 90°08' east longitudes. The total area of the district is 1378.99 sq km.

3.1.2 Climatic conditions

The district enjoys the tropical monsoon climate. The hot summer, the long rainy season and the pleasant spring cum winter are the main noticeable seasons prevailing in the district. The summer begins at the end of March and is ended with the rainy season that continues up to September. The duration of the winter is recorded from early November to let February. The highest and the lowest mean temperatures recorded in 2011 were 36°c and 12.7°c during the months of April and January respectively. The average relative humidity is around 74%. There is plenty of rainfall occurs during the months of May to July. The annual rainfall recorded in 2011 was 2376 millimeters (BBS, 2011).

3.1.3 Rivers of Manikganj

The main rivers flowing through the district are the Padma, the Jamuna, the Dholeshwri, the Ichamoti and the Kaliganga. The Padma, the Jamuna and the Dholeshwri are navigable throughout the year. The other distributaries are greatly contributing to the agriculture in the district. Total length of the rivers flowing over the district is about 193 km with an area of about 233.00 square kilometers (89.94 square miles). An extensive area of the district especially riverine area of the upazila of Harirampur, Shibalaya and Daulatpur becomes victim to riverbank erosion every year (Community Report Manikganj district, 2015)

3.1.4 Agricultural crops and fruit

Main crops of Manikganj district's are paddy, jute, sugarcane, wheat, tobacco, mustard, sesame, potato, ground nut, onion, chili, garlic, 'khesari', lentil, leguminous pulse and vegetables. The main fruits are mango, jackfruits, 'sofeda', banana, papaya, guava, coconut, palm and 'kamranga'.

3.1.5 Literacy rate

Average literacy rate is 49.2 percent.

3.1.6 Occupations

Main occupations include agriculture, fishing, agricultural laborer, wage laborer, industry, commerce, construction, service, transport etc.

3.1.7 Exports

Main exports are tobacco, cotton, and silk fabrics, molasses, paddy, jute, wheat, potato, milk, poultry, metal products, ground nuts, oil seeds, electric poles and gas cylinder.

3.2 Shibalaya Upazila

Shibalaya is the second largest upazila of Manikganj district in respect of population which occupies an area of 199.65 square kilometers and is located between 23°44' and 23°55' north latitudes and between 89°42' and 89°56' east longitudes. The upazila is bounded on the north by Daulatpur and Ghior upazila, on the east by Harirampur and Ghior upazila, on the south by the Harirampur and Goalandaghat upazila and on the west by Bera upazila of Pabna zila and Goalandaghat upazila of Rajbari zila. It is about 24 kilometers west from the district head quarter.

Around 500 families of Mandrakhola, Noyakandi, Jogotdia, Kazirtek, Baulikanda, Baghutia, Pachuria and Saljana villages of Arua union in Shibalaya upazila lost their homesteads to the Padma in this year. More than 200 homesteads of Dhubalia village, Jafarganj High School and around 100 shops of Jafarganj Bazar went into river Jamuna this year. (Daily Star, 2015)

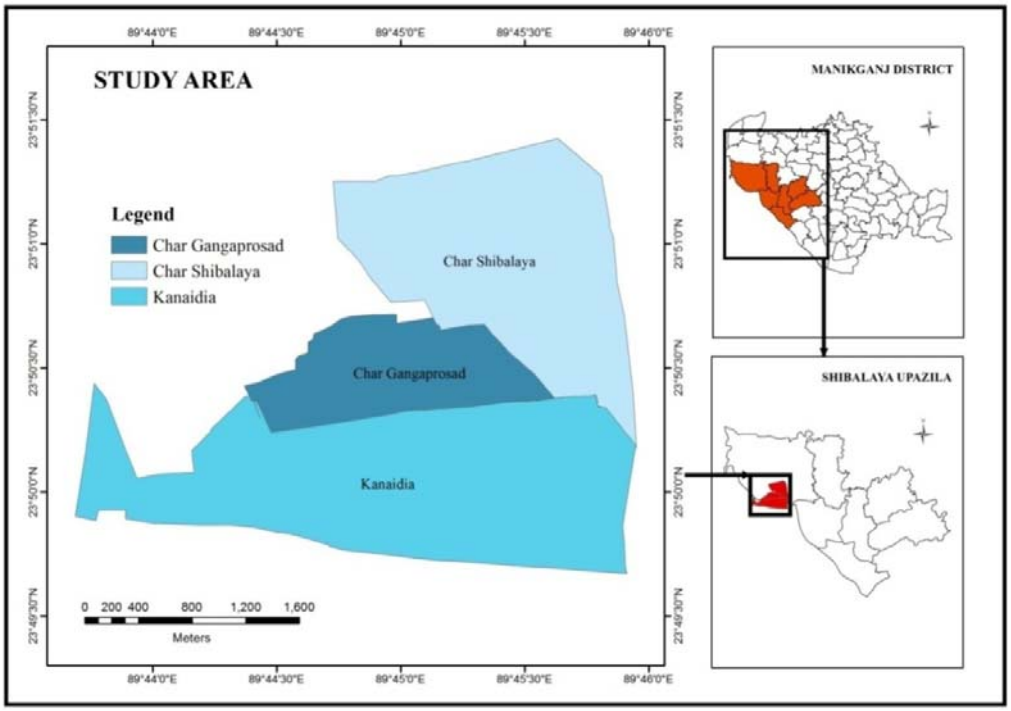
Teota union has 32 mauza. Of these 32 mauza 21 mauza have been eroded completely or partially due to riverbank erosion. The number of completely eroded mauza of Teota union is eight. Of the 25 mauza of Shibalaya eight has been partially or completely eroded due to riverbank erosion.

3.3 Study Area: Selected Mauzas

The current study area includes Char Shibalaya, Kanaidia and Char Ganga Prasad Mauza of (Shibalaya union of) Shibalaya upazila of Manikganj covering an area 7.2 kilometers. The area

is about 3 kilometers north-west from the main lands of Shibalaya. These three mauza are completely isolated from the main land by the mighty river Jamuna and is the most vulnerable river erosion phone area of the country. In the rainy season these three mauza looks like few isolated islands on the western bank of the Jamuna. The area has been selected based on geographical location and vulnerability of livelihoods of community people living there.

Both Char Shibalaya and Kanaidia mauza have two sheets each and Char Ganga Prasad mauza has only one sheet of RS mauza map. Digitize map of the selected study area has been prepared using five sheets of these three mauza, collected GPS reading from the field survey, digitize Google Earth Image, ArcView GIS 3.3 and ArcGIS 10.2.1 software which have been shown in map 3.1.



(Source: Google Earth, Compiled by the Author, July 2015)

MAP 3.1: Digitized map of the study area.

Administrative map of Manikganj have been taken from district websites of Manikganj district.

3.3.1 Char Ganga Prasad Mauza

This is a small mauza of Shibalaya union. Its total area is 273 acres. It is bordered by Alokdia, Kanaidia and Char Shibalaya on the north, Kanaidia on the west, Char Shibalaya on the east and Alokdia on the west.

This mauza has both SA and RS Mauza map. Its JL No. is 554 for SA map and 9 for RS map. SA map has been prepared during the period of 1958-1962 and RS map from 1975-1980. Total

area in SA map was less than RS map. SA map has only 140 holdings including three halots. Holding number 88 comprises almost 50 percentage area of the SA map. Then it was inside the river Padma. Whereas, RS mauza map of Char Ganga Prasad has 171 plots. In the Rs map, the land area of previous 140 plots has been redistributed into 102 plots. 69 plots have been included in the expanded area in the mid-northern side of the mauza.

Present Government has built up an Ashrayan project (Locally known as Ashroy Kendro) on 5 acres of lands of this mauza 3 years ago which provided permanent shelter for 120 families of surrounding river eroded mauzas. This project is now on the bank of the river Jamuna and is also at a risk of river erosion.

3.3.2 Mauza Char Shibalaya

Char Shibalaya is one of the severe erosion phone mauza of Shibalaya upazila covering an area of 648 acres which is about 3 km north-west from the main lands of Shibalaya and is surrounded by Alokdia on the north, Alokdia, Char Ganga Prasad and Kanaidia on the west, the Jamuna on the east and Alokdia, Kanaidia and Char Ganga Prasad on the west. JL number of this mauza map is 10 for Revisional Survey (RS) and 30 for State Acquisition Operation (SA Map).

In the RS map Sheet no 1 has 327 plots, 2 shut dag and 4 bata dag including one halot whereas Sheet no 2 of RS mauza map has 165 plots, 3 shut dag and 5bata dag. In the SA map of sheet-1 has total 391 plots, 14 shut dag and three halots and total no of plot at sheet No 2 is 155.
In both this maps existence of halots indicate cultural features of the mauza at the time of preparing the maps. The mighty river Jamuna has been shown in the eastern side of these mauza maps. Considering 1980 as base year, river erosion study of this research has been conducted.

3.3.3 Kanaidia mauza

Graticule Settings: This mauza lies between 23°49'40" to 23°50'30" north latitude and between 89°43'40" to 89°46'00" east longitude.

Location: Kanaidia is bounded by Alokdia, Char Ganga Prasad and Char Shibalaya on the north, Boro Goalondo and Alokdia on the west, Char Deuli on the south and Goalondo thana on the east. This mauza is severe erosion phone from both sides of the mauza by the two main channels of the Jamuna

Administrative name of the mauza is Kanaidia bearing the JL number 8 and Revenue Survey number 459. According to Union land office Shibalaya Kanaidia has a land area of 892.4

Acres. Kanaidia mauza has two sheets of RS maps, sheet one and sheet two. Probably due to unfavorable geographic position Cadastral Survey (CS) and State Acquisition Operation (SA) of this mauza have not been performed. Only Revisional Survey has been done during the period of 1975-1982. That's why only RS mauza map is available for this mauza.

Rice, wheat, potatoes, tomatoes, mustard, different kind of pulses and plenty of vegetables grow here. That's why the people of this mauza cannot leave the illusion of their lost lands and living here for more than two decades in spite of repeated riverbank erosion.

Kanaidia Mauza Seat No.1

This sheet of Kanaidia mauza has a total 437 plots, 4 Suta dag, 20 bata dag and 8 halots (Village path). Details analysis of this mauza sheet has been given in chapter five.

(Source: Field Survey, 2015)

Figure 3.1: Extreme remote area of Kanaidia mauza (Sheet-1).

Kanaidia Mauza Sheet No 2

Location: This mauza is bounded by Char Ganga Prasad and Char Shibalaya on the north, Kanaidia mauza sheet number 1 on the west, Char Deuli on the south and Golando thana on the east.

This mauza sheet comprised with 302 plots including four bata dag and three Suta dag and 10 halots. The area of this sheet is more transient. About eighty percent area of this sheet has gone under deep water because of intensive river erosion of this newly accreted char land. The remaining 20 percentage is used for pasturing and agricultural purpose. There is no settlement in the area of this sheet of Kanaidia mauza.

Chapter 4

DATA, MAPS AND METHODS

For systematic, logical and sequential organization of the current study i.e., from problem identification to recommendation; different steps of this thesis have been plotted in the next framework. Although, this study has been emphasized on primary source of data, secondary source such as mauza maps and Google earth platform were the basis for analysis and development of primary data.

Thesis Structure/Framework

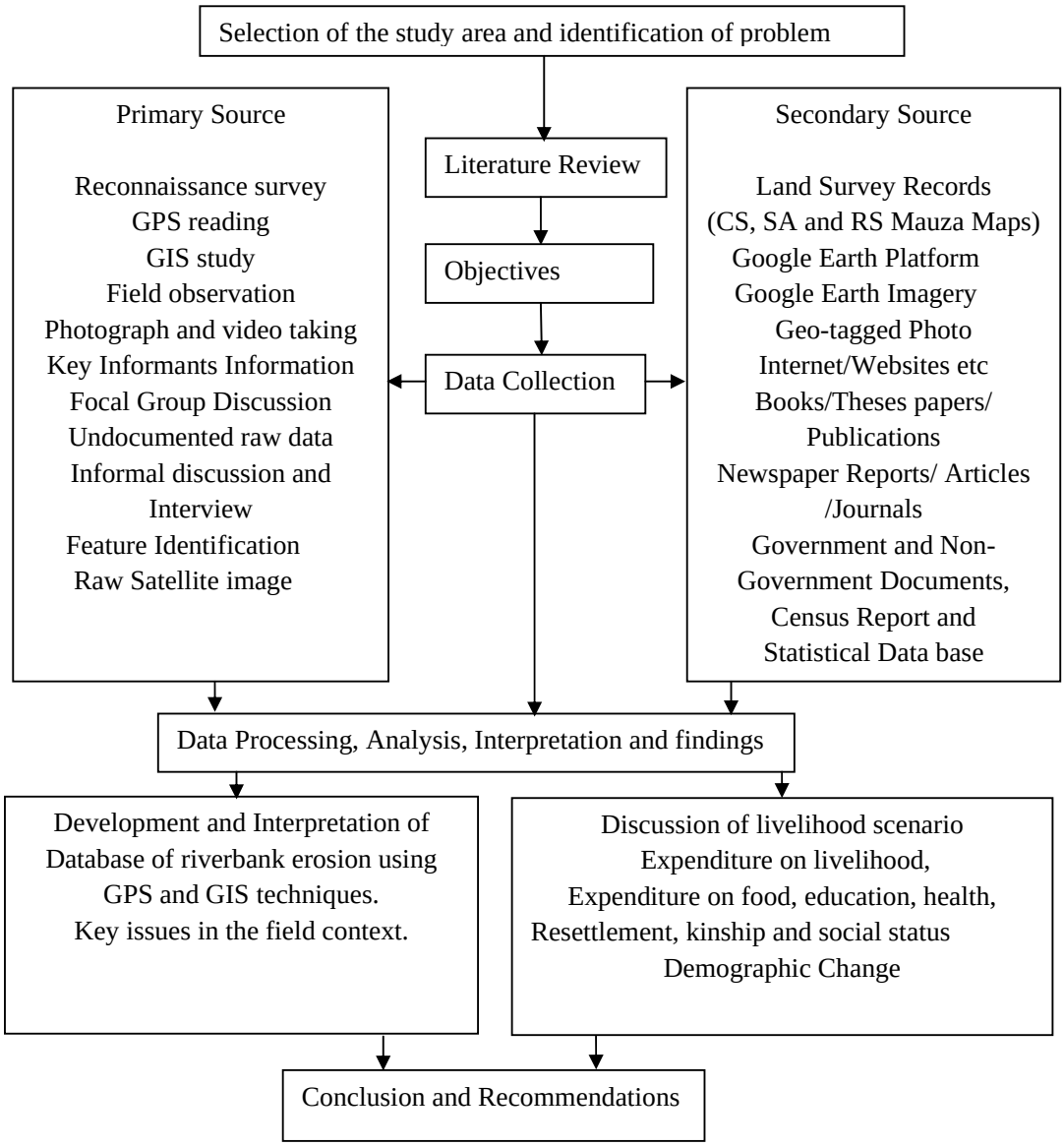


Figure 4.1: Frameworks of the thesis

To fulfill the objectives of this study a wide range of primary and secondary data source has been used. A detailed list of data source is given below.

List of Primary data Source

1. Reconnaissance survey
2. GPS reading
3. GIS Study
4. Field observation
5. Photographs, video and note taking
6. Key Informants Information
7. Focal Group Discussion
8. Undocumented raw data
9. Informal discussion & interview
10. Feature identification
11. Raw Satellite image

List of Secondary Data Source

1. Land Survey Records

1.1 Cadastral Survey (CS Mauza Maps)

1.2 State Acquisition Operation (SA Mauza Maps)

1.3 Revised Survey (RS Mauza Maps)

2. Google Earth Platform
3. Google Earth Imagery
4. Geo tagged photo
5. Internet
6. Government and non-government website
7. Books/ /Theses papers/Publications
8. Newspaper Reports/ Articles/ Journals
9. Government and Non-Government Documents
10. Census Report and Statistical data base.

4.1 Primary Data Collection

Primary data and information collection has been done for 10 days from July 06, 2015 to July 15, 2015 through extensive field observation in the study area.

4.1.1 **Development of Primary Data Collection Tools**

A set of questionnaire for sample survey and a checklist for FGDs were developed to collect the primary data/information from the study sites. A number of issues have been considered

including the erosion experience, measures they have observed to protect erosion, nature of erosion, peoples sufferings and livelihood impacts of erosion hazards on vulnerable groups. Primary data has been collected from the local people – both victims and people who have witnessed riverbank erosion including local representatives, school teachers, village leaders, UP Chairmen, UNO, Executive Engineer of BIWTA Aricha, Bangladesh Water Development Board Manikganj and other key persons who are experienced in river erosion in Shibalaya. Moreover, I have surveyed the total area and GPS tracking have been carried out using GPS machine and different RS mauza maps.

4.1.2 Site Selection and Reconnaissance Survey

Considering the vulnerability of the river eroded people of char areas, some mauzas in Shibalaya Upazila have chosen which are basically isolated from the main land by the river Jamuna. Google earth map has been used for preliminary selection of the study area. Then an in-depth reconnaissance survey of the area was conducted before final selection of the study area for better understanding of the physical features, settlement areas and livelihood of the people of the surrounding areas. Reconnaissance survey or familiarization tour was also essential to build a theoretical framework to carry out the research. Moreover, it helps to familiarize the local community environment in details.

4.1.3 Tracking the Survey areas using GPS

To calculate the eroded area of the study area, modern technology (i.e. Geographical Information System) has been used. Data have been collected using Geographical Positioning System. GPS readings have been overlapped on Google Earth Maps to prepare maps to show present land use pattern of the study area. While tracking the study area and taking GPS navigation reading; RS Mauza Maps were very useful. To exactly identify the number of plot and location of the GPS navigation points or ground control point in the mauza maps, expert's assistance from the local peoples have been taken by the courtesy of the community people.

4.1.4 GIS Study

Geographical Information System/Service/Science is a system designed to capture, store, manipulate, analyze, manage and present all types of geo-referenced data. It is a process of merging of cartography, statistical analysis and data base technology. GIS is mainly used in research work where creation of new maps is crucial. During my research I have intensively used GIS technology to prepare maps and analyze my study area. ArcView 3.3 and ArcGIS 10.2.1 software have been used to prepare maps. For data presentation and calculation Micro-soft excel has been used along with the ArcView and ArcGIS software. I have also studied

Remote sensing technology based software ERDAS IMAGINE to have a complete understanding of my study area.

4.1.5 Field observation

The most significant part of the primary data sources was the field observation. For the field observation the actual appearance of the study area was so much helpful to continue my study.

4.1.6 Photographs, video and note taking

Several photographs and videos are taken from the study area such as key establishments, settlement, river, riverbanks etc.

4.1.7 Key Informants Information

Local people are direct observers of river erosion. They can provide the reliable information about the past history of the locality. Interviews were taken with different professionals for searching the authentic information regarding livelihood of the river eroded people.

4.1.8 Focal Group Discussion

Using qualitative approach, Focus Group Discussion was conducted comprising both men and women. Most of male member's occupation is farming & fishing. Some are small businessmen (Shopkeepers), rickshaw puller, garment workers and day labor. Most of the women engaged themselves in household activities & sometimes they also involved in agricultural activities and cattle feeding. Focus group helps to gather a wide range of information in relatively short time. In this research three FGD have been conducted in three mauza. Total respondent in three groups were 50 in number. They are living permanently in char for a long time fighting with natural calamities. The participants were asked question regarding the erosion related hazard, livelihood, agricultural production, income generation, food security, education, health and sanitation in addition to adaptation technique applied in the locality. The data collected from FGD were crossed checked by the interviewee from different households. With the courtesy of BRAC office Shibalaya and a school teacher, few village leader locally called Matobbor along with other local people, Focal Group Discussion were organized.

4.1.9 Undocumented raw data

While field survey I have received some undocumented raw data from Teota and Shibalaya union parishad, Teota and Shibalaya union land office and Shibalaya upazila Statistics office which is very useful information about river erosion in Shibalaya upazila and my study area.

4.1.10 Informal Discussion/ Interview

During the field survey I have talked with many local people. From the informal conversation many important information has came out which I have note down for writing my dissertation. Several interviews have been taken of the local dwellers. It helps us to see their pathetic condition due to riverbank erosion.

4.1.11 Feature Identification

Different types of physical and cultural features of the research area have been identified during the research work. Various types of features have been identified from field observation as River, Vegetation, Settlement, School, Mosque, Water bodies, Paths, low lying land etc.

4.1.12 Raw satellite Image

During this research work I have taken raw satellite image from the Google Earth pro. Then I process these raw satellite images and I have created map.

4.1.13 Expert discussion

During the time of data processing and analysis, expert discussions helped to identify the physical and cultural features.

4.2 Secondary Data Collection

Secondary data for this study has been gathered in two steps. In first step, before going to the study area literatures were consulted in BIGD library. It includes book chapters, publications, journals, census reports, important articles, thesis reports, related news/articles published in newspapers and internet. In the second step, during the field survey, secondary data/materials were collected from local offices.

4.2.1 Land Survey Records

Cadastral Survey

During the British regime colonial power conducted the first land survey in areas which is now recognized as Bangladesh. It was a cadastral survey which started in 1890 and completed in 1940. Mauza map prepared by that time is known as CS Mauza Maps.

State Acquisition Operation

After Pakistan had been created in 1947, the Pakistan Government conducted a survey from 1956 to 1963, known as State Acquisition (SA) Survey. The mauza maps prepared at that survey are known as SA map.

Revisional Settlement survey

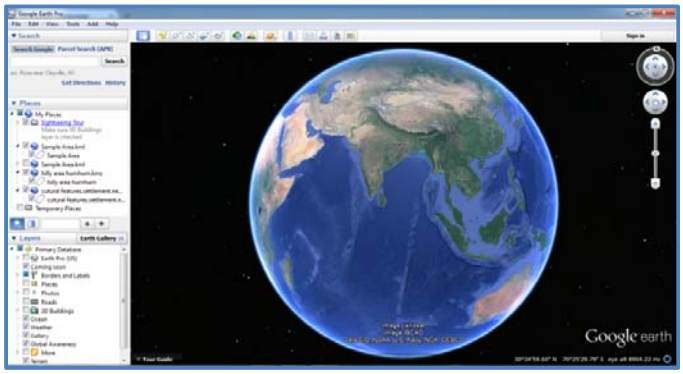
The Pakistan government also started a Revisional Settlement survey in 1966 to reduce difficulties faced by the State Acquisition survey has resulted thousands of civil cases being filed over landownership. This survey has not yet been completed. RS has been completed only in six districts. Department of survey has completed Mymensingh district survey in 2012.The survey is going on another 10 district in Bangladesh. The maps prepared by RS survey are known as RS Mauza map.

4.2.2 Collection and Processing of Mauza Maps

First geo-code information of Shibalaya upazila has been downloaded from the internet to get JL numbers of the desired mauza maps. Then the mauza maps have been collected from the directorate of land records, Tejgaon, Dhaka. Then mauza maps have been scanned with the help of Auto Cad Machine. Both soft and hard copies of the Mauza maps have been used for further studies.

4.2.3 Google Earth Platform

Google earth is a virtual glove, map and geographical information program that was originally called Earth Viewer3D, and was created by Keyhole Inc (Mahmud, 2013). It maps the earth by the superimposition of images which obtained from satellite imagery, aerial photography and GIS 3D globe. From the Google earth diversified topography of the real world can be visualized. Physical and Cultural features was analyzed from the Google Earth of the study area. Mauza maps have been overlapped on the Google platform for details study of the area.



(Source: Google Image Landsat, 2015)

Figure 4.2: Google Earth Pro

4.2.4 Google Earth Imagery/Data/Image Process Technique

In this research Google Earth and GIS both techniques have been used for image and data processing. Google earth image for December 2006, January 2013 and July 2015 have been

widely used by the Author for details information and data base development on land feature, land use and calculation of erosion of the study area.

4.2.5 Google Earth working process

At the very beginning study area had been located in Google earth software. Detected the feature and identified them. Then digitized them and measured the extent. Finally I produced map by Arcview 3.3 and ArcGIS 10.2.1; to identify physical and cultural features and to assess the significant features. The following procedures have been maintained:

-At first, the study area has been located in Google Earth software and gave a boundary by comparing it with administrative mauza maps.

-Then, different feature like river, road, settlement, vegetation have been detected with personal observation and Google Earth image information.

-After detecting features, digitized them according to their shape and size using digitizing tools- point, path and polygon.

-For digitizing large features like vegetation, pond or agriculture land, polygon tool has been used.

-Digitizing linear features like road, footpath, etc path tool has been used.

-Again for digitizing small and scattered features like settlement and infrastructure etc. point tool has been used.

-For area measurement ruler tool of Google Earth software, ArcGIS dbf file and Excel file have been used.

For producing maps this Google earth document has been converted to shape file of ArcView 3.3 and ArcGIS 10.2.1 software's.

4.2.6 Internet

Now is the era of Information and communication technology. Internet is now the leading information source of the world. I have read lots of published articles related to riverbank erosion from the internet.

4.2.7 Census Report and Statistical Data base.

For Demographic information Census report is very important. Census report can provide details data base on population, household, education status of the area, income of the households etc. Statistical database of different office is another important data source of this report. Current data base on population, growth rate, population density and other demographic information was collected from Bangladesh Bureau of statistics and disastrous related information from Upazila Project Implementation Officer.

4.2.8 Government and Non-Government websites

For my study I have widely browsed the websites of Bangladesh Water Development Board (BWDB), Bangladesh River Research Institute (BRRI), Joint River Commission, Bangladesh, Disastrous Management and Rehabilitation Cells of PM office, Ministry of Water resources Bangladesh, IUCN, FAO, BRAC, BSS, District web portal of Manikganj and web portal of Shibalaya Upazila.

4.2.9 Books/Thesis papers/Publications/Journals

Books and publications are another important secondary source of information for the literature review and writing of my thesis paper.

4.2.10 Newspaper Reports/Articles

Several news paper articles on riverbank erosion in Shibalaya, Daulatpur, and Manikganj especially Bank erosion of Jaffarganj, Teota, Shibalaya encouraged the Author to select the topics of dissertation of MAGD program. Special thanks to the Daily Star and Financial Express for their important news.

4.2.11 Government and Non-Government Documents

For collection of secondary information the Author has visited and collected information from the following offices-

1. Directorate of land records and survey, Tejgaon, Dhaka.
2. Bangladesh Bureau of Statistics, Manikganj
3. Bangladesh Water Development Board, Manikganj
4. UNO Office Shibalaya, Manikganj
5. Office of Statistics, Shibalaya
6. Project Implementation Office, Shibalaya.
7. BRAC Local Office Shibalaya
8. Land Survey and Settlement Office Shibalaya
9. BIWTA, Aricha, Shibalaya, Manikganj
10. Union Parishad, Shibalaya and Teota
11. Union Land office Shibalaya and Teota
12. Department of Geography and Environment, Jahangirnagar University, Saver, Dhaka.

4.3 Methods of Assessment of Livelihood Impact

For assessment of impact livelihoods in context to riverbank erosion, both primary and secondary data source have been used. Especially, the questionnaire survey using focal group discussion and key informants information were very effective.

Chapter 5
DATA AND ANALYSIS

Although the main focus of this study is to observe the impact of riverbank erosion on livelihoods of the community people of riverine area of Bangladesh, multi-dimensional task was involved and emphasis was given to collect mauza maps and GIS and GPS software based map development of selected mauzas. For convenience of the study, analysis of this study has been completed emphasizing the four objectives; context of mauzas and maps, development and interpretation of database on riverbank erosion using GPS and GIS techniques, analysis of mauza sheet wise selected features form overall field context and livelihood scenario in the context of riverbank erosion.

5.1 Context of Mauza and Maps

Small study area for which details description such as graticule settings, physical and cultural features etc is not available in the local administrative maps and also where there are no maps at all except mauza maps; field survey along with a suitable GPS machine and mauza maps could be the best tools for details study and spatial arrangement of that particular area.

In chapter three it has been mentioned that this study is with Char Shibalaya, Kanaidia and Char Ganga Prasad mauza of Shibalaya union of Shibalaya upazila of Manikganj district. These three mauza have five sheets. All the mauza have no three (CS, SA, RS) types of mauza map sheets. Only RS mauza map is available for all the mauza of this study area. That's why only RS mauza maps and their photocopies had been used during the field survey of the study. The study area (7.2 sq. km.) has been traveled during field survey with a Geographical Positioning System (GPS) machine, recorded and noted down GPS navigation from different suitable position. Village leaders (Matobbor) and land holder helped us to identify different holdings of these mauza. GPS reading also have been taken from the point of the key cultural features such as schools, mosques and Ashrayan project. Latitude and longitude of different position of this study area have been projected in table 5.1.

After collection of CS, SA and RS mauza maps, these have been scanned with the help of Auto Cad machine using a resolution of 200 DPI (Dot per Inch) in JPG format. Then, JPG format soft copies of mauza maps have been used to prepare Google Earth image of the study area, digitize maps of land use pattern and magnitude of erosion of the study area. Scanned mauza maps have been adjusted with exact scale of mauza maps. Afterwards, scanned mauza maps have been overlapped on the Google Earth and fixed it using GPS coordinate readings. In this way Google Earth Imageries and different types of digitize map have been prepared for different mauza of the study area. For compiling maps, the author has used Google Earth Pro, ArcView3.3 and ArcGIS 10.2.1 software.

Table 5.1: GPS Coordinate Reading 89°4444"

Mauza	Track No	Latitude	Longitude	Plot No of RS map	JL+ Sheet No	Land use/ Position
Char Shibalaya (CS)	CS1	23°51'06"	89°44'47"	122	0101	Agriculture, settlement
	CS2	23°51'12"	89°45'06"	1, North/west corner of Alokdia and CS	0101	Agriculture, settlement
	CS3	23°50'48"	89°44'58"	26, Border of Alokdia and CS.	0101	Agriculture
	CS4	23°50'56"	89°45'06"	158, South /West	0101	Agriculture
	CS5	23°50'46"	89°45'06"	607, 5 meters into the river from the bank	0102	Agriculture
	CS6	23°51'15"	89°44'44"	601, Joining of two sheets of CS	0102	Agriculture, settlement
	CS7	23°50'45"	89°45’00"	607	0102	Agriculture, settlement
Char Ganga Prasad (CGP)	CGP1	23°50'39"	89°45'01"	25, North/West corner	0091	Agriculture, settlement
	CGP2	23°50'20"	89°45'07"	South border of plot 40&41.	0091	S/E corner of Ashrayan Project
	CGP3	23°50'19"	89°45'07"	East border of CGP and K.	0091	Agriculture land near the Ashrayan project.
	CGP4	23°50'29"	89°44'35"	69, South/west corner	0091	Agriculture
	CGP5	23°50'34"	89°44'39"	64, North/South corner	0091	Agriculture, settlement
	CGP6	23°50'26"	89°44'25"	71, north/east corner	0091	Agriculture
Kanaidia (K)	K1	23°49'36"	89°44'36"	137west/South corner	0081	Agriculture
	K2	23°50'11"	89°44'25"	292	0081	Agriculture
	K3	23°50'21"	89°44'26"	284	0081	Agriculture, settlement
	K4	23°49'49"	89°45'10"	36, South/West corner	0082	Agriculture
	K5	23°50'10"	89°45'08"	1137, North/West corner	0082	Agriculture

(Source: Field Survey, July 2015)

5.1.1 Mauza Char Ganga Prasad

Char Ganga Prasad is a small but erosion phone mauza of Shibalaya union of Shibalaya upazila covering an area of 273 acres. It is about 3 kilometer from Aricha launch platform.

Geographical Settings: It lies between 23°50'14" to 23°50'43" north latitude and 89°44'23" to 89°45'38" east longitude.

Google Earth image of Char Ganga Prasad

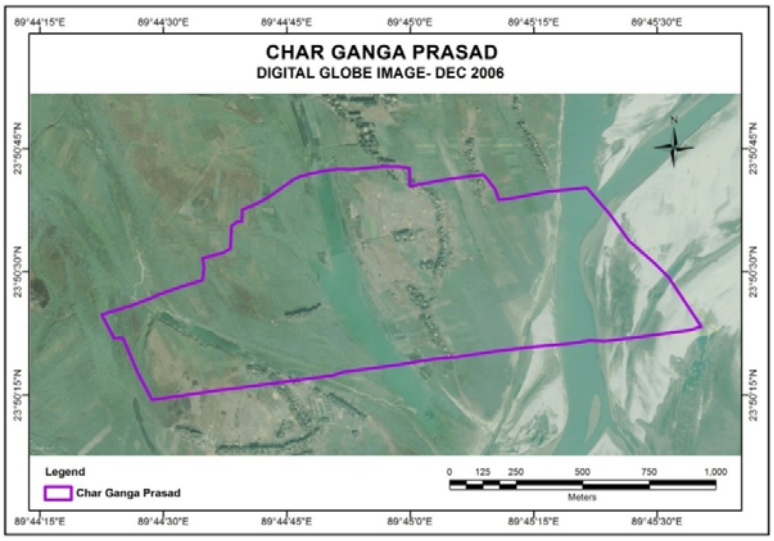
Observations of Google earth imageries of Char Ganga Prasad of December 2006, January 2013 and July 2015 (Map 5.1-5.3), give a clear picture of significant physical and cultural change in the area of this sheet that has occurred during the period of January 2007- July 2015 both due to natural and human intervention to cope up with the undesirable situation. It is noticeable that all the Astrium Image shown in this research for July 2015 has been prepared by adding observed field data during field survey with actual Google earth image of 29 March, 2014. The area has been surveyed on second week of the month of July, 2015. According to findings in the field on July 2015 the scenario of Char Ganga Prasad Mauza and other four Mauza sheets have been shown by demarcation line in the globe image.

Close observation of Digitalized Globe imagery of Char Ganga Prasad of December 2006 and overlapping the mauza map in Google Earth platform coupled with GPS and GIS study, it has been predicted that there were settlement and homestead vegetation in plot 23-29, 87-90, 110-115, 135, 137-139, 141-145 and 146 in that time. However, plot number 146 to 171 was partially eroded due to a south-westward channel of the Jamuna.

In December 2012, plot number 147 to 155 of this mauza was partially and 156 to 171 was completely eroded land. Although settlement from plot number 27, 28 and 137 has been replaced, plot number 19, 20, 22, 30, 31, 34- 37, 105-109, 116, 118, 120, 132, 133 and 140 have been included for extension of settlement with previous holdings number 23-29, 87-90, 110-115, 135, 138-139, 141-145 and 146. Plots 146-171 have emerged as newly accreted lands which were partially eroded in 2006. Emergence of newly accreted char lands had created hope among the owner of the lost land as well as landless people of that area.

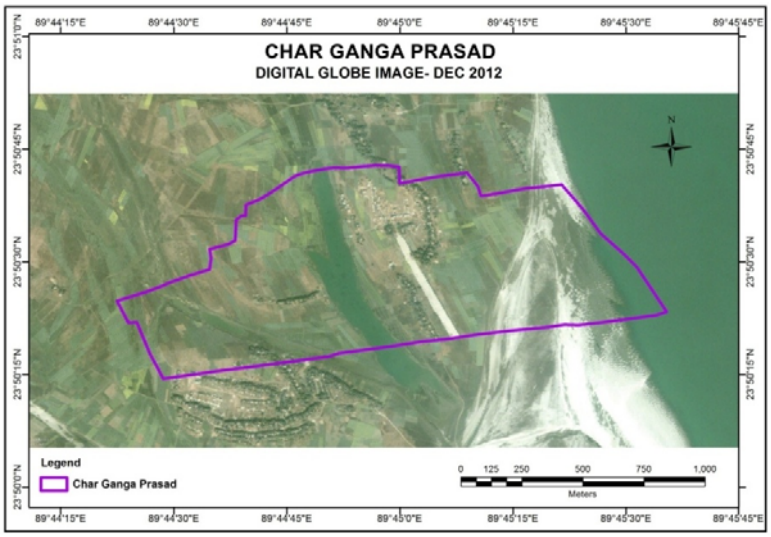
In March 2014, there were settlement and homestead vegetation in plots 18-26, 29-31, 34-35, 37, 101-116, 132, 134,135, 138-145 and 146. Total number of plots used for settlement and home stead vegetation was 42 in number. Completely new settlements were in plots 18, 21 and 101-103 and 104.

After March 2014 within a time period of one and quarter years from April, 2014 to June 2015, the condition of this mauza has further deteriorated due to extreme riverbank erosion. About 300 meters wide area of land of this mauza has been newly eroded and 40 acres land has gone into river. Human settlement in plot number 25, 26, 29 and 138-145 and 146 are in the risky zone of bank erosion. Even the Ashrayan project which was built in mid 2013 is now in a big threat by river erosion. This project is now adjacent to the deep steep bank of the Jamuna. Plot number 27, 28, 139-150 and 151 are newly added eroded land in this year. Plot no 27, 139-145 and 146 are partially eroded. Plot number 28, 147-170 and 171 are completely eroded.



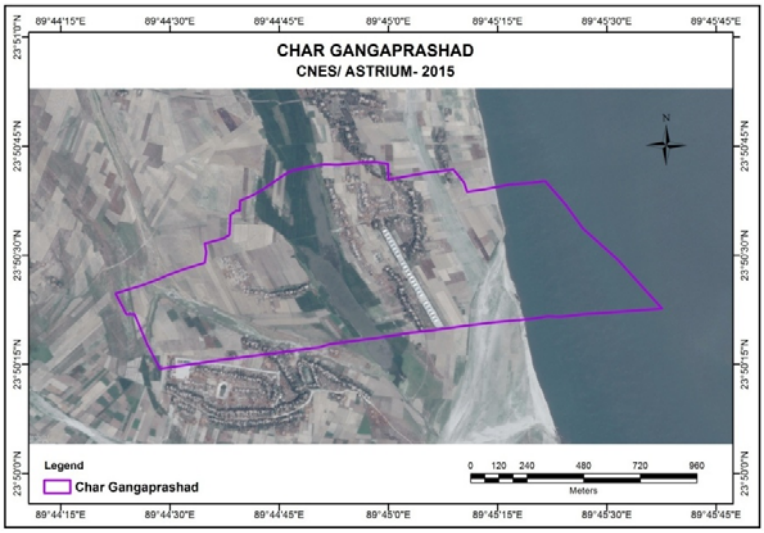
MAP 5.1: Image of Char Ganga Prasad mauza in December 2006.

(Source: Google Earth, Compiled by the Author, July 2015)



MAP 5.2: Image of Char Ganga Prasad mauza in December 2012.

(Source: Google Earth, Compiled by the Author, July 2015)



MAP 5.3: Image of Char Ganga Prasad mauza in July 2015.

(Source: Google Earth, Compiled by the Author, July 2015)

5.1.2 Mauza Char Shibalaya

Char Shibalaya is another vulnerable and eroded mauza of this study area which is about 3 kilometers north-west from Aricha Launch platform. It is a well known mauza among 202 mauzas of the upazila which is unprotected from erosion and nature's furies. Due to its existence in extreme erosion zone of the river Jamuna, this mauza area is continuous in the game of erosion and sedimentation, never in stable for long time. According to available dependable informative document (SA and RS mauza map) and local people's information, during the preparation time of both SA and RS mauza map, the whole area of the mauza was useable as agriculture land and settlement. State Acquisition of this mauza was performed from 1958-1962 and Rivisional Settlement survey of this mauza had been carried in 1974-83. Administratively Char Shibalaya has two sheets of mauza maps-Char Shibalaya mauza (Sheet-1) and Char Shibalaya mauza (Sheet-2).

Char Shibalaya Mauza (Sheet-1)

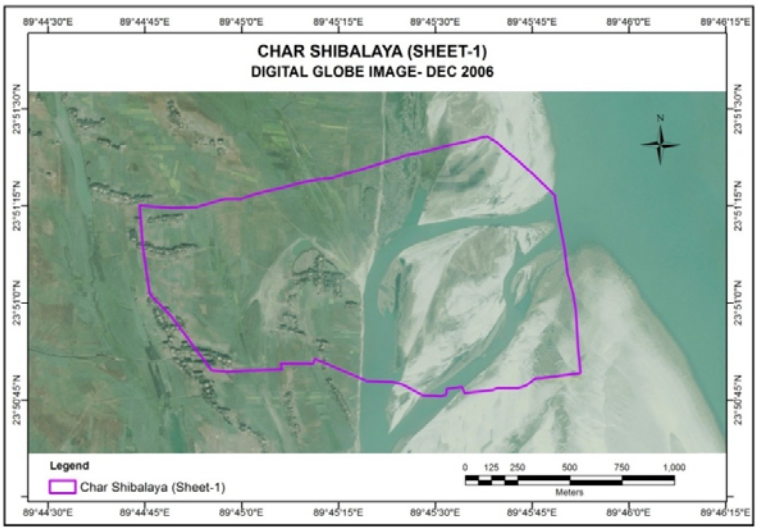
Graticule settings: Geographically, Char Shibalaya mauza (Sheet-1) lies in between 23°50'45" to 23°51'26" north latitude and 89°44'44" to 89°45'26" east longitude.

Digital Globe Image of Char Shibalaya Sheet-1 for December 2006, December 2012 and July 2015 has been shown in map 5.4, 5.5 and 5.6 respectively. From these images it is noticeable that there are many changes in physical and cultural features of this mauza during this period.

In December, 2006 there were settlement in plot number 1, 2, 3, 6, 7, 8, 11-13, 16-19, 104, 123-25, 127, 145-148, 161-164, 168-170, 172-174, 178-80, 191-93, 195-200 and 325 of this mauza sheet. There were 16 partially eroded and 98 completely eroded plots. Up to December, 2006 the mauza had eroded 969 meters from the main land of the mauza. In that year there was a light of hope to the land owners of eroded lands of this mauza due to emergence of newly accreted land within the mauza boundary.

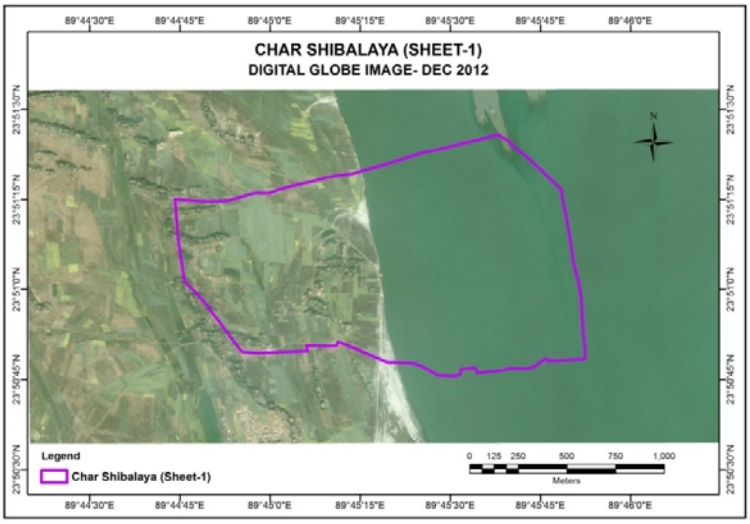
Two Distributaries of water were flowing through the mauza from the east side of the main channel of the Jamuna to south-west. Later on, these two channels have been joined outside of this mauza to main flow of confluence points of the Ganga and the Jamuna. In between two channels lands including the lands in the upstream and east side of the second channel there were newly accreted land which were not potential for cultivation in 2006. That's why; it had been shown as sandy fallow land in this research.

The little hope that arose in minds of land lost people in 2006 completely abolished in December 2012. All the sandy accreted lands had been washed away with in this short time period of 6 years. The boundary line of the mauza was 994 meters east from the south-west corner of existing non-eroded land of this mauza sheet in December 2012.



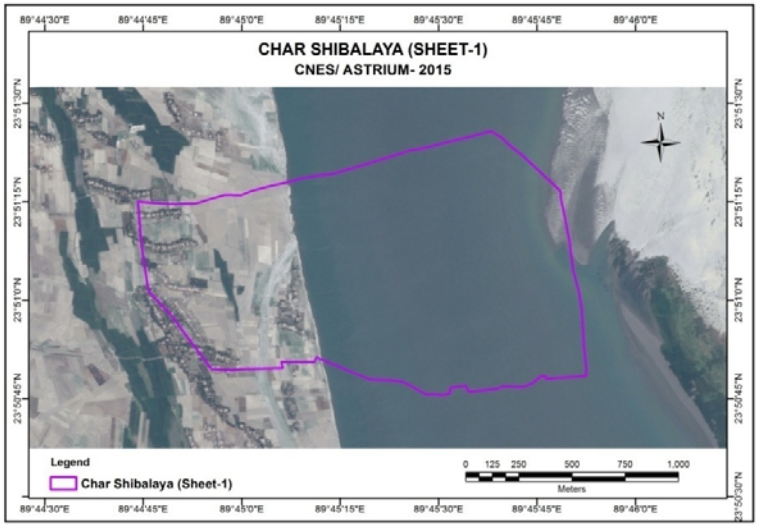
MAP 5.4: Image of Char Shibalaya mauza (Sheet-1) in December 2006.

(Source: Google Earth, Compiled by the Author, July 2015)



MAP 5.5: Image of Char Shibalaya mauza (Sheet-1) in December 2012.

(Source: Google Earth, Compiled by the Author, July 2015)



MAP 5.6: Image of Char Shibalaya mauza (Sheet-1) in July 2015.

(Source: Google Earth, Compiled by the Author, July 2015)

In 2012, among 428 acres land of this sheet, 256 acres were in 30-40 feet depth riverbed of the mighty river Jamuna. There were 50 plots with settlement and homestead vegetation. Plot number 28, 29, 100, 102, 103, 181-183, 192-194, 197-200 and 237 was partly eroded on the contrary, plot number 30-63, 65-100, 201-236, 238 and 239; a total of 198 plots were completely eroded.

The condition of the mauza had been further exacerbated within the next two and half year adding more lands to the eroded portion by July 2015. In 2015, there are homestead and vegetation in 30 plots. Plot number 23-26, 110, 111, 161-163, 165, 177-179 and 180 is partially eroded. Plot number 27-29, 96, 100, 102-109, 165-176, 181- 200 and 237; a total of 46 plots have been newly added as completely eroded land. By 2015 a total of 244 plots have been completely eroded.

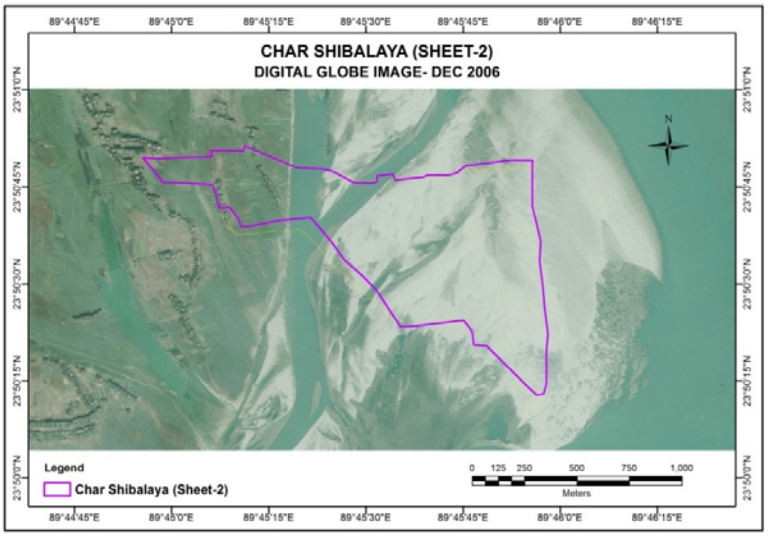
Mauza Char Shibalaya, Sheet-2

Graticule setting: Geographically, Char Shibalaya mauza (Sheet-2) lies in between 23°50'13" to 23°50'51" north latitude and 89° 44' 55"to 89° 45' 58" east longitude.

Total area of mauza Char Shibalaya (Sheet-2) is 220 acres and total number of plot is 165. Digital Google Earth imageries of Char Shibalaya sheet-2 for December 2006, December 2012 and July 2015 have been shown in Map 5.7, 5.8 and 5.9 respectively.

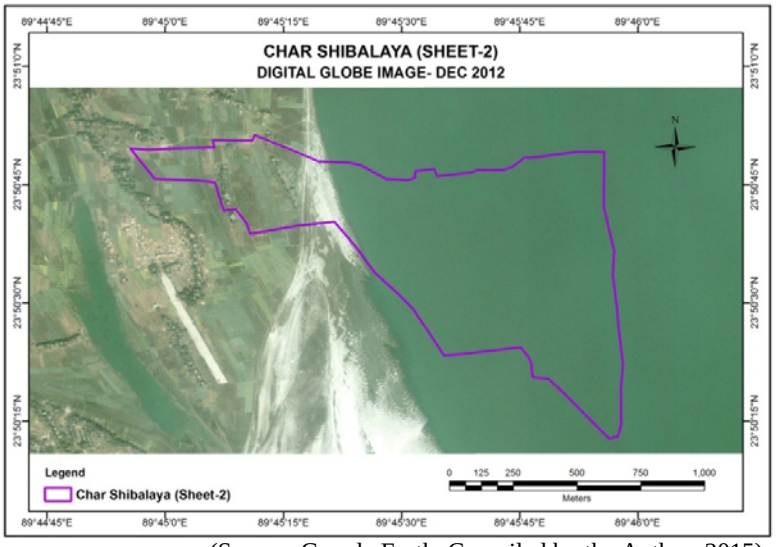
In December 2006, only few settlements were observed in plot number 603, 604, 607- 609, 618, 623, 625-26, 628, 629,766 and 767. 154 acres of land was separated by a narrow channel of the Jamuna that was low-lying newly accreted Char land and used for ground nut and Boro cultivation. Salient features of this newly accreted but low-lying Char land was actually very unstable, erosion phone and unsuitable place for settlement and permanent vegetation except short duration crops during dry season. Only 18 plots from north-west part were completely undisturbed, other plots were either eroded or newly accreted. Only 4.5% area was used as settlement and homestead vegetation. Plot 619, 621-629, 631-36, 639-647, 649-657, 659, 661, 664-676, 678, 701, 704-705, 720, 730-733, and 766 was partially and 620, 630 and 648 was completely eroded. From north-east corner of the mauza 646 meter was not inside the river and from south-east corner 260 meters was not in the river. From north east corner 1063 meters was inside the river at the same time from south-east corner 1116 meters was inside the river.

In December 2012, only 17 plots from the extreme north-west was undisturbed by riverbank erosion. 32 plots were partially eroded. These are 620-636, 649-648, 651, 653, 655, 657 and 659. Settlement from plot no 618, 619 and 623 had been eroded into the river.



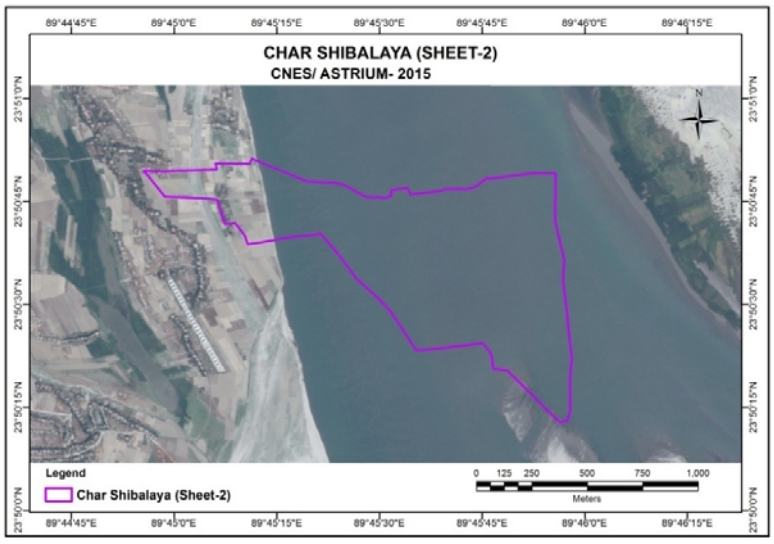
MAP 5.7: Image of Char Shibalaya mauza (Sheet-2) in December 2006.

(Source: Google Earth, Compiled by the Author, 2015)



MAP 5.8: Image of Char Shibalaya mauza (Sheet-2) in December 2012.

(Source: Google Earth, Compiled by the Author, 2015)



MAP 5.9: Image of Char Shibalaya mauza (Sheet-2) in July 2015.

(Source: Google Earth, Compiled by the Author, 2015)

Densely populated settlement area with plots number 609, 624, 625 and 626 were in risky position due to nearest steep slope of the Jamuna bank. Rest 114 plots including low-lying sandy soils have been completely eroded due to bank erosion of the Jamuna. Completely eroded plots were 637, 638, 649, 650, 652, 654, 656, 658, 660-761, 764-766 and 768.

The conditions of the villagers are more dangerous by July 2015. Only two plots bearing plot number 601 and 602 from extreme the north-west corner remain as non-eroded. Plot 601 has the only settlement in this mauza sheet. Partially eroded plots are 603, 604, 606, 607 and total eroded land in this mauza in 2015 is about 214 acres.

5.1.3 Kanaidia Mauza

Kanaidia mauza is about 3 km north-west of Aricha River port. This is in young Brahmaputra river flood plain. Although the soil of this alluvial soil is very fertile, this mauza is subject to erosion from both sides of the mauza, east and west. Kanaidia mauza also has two sheets; Kanaidia mauza (sheet-1) and Kanaidia mauza (sheet-2).

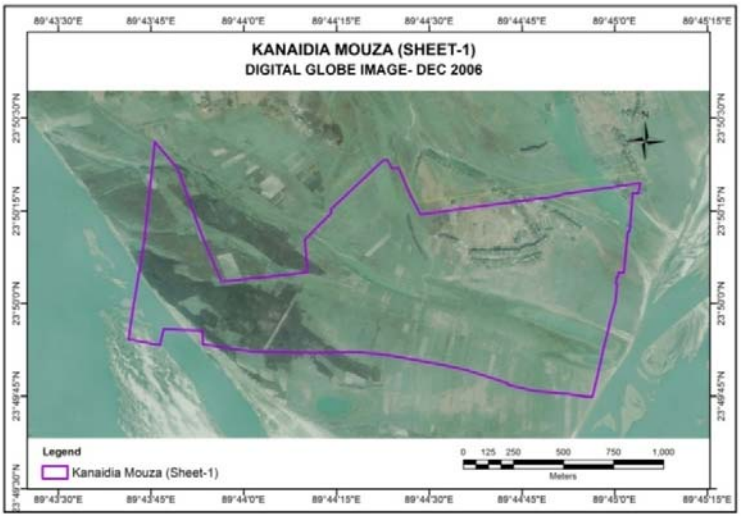
Kanaidia Mauza (Sheet-1)

Graticule settings: Kanaidia mauza (sheet-1) boundary lies in between 23°49'45" to 23°50'46" north latitude and 89°43'41"- 89°45'04"east longitude.

Total land area of this mauza sheet is 42 acres and total number of plot is 437. Digital Globe images of Kanaidia mauza (Sheet No.1) for December 2006, December 2012 and July 2015 have been shown in map 5.10, 5.11 and 5.12.

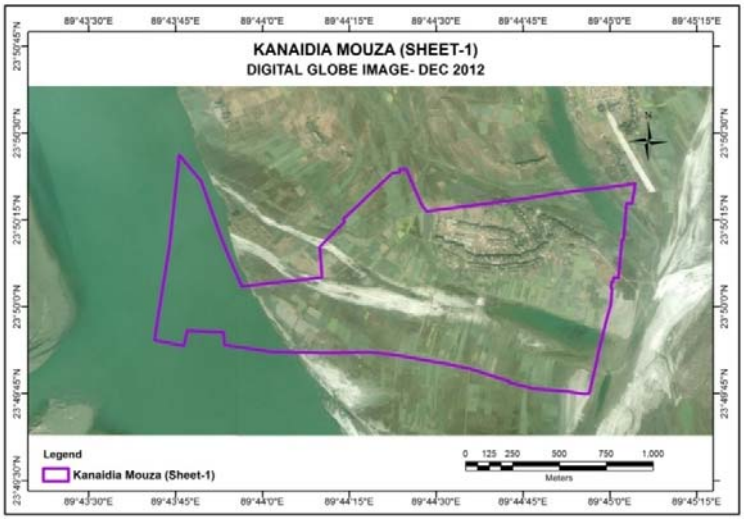
According to Google Earth images of Kanaidia (Sheet-1) in December, 2006 plot no. 248-57, 299-307, 309-10, 314, 321-24, 325, 328-30, 331-5, 338-42, 344-47, 351-53, 356, 364 and 366; a total 50 plots had been used as settlement, homestead garden as well as agriculture purpose. Total partially eroded plot at that time was six in number. These were 1, 4, 14, 433, 434 and 435. Plot number 314, 317 and 318 were used as vegetative growth.

Up to December 2012, total loss of lands from Kanaidia mauza (Sheet-1) was 79.2 acres. Loss of “local dweller’s” land was 25.2 acres and loss of khas land was 49 acres. From south-west boundary to eastward, movement of the river was 710 meters. Close examination of Astrium image also indicates that land owners of this mauza had lost 9 plots completely and 19 plots partially within 6 years period from January 2007 to December 2012. Plot number 1-3, 14 and 431-435 was completely eroded. Plot number 4-13, 422-428, 430 and 441 was partially eroded. In 2012 there were still 50 settlements.



MAP 5.10: Image of Kanaidia Mauza (Sheet-1) in December 2006.

(Source: Google Earth, Compiled by the Author, 2015)



MAP 5.11: Image of Kanaidia Mauza (Sheet-1) in December 2012.

(Source: Google Earth, Compiled by the Author, 2015)

MAP 5.12: Image of Kanaidia Mauza (Sheet-1) in July 2015.

(Source: Google Earth, Compiled by the Author, 2015)

By July 2015, total loss of land property is 97.7 acres of which 52.2 acres are khas land and 46.5 acres community people's property. From the east side of this mauza sheet 833 meters had been devoured into the Jamuna. 23 plots had been completely eroded by 2015. These are 1-14, 422, 423, 429-434 and 435. Plot number 423-428, 437-440 and 441 is partially eroded land at this time. Establishment of new settlement is observed in plot number 119, 120, 311, 312, 313, 315, 317 and 318.

Kanaidia mauza (Sheet-2)

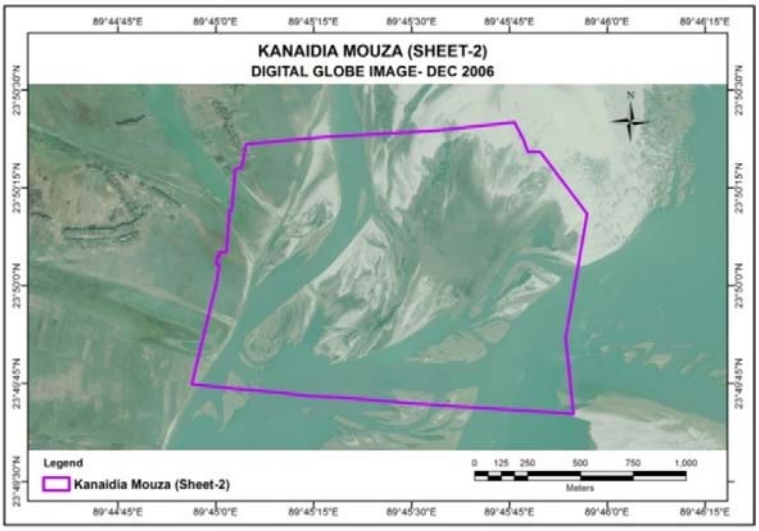
Graticule Settings: Kanaidia mauza (sheet-2) boundary lies in between 23°49'40" to 23°50'25" north latitude and 89°44'56"- 89°45'57" east longitude.

Total Area of Kanaidia mauza (Sheet-2) is 471.4 acres. In 2006, there was no settlement in the area of this sheet, more than 80% area was either in the river or char land. Sandy Char land was suitable only for cultivation of ground nuts and low-lying swampy land was used for Boro rice cultivation. Plot number 1101-1105, 1109-1112, 1144, 1145, 1147-1154, 1156-1158 and 1159 were completely non-eroded. Rest of the plots in the eastern side was partially or completely eroded. In this mauza sheet there were also some newly accreted lands at that time. Volumetrically about 50% of the remaining area was eroded.

Digital Globe Image of 12 January, 2013 gives us the clear picture of Kanaidia mauza sheet-2. For convenience of my study I am considering it as the image of December, 2012. Due to few days difference there may be insignificant difference in findings. According to the close observation of the spatial view, it is clear that newly accreted lands and riverine part of this sheet comprise more than 50% area of the mauza. Plot number 1270, 1276-79, 1296-1307, 1309-1317, 1319-1325, 1327, 1329, 1392, 1394-1402 and 1405; a total of 46 plots were completely eroded. Partially eroded plots were 24 in number bearing plot number 1253, 1254, 1263, 1264, 1269, 1271, 1275, 1280-82, 1288, 1290-1292, 1294, 1295, 1326, 1328, 1330, 1331, 1383, 1389, 1390 and 1393. There was no settlement in this mauza at that time.

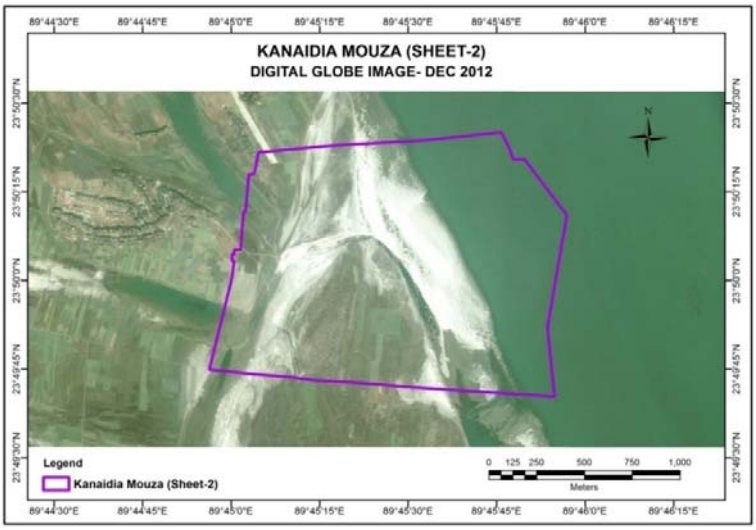
By July 2015, this mauza lost 120 plots completely. These are plot number 1110-1115, 1252-1255, 1259, 1261-1263, 1265-1341, 1360, 1370, 1372-1385, 1388-1390, 1392-1400 and 1401. Plot number 1107-1109, 1116-1118, 1120, 1121, 1250, 1256-1258, 1339, 1342-1344, 1347, 1349, 1358, 1361, 1362, 1365-1368 and 1370; a total of 27 plots are partially eroded. Even at this year there is no settlement at all.

Astrium image of Kanaidia for December 2006, December 2012 and July 2015 have been shown in map 5.13, 5.14 and 5.15 respectively.



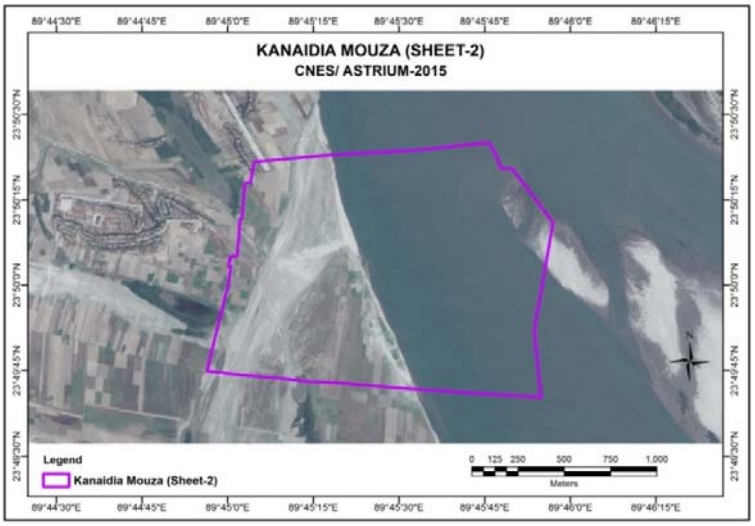
MAP 5.13: Image of Kanaidia Mauza (Sheet-2) in December 2006.

(Source: Google Earth, Compiled by the Author, July 2015**)**



MAP 5.14: Image of Kanaidia Mauza (Sheet-2) in December 2012.

(Source: Google Earth, Compiled by the Author, July 2015)



MAP 5.15: Image of Kanaidia Mauza (Sheet-2) in July 2015.

(Source: Google Earth, Compiled by the Author, July 2015)

5.2 Development and Interpretation of Database on Riverbank Erosion using GPS and GIS Technique

For calculation of river erosion of the study area GIS techniques and micro-soft excel have been used. For development of data base on riverbank erosion, a series of maps and data have been prepared depending on Google Earth imagery of my study area, ArcView GIS 3.3, ArcGIS 10.2.1, and Microsoft excel software. Based on availability of Google earth imagery the Author has selected three time period imagery for detail study of mauza sheets.

5.2.1 Eroded and Non-eroded lands of Char Ganga Prasad Mauza

During RS survey of this mauza, there was no eroded land. Owing to its extreme vulnerability to river erosion, fate of the people of this mauza is always dependable on nature. Conservation of lands of a region depends upon its geographic location, slope of the lands, rainfall pattern, steepness of the riverbanks, flowing water currents, nature of soils, nature of vegetation etc.

In this research, although only 20.25 acres (7%) of land of Char Ganga Prasad has been indicated as eroded land by December 2006, in association with newly accreted land it is 56 acres which is more than 20% of the total areas of the mauza. It is noticeable that the newly accreted soils were sandy and very transient in nature.

In December 2012, area of eroded lands was three folds in comparison with 2006. Of total 273 acres land 58 acres was eroded by December 2012 (exactly, 10 January 2013). By December 2006 only 7% of the total land area of Char Ganga Prasad was eroded but by December 2012 total eroded lands of this mauza was 21%. Eastern part of the mauza was severely eroded.

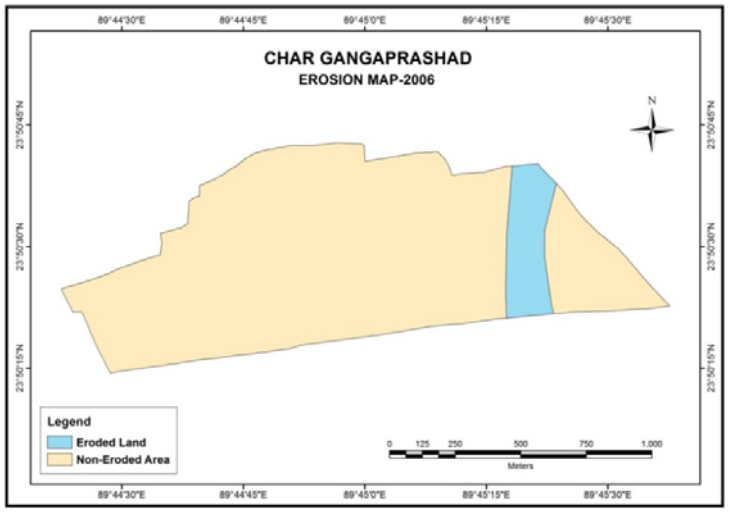
In comparison with the year 2012 eroded land is almost double by July 2015. In 2012 total eroded lands was 21% which is now 35.40%. In December 2006 and December 2012 percentage of eroded and non-eroded lands of char Ganga Prasad Mauza was 7%, 21% and 93%, 79% respectively, while by July 2015 it is 35.40% and 64.60%. Amount and percentage of eroded as well as non-eroded lands in my study area in December 2006, December 2012 and July 2015 have been shown in table 5.2.

Table 5.2: Eroded and Non-eroded land of Char Ganga Prasad mauza.

Total Land area of Char Ganga Prasad mauza is 273 acres.	Time of experiment	Erosion Pattern			
		Eroded		Non-eroded	
		Area in acres	Area (%)	Area in acres	Area (%)
	December, 2006	20.25	7	252.75	93
	December, 2012	58	21	215	79
	July, 2015	97	35	176	65

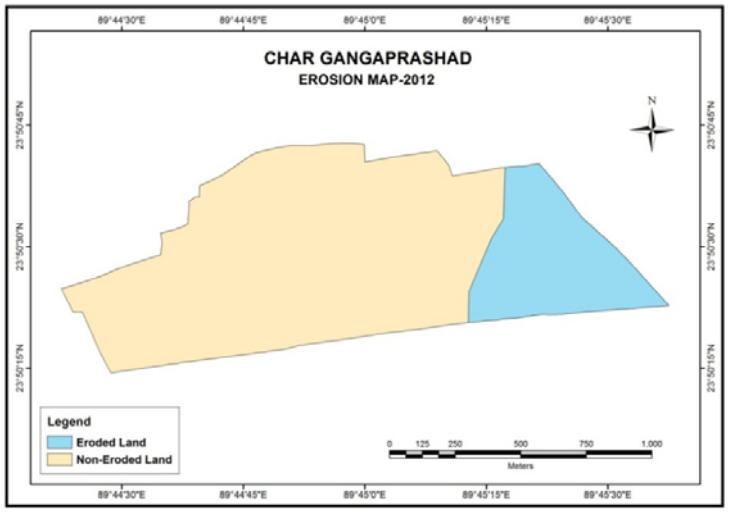
(Source: Field Survey, 2015)

Trends of Erosion of Char Ganga Prasad within December 2006, December 2012 and July 2015 have been digitized in map 5.16, 5.17 and 5.18 respectively.



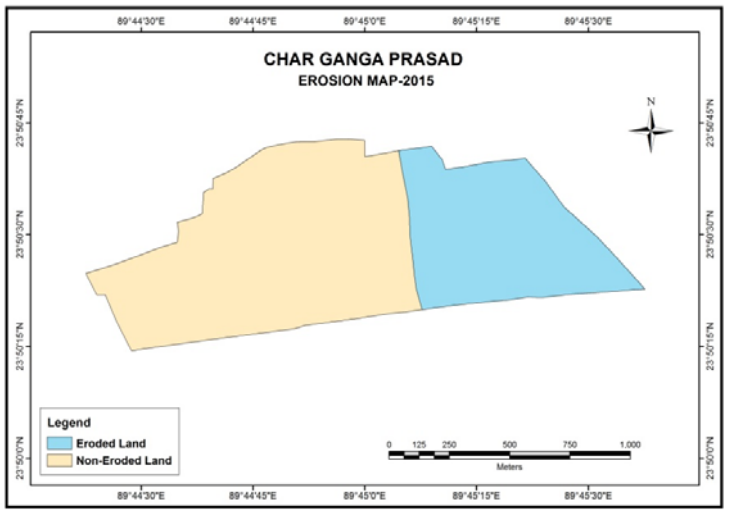
Map 5.16: Map of Eroded and Non-eroded lands of Char Ganga Prasad mauza in December 2006.

(Source: Google Earth, Compiled by Author, 2015)



Map 5.17: Map of Eroded and Non-eroded lands of Char Ganga Prasad mauza in December 2012.

(Source: Google Earth, Compiled by the Author, 2015)



Map 5.18: Map of Eroded and Non-eroded lands of Char Ganga Prasad mauza in July 2015.

(Source: Google Earth, Compiled by the Author, 2015)

For further clarification percentagewise eroded and non-eroded lands in December 2006, December 2012 and July 2015 for this mauza have been shown in figure 5.1, 5.2 and 5.3 respectively.

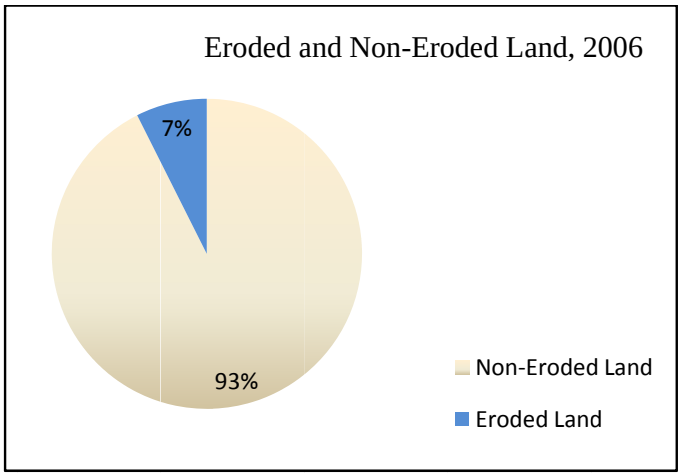


Figure 5.1: Pie Chart of Eroded and Non-eroded land of Char Ganga Prasad in December 2006.

(Source: Field Survey, 2015)

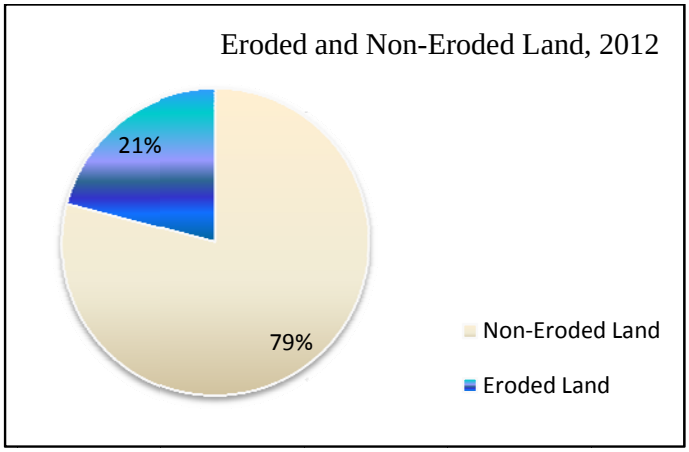


Figure 5.2: Pie Chart of Eroded and Non-Eroded Land of Char Ganga Prasad in December 2012.

(Source: Field Survey, 2015)

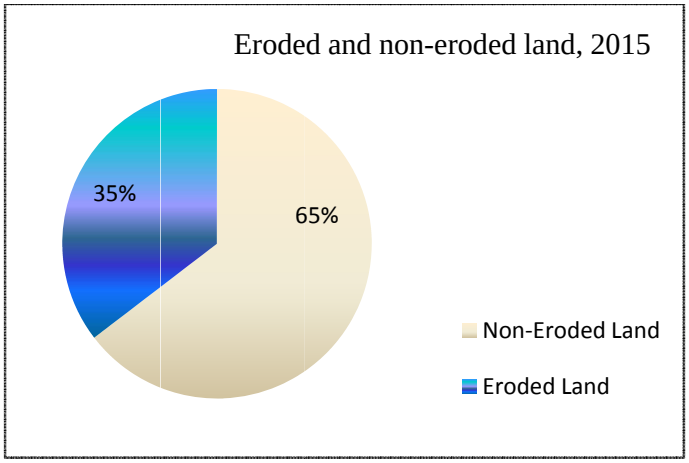


Figure 5.3: Pie Chart of Eroded and Non-eroded land of Char Ganga Prasad in July 2015.

(Source: Field Survey, 2015)

5.2.2 Eroded and Non-eroded Land of Char Shibalaya (Sheet-1)

Due to rapid shifting of channels of the Jamuna, mauza Char Shibalaya (Sheet-1) is always unstable and subject to accretion and erosion continuously. Astrium view of this mauza sheet in December 2006 indicates that only 26% i.e., 117 acres of land was eroded at that time, whereas it reached to 60% in December 2012. Total area of this mauza sheet is 428 acres of which 256 acres was eroded and only 172 acres was non-eroded in December 2012.

Condition of lands of this mauza has been further deteriorated. Additional 200 meters has gone into the river from the east side of the mauza. According to the Astrium view in July 2015, width of the total eroded area was 1196 meters from the south-west corner of the mauza. Up to July 2015, about 333 acres of land has been eroded which is approximately 78% of total area of this mauza. On the other hand, only 95 acres comprising only 22% of lands remains as non-eroded lands.

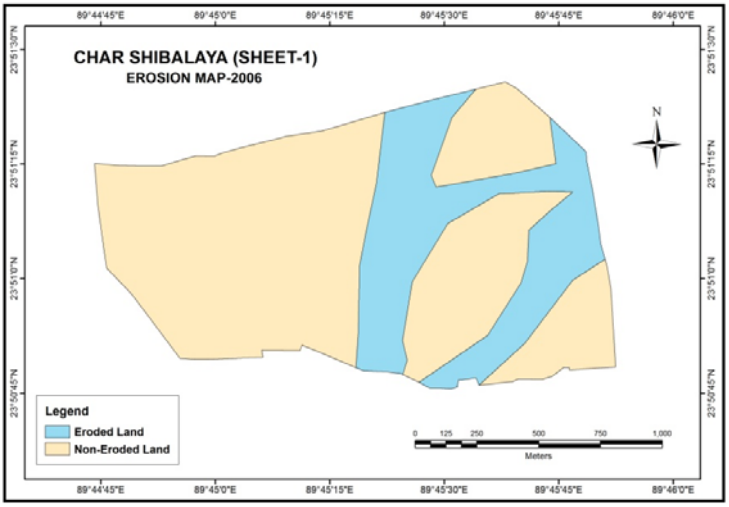
Year wise distribution of eroded and non-eroded lands of Char Shibalaya (Sheet-1) has been shown in table 5.3.

Table 5.3: Eroded and Non-eroded land of Char Shibalaya (Sheet-1)

Total Land of Char Shibalaya Sheet-1 is 428 acres	Observation Time	Erosion Pattern			
		Eroded		Non-Eroded	
		Area (acres)	Area (%)	Area (acres)	Area (%)
	December 2006	117.06	27	310.94	73
	December 2012	256	60	172	40
	July 2015	333	78	95	22

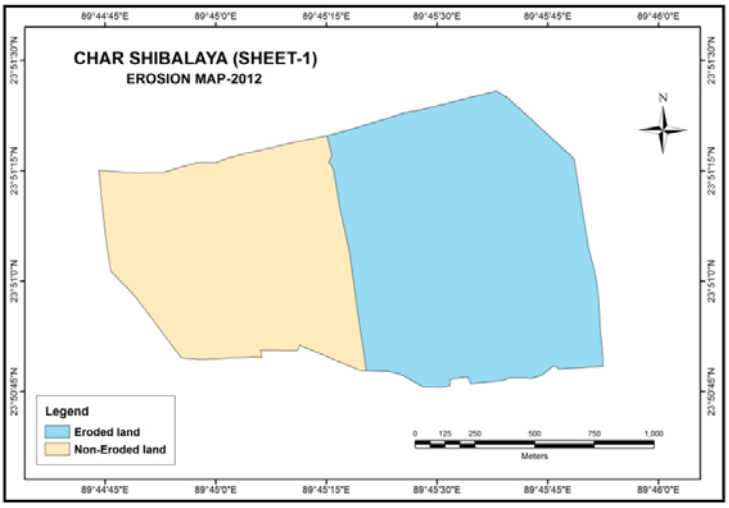
(Source: Field survey, 2015)

Eroded and non-eroded lands of this mauza sheet has been shown in digitized map 5.19, 5.20 and 5.21 for December 2006, December 2012 and July 2015 respectively.



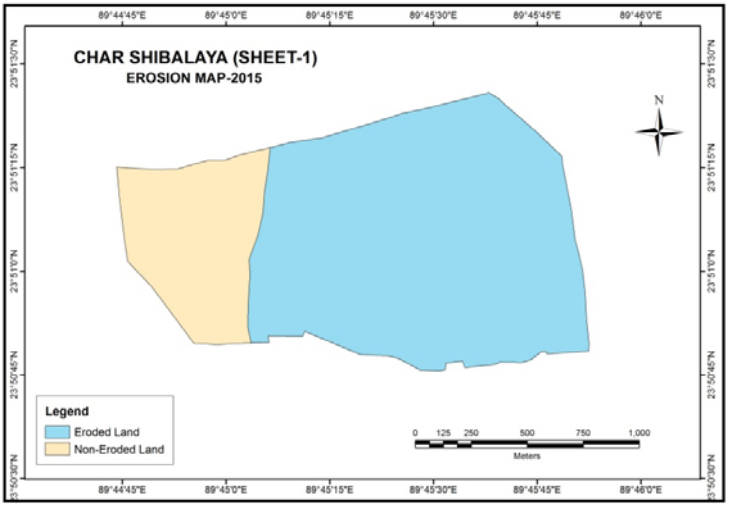
Map 5.19: Map of Eroded and Non-eroded land of Char Shibalaya (Sheet -1) in December 2006.

(Source: Google Earth, Compiled by the Author, 2015)



Map 5.20: Map of Eroded and Non-eroded land of Char Shibalaya (Sheet-1) in December 2012.

(Source: Google Earth, Compiled by the Author, 2015)

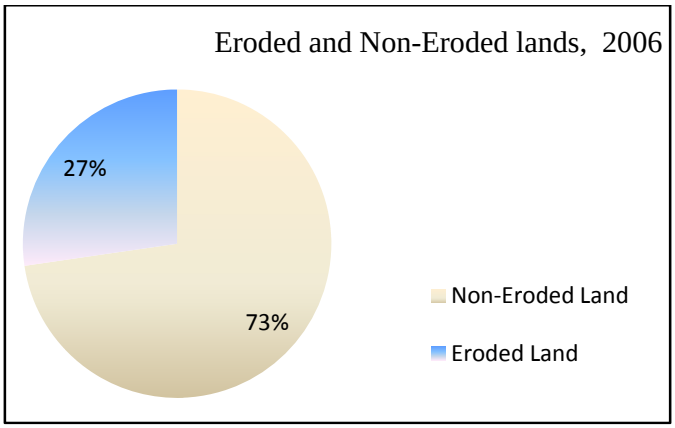


Map 5.21: Map of Eroded and Non-eroded land of Char Shibalaya (Sheet-1) in July 2015.

(Source: Google Earth, Compiled by the Author, 2015)

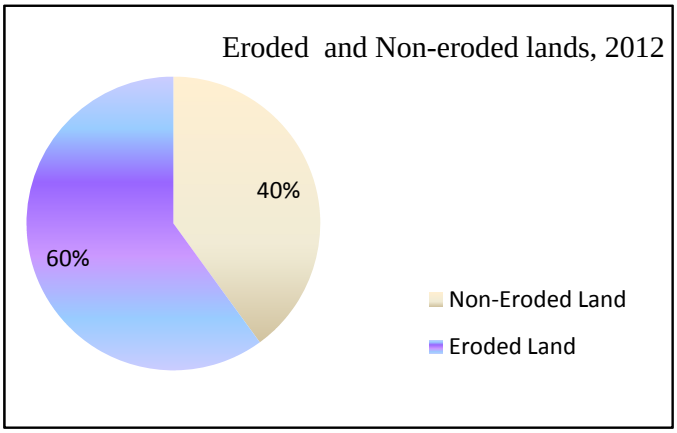
Distribution of Eroded and Non-eroded lands

For Further clarification, percentagewise distribution of eroded and non-eroded lands in this mauza sheet for December 2006, December 2012 and July 2015 have been shown in figure 5.4, 5.5 and 5.6 respectively.



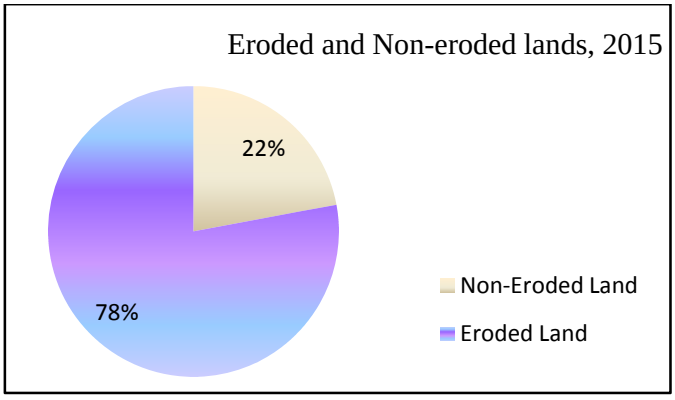
(Source: Field Survey, 2015)

Figure 5.4: Pie Chart of Eroded and Non-eroded land of Char Shibalaya (Sheet-1) in December 2006.



(Source: Field Survey, 2015)

Figure 5.5: Pie Chart of Eroded and Non-eroded land of Char Shibalaya (Sheet-1) in December 2012.



(Source: Field Survey, 2015)

Figure 5.6: Pie Chart of Eroded and Non-eroded land of Char Shibalaya (Sheet-1) in July 2015.

5.2.3 Eroded and non-eroded lands Char Shibalaya mauza (sheet-2)

Char Shibalaya mauza sheet 2 is a severe erosion phone area. If we think back of about 55 years when SA map was prepared, if it is not possible let's go back of about 35 years when RS mauza map was prepared, the mauza was completely an enriched mauza in the bank of the river Jamuna (SA Map and RS Map of Char Shibalaya of 1962 and 1983). But due to furious activities of the mighty river Jamuna the scenario is completely different now, only a small portion of lands is used by the residents of the mauza for agriculture and homestead.

In December 2006, of the 220 acres of land Char Shibalaya mauza (sheet-2), 199.31 acres was in the river bed. Only 20.69 acres was not eroded. This portion was also in risk of erosion. In December 2012, 80% area of this mauza sheet was eroded only 20% was undisturbed. Whereas, by July 2015, almost 97% lands of this mauza sheet has been eroded into river. A very insignificant portion of the area i.e., only 3 percentage is now non-eroded area. Of the 220 acres of land of Char Shibalaya mauza Sheet-2 in July 2015, 213.82 acres is in the river bed. A very insignificant, only 6.18 acres has not yet been eroded. This portion is also in dire state of erosion. According to local people's comments, it is mentionable that half of the eroded land is used for Boro rice cultivation during the Rabi monsoon because it almost dries up due to over siltation in the river bottom.

Vulnerability of Erosion

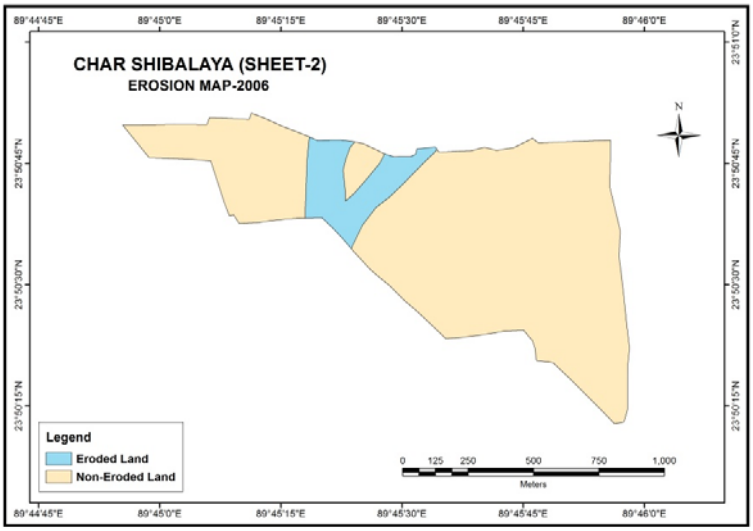
Total eroded and the land which has not yet been affected by erosion in December 2006, December 2012 and July 2015 have been shown in table 5.4.

Table 5.4: Eroded and Non-eroded land of Char Shibalaya (Sheet-2)

Total Land of Char Shibalaya Sheet-2 is 220 acres	Observation time	Erosion Pattern (Area in acres)			
		Eroded		Non-eroded	
		Area (acres)	Area (%)	Area (acres)	Area (%)
	December 2006	20.69	9	199.31	91
	December 2012	175.54	80	44.46	20
	July 2015	213.82	97	6.18	3

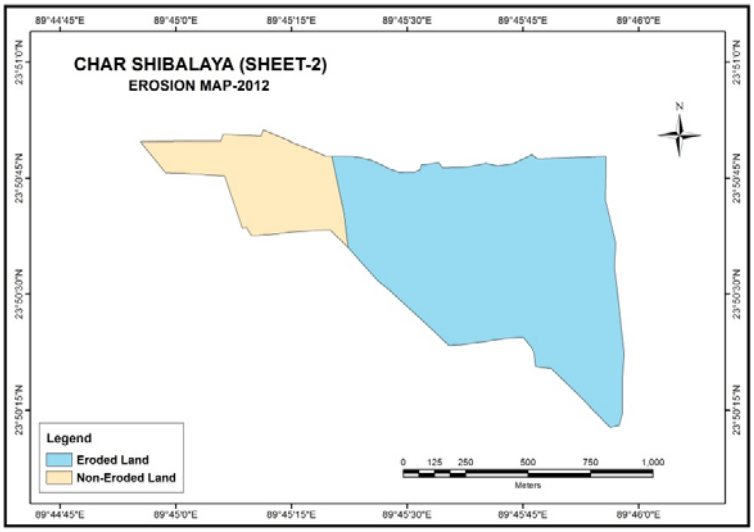
(Source: Field survey, July 2015)

Digitized map of eroded and non-eroded area of char Shibalaya mauza sheet-2 in December 2006, December 2012 and July 2015 have been shown in map 5.22, 5.23 and 5.24.



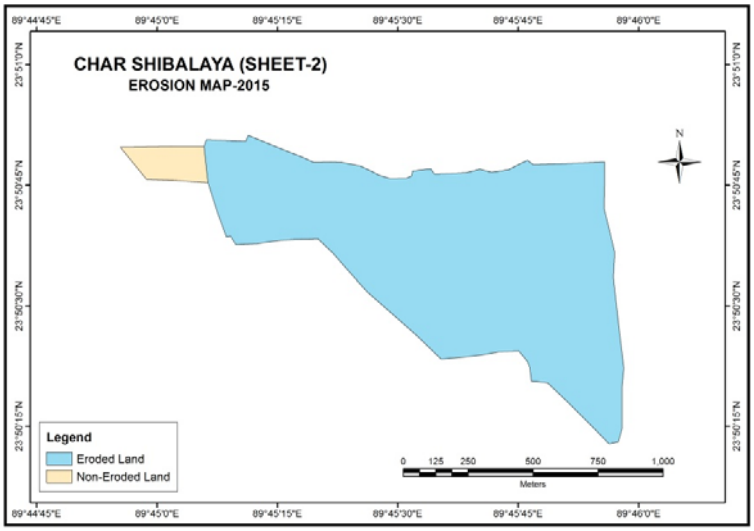
Map 5.22: Map of Eroded and Non-eroded land of Char Shibalaya mauza (sheet-2) in December 2006.

(Source: Google Earth, Compiled by the Author, 2015)



Map 5.23: Map of Eroded and Non-eroded land of Char Shibalaya mauza (sheet-2) in December 2012.

(Source: Google Earth, Compiled by the Author, 2015)



Map 5.24: Map of Eroded and Non-eroded land of Char Shibalaya mauza (sheet-2) in July 2015.

(Source: Google Earth, Compiled by the Author, 2015)

Percentage wise Distribution of Eroded and Non-eroded lands

Eroded and non eroded portions of Char Shibalaya mauza sheet-2 have been shown in figure 5.7, 5.8 and 5.9 for different times.

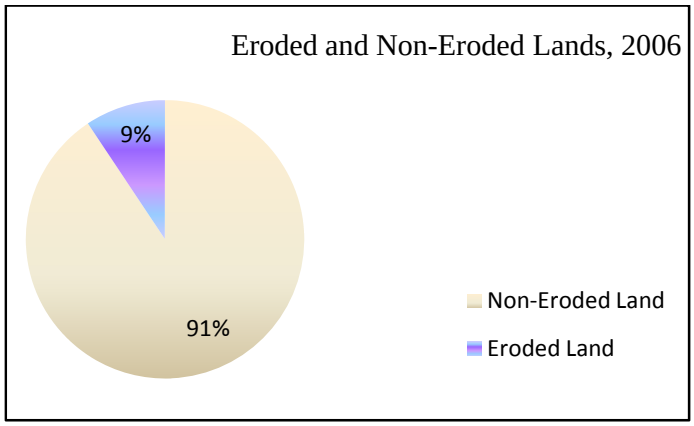


Figure 5.7: Eroded and Non-eroded land of Char Shibalaya Sheet-2 in December 2006.

(Source: Field Survey, July 2015)

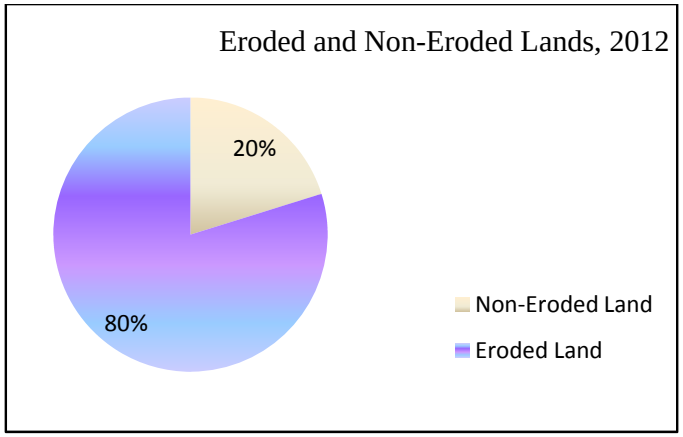


Figure 5.8: Eroded and Non-eroded land of Char Shibalaya Sheet-2 in December 2012.

(Source: Field Survey, July 2015)

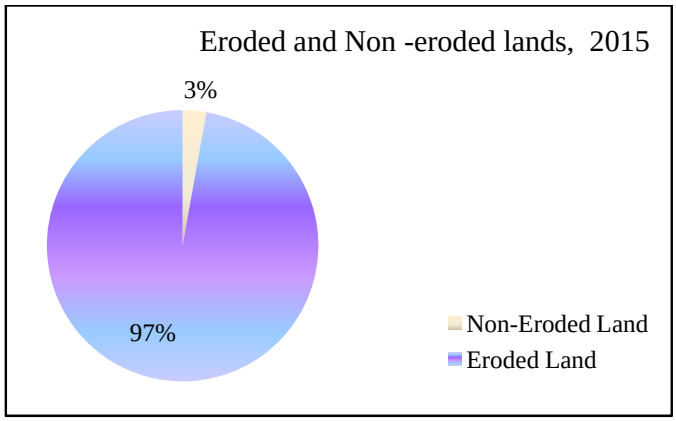
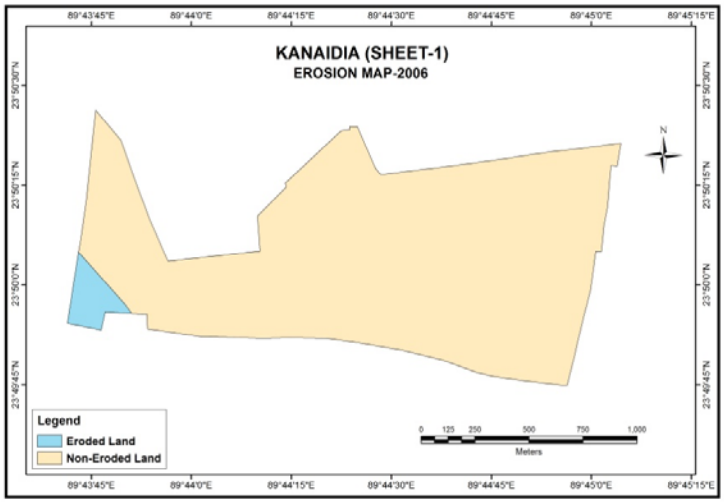


Figure 5.**9:** Eroded and Non-Eroded Land of Char Shibalaya (Sheet-2) in July, 2015.

(Source: Field Survey, July 2015)

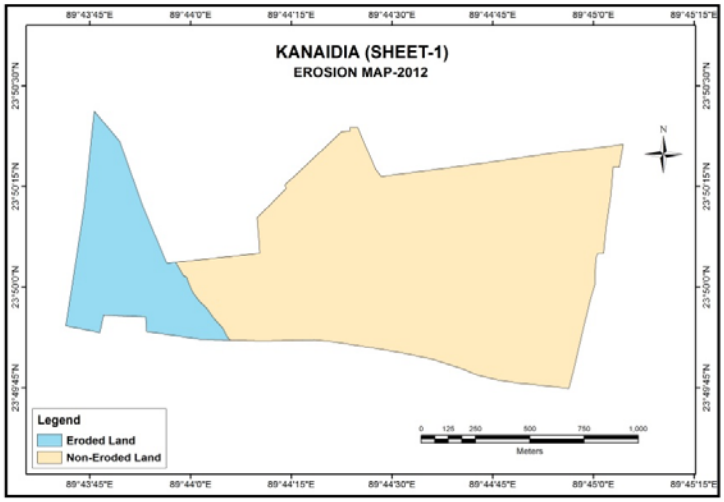
5.2.4 Eroded and Non-Eroded Lands of Kanaidia Mauza (Sheet-1)

Like other mauza sheets digitized map of eroded and non-eroded lands have been prepared. Pale tints of yellowish-orange color represent non-eroded part of the mauza sheet and blue colored part in the south-west corner of the mauza is eroded up to writing this report. According to the digitized map of eroded and non-eroded lands of Kanaidia mauza in December 2006, little erosion has been observed in the south-west corner of the mauza. In December 2006, total erosion was 13.18 acres (Khas Land 12.9 acres and riverine dweller's property 0.28 acres). Of total 421 acres of land 344.81 acres was non-eroded and 76.19 acres was eroded in December 2012. Quantitatively, 98.4 acres of eroded land and 322.36 acres of non-eroded land had been observed during field survey in July 2015.



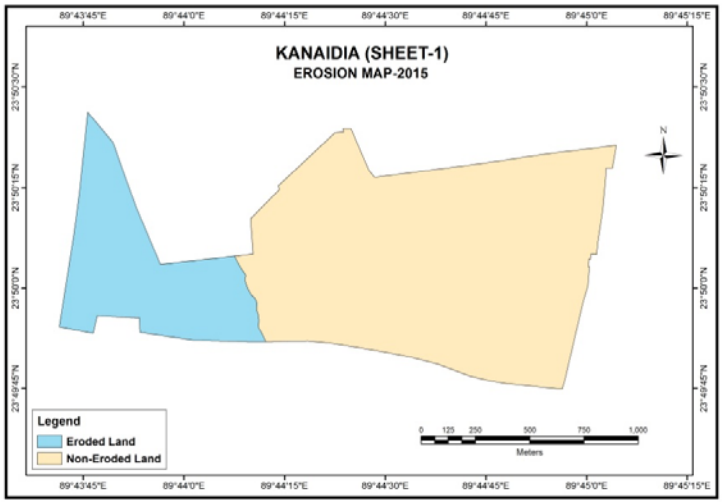
(Source: Google Earth, Compiled by the Author, 2015)

Map 5.25: Map of Eroded and Non-eroded land of Kanaidia mauza (Sheet-1) in December 2006.



(Source: Google Earth, Compiled by the Author, 2015)

Map 5.26: Map of Eroded and Non-eroded land of Kanaidia mauza (Sheet-1) in December 2012.



Map 5.27: Map of Eroded and Non-eroded land of Kanaidia mauza (Sheet-1) in July 2015

(Source: Google Earth, Compiled by the Author, 2015)

Amount of eroded and non-eroded lands of Kanaidia sheet-1 in December 2006, December 2012 and July 2015 has been shown in table 5.5.

Table 5.5: Eroded and Non-Eroded Land of Kanaidia Mauza (Sheet-1)

Total Land of Kanaidia Sheet-1 is 421 acres	Experiment time	Erosion Pattern (Area in acres)			
		Eroded		Non-Eroded	
		Area in acres	Area (%)	Area in acres	Area (%)
	December 2006	13.18	3	407.82	97
	December 2012	76.19	18	344.81	82
	July 2015	98.64	23	322.36	77

(Source: Field survey, July 2015)

In comparison with other area in this study, condition of lands is better in Kanaidia (sheet-1). In December 2006, 3% lands was eroded and 97% lands was used for different use which was then undisturbed. In December 2012, 18% area was eroded and 82% area was non-eroded. However, in July 2015, there are 23% eroded and 77% non-eroded land.

Fraction of eroded and non-eroded lands of Kanaidia (sheet-1) in December 2006, December 2012 and July 2015 has been shown in figure 5.10, 5.11 and 5.12 respectively.

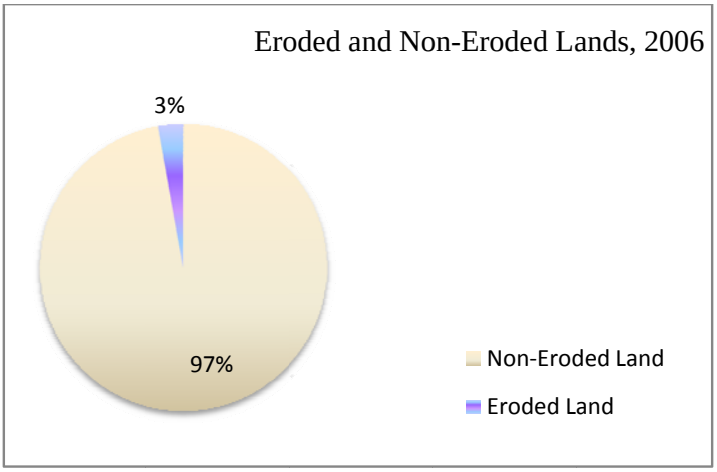


Figure 5.10: Eroded and Non-eroded land of Kanaidia Sheet-1 in December 2006.

(Source: Field survey, July 2015)

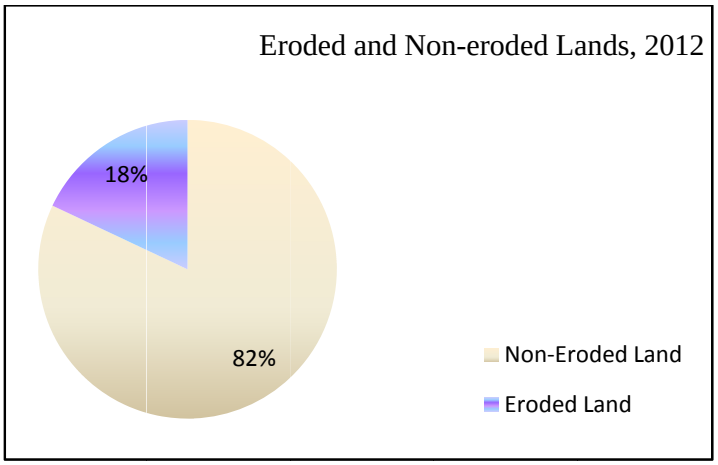


Figure 5.11: Eroded and Non-eroded land of Kanaidia (Sheet-1) in December 2012.

(Source: Field survey, July 2015)

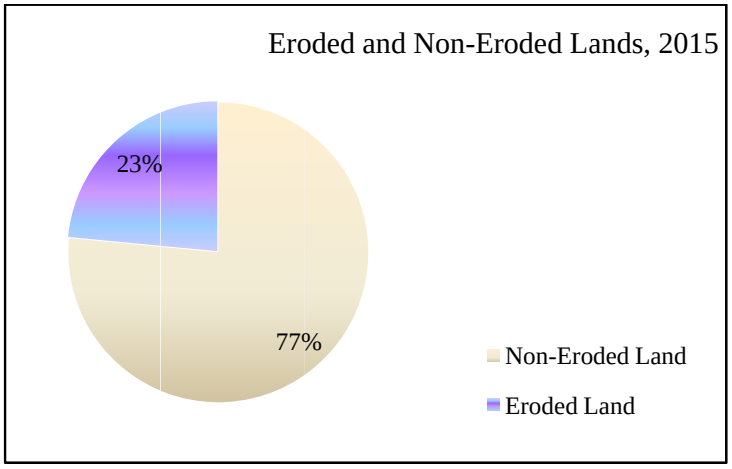
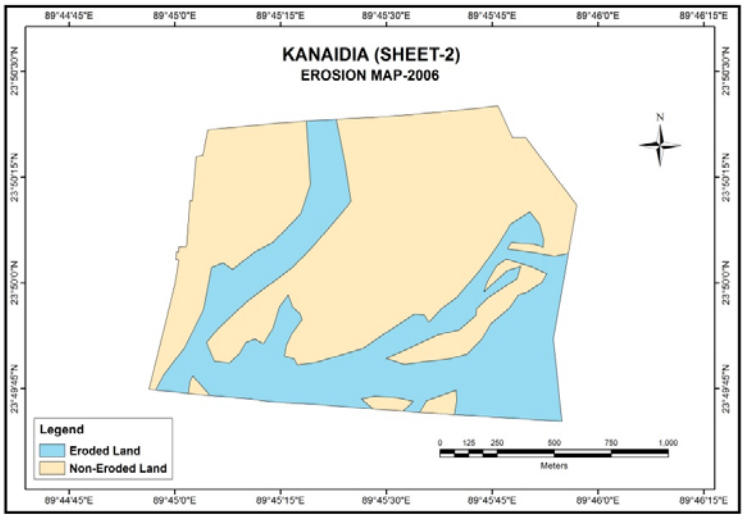


Figure 5.12: Eroded and Non-Eroded Land of Kanaidia (Sheet -1) in July 2015.

(Source: Field survey, July 2015)

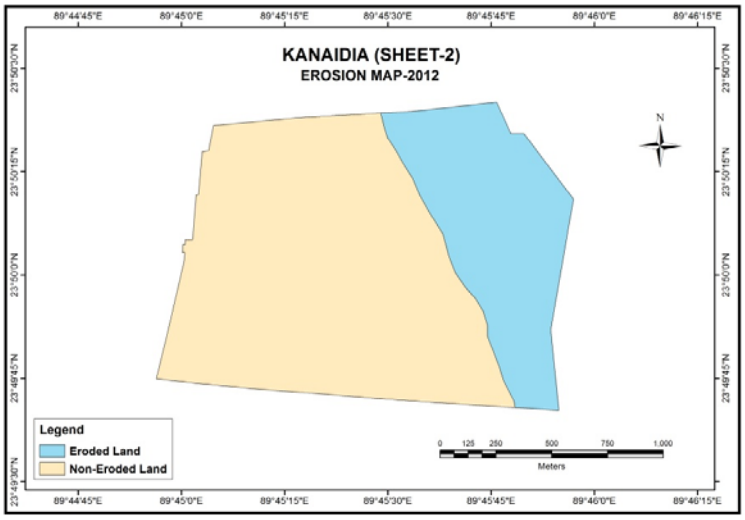
5.2.5 Eroded and Non-eroded land of Kanaidia Mauza (sheet-2)

Based on Google Earth Imagery of Kanaidia sheet-2 of December 2006, December 2012 and July 2015, digitized maps of eroded and non-eroded lands of this mauza sheet have been prepared. Pale tints of yellowish-orange color represents non-eroded land whereas, blue color indicates eroded lands which have been shown in Digitized Map 5.28, 5.29 and 5.30. By analyzing these digitized maps eroded and non-eroded lands of this mauza sheet have been determined.



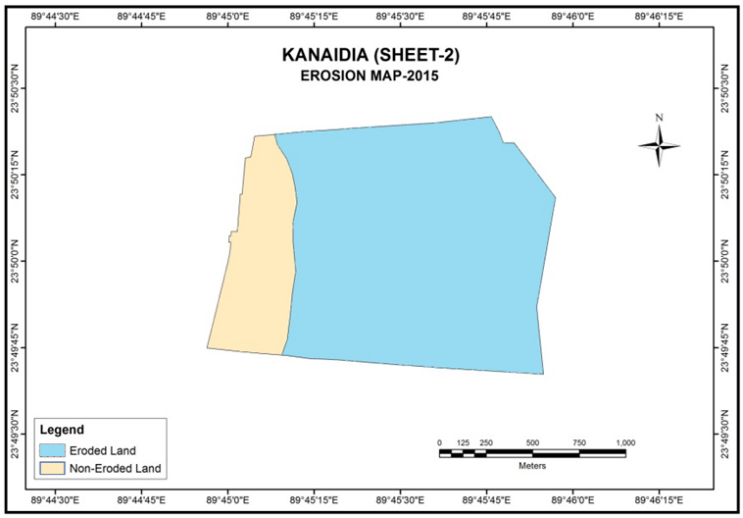
Map 5.28: Map of Eroded and Non-Eroded Land of Kanaidia mauza (Sheet-2) in December, 2006.

(Source: Google Earth, Compiled by the Author, 2015)



Map 5.29: Map of Eroded and Non-Eroded Land of Kanaidia Mauza (Sheet-2) in December 2012.

(Source: Google Earth, Compiled by the Author, 2015)



Map 5.30: Map of Eroded and Non-Eroded Land of Kanaidia Mauza (Sheet-2) in July 2015.

(Source: Google Earth, Compiled by the Author, 2015)

According to calculated value, of the total 471.4 acres of land 200 acres was eroded where as 271.4 acres was non-eroded in December 2006. In December 2012, quantitatively, 321.40 acres was non-eroded and 154 acres was eroded lands. In July 2015, 386.80 acres was eroded and the remaining 84.60 acres was non-eroded lands. These have been shown in table 5.6.

Table 5.6: Eroded and non-eroded land of Kanaidia mauza (Sheet-2)

Total Land of Kanaidia Sheet-2 is 471.40 acres	Experiment time	Erosion Pattern (Area in acres)			
		Eroded		Non-Eroded	
		Area in acres	Area (%)	Area in acres	Area (%)
	December 2006	200	42.43	271.40	57.57
	December 2012	154	32.67	321.40	67.33
	July 2015	386.80	82	84.60	18

(Source: Field survey, July 2015)

In December 2006 distributions of eroded and non-eroded lands was 42.43% and 57.57%, in December 2012, 32.67% and 67.33%, in July 2015, 82.05% and 17.95% which have been shown in Figure 5.13, 5.14 and 5.15.

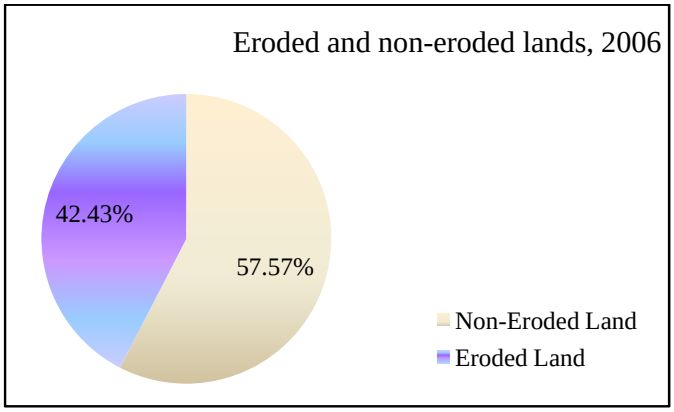


Figure 5.13: Eroded and non-eroded land of Kanaidia (Sheet-2), in December 2006.

(Source: Field survey, July 2015)

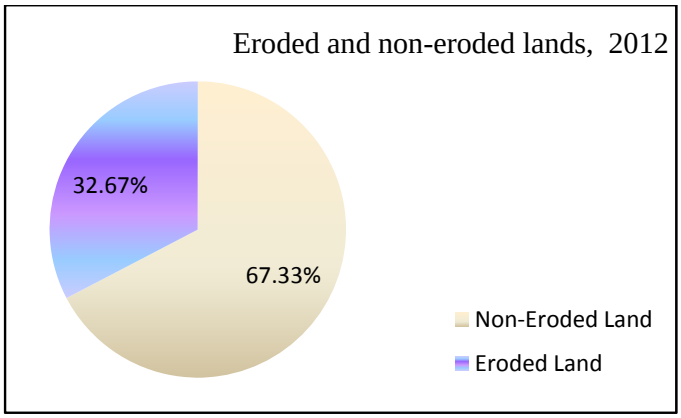


Figure 5.14: Eroded and non-eroded land of Kanaidia (Sheet-2) in December 2012.

(Source: Field survey, July 2015)

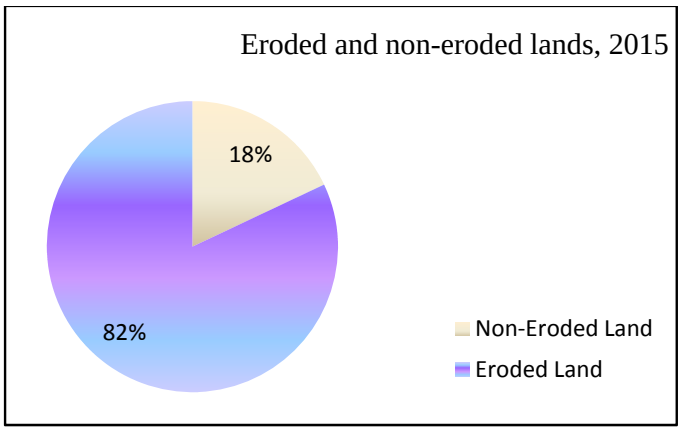


Figure 5.15: Eroded and non-eroded lands of Kanaidia (Sheet-2) in July 2015

(Source: Field Survey, July 2015)

5.3 Mauza Sheet Wise Selected Features form Overall Field Context

For details study of an area, understanding of its physical and cultural features is indispensable. Physical features indicate natural states of that particular area such as existence of river, swampy area, khals, bills, natural forest, hills etc. Whereas, manmade features such as agricultural crops, homestead vegetation, ponds, schools, college, roads etc are cultural features. Although current study area is very small, only 7.2 square kilometers, there is a diversified physical and cultural variation in different times, both due to natural and human interventions.

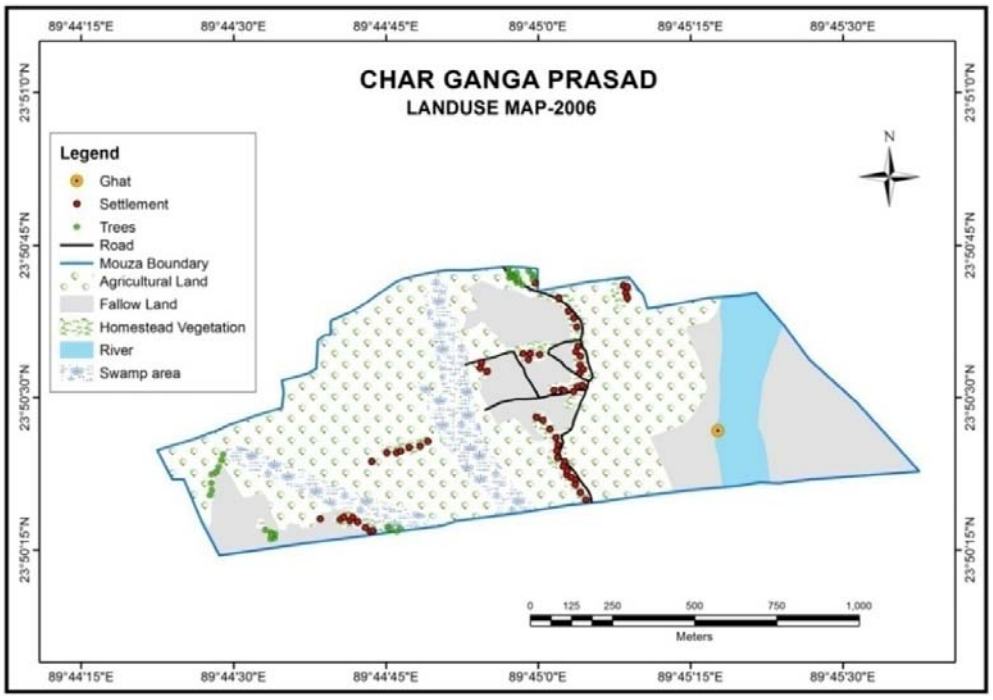
5.3.1 Physical and Cultural Features of Char Ganga Prasad Mauza

For observing the land use pattern of the study area GIS techniques and micro-soft excel have been used. For development of database on physical and cultural features or land use, a series of maps and data have been prepared depending on Google earth imagery of the study area, ArcGIS 10.2.1, ArcView GIS 3.3 and Microsoft excel software. Based on availability of Google Earth imagery the author has selected three time period imagery for detail study of mauza sheets.

Digitized land use maps of Char Ganga Prasad have been prepared for December 2006, December 2012 and July 2015 which have been shown in Map 5.31, 5.32 and 5.33. Close observation of digitized land use maps of Char Ganga Prasad mauza in January 2013 and July 2015 give a clear picture of significant physical and cultural change in the area of this sheet that has occurred during the period of January 2007 to July 2015. It is noticeable that land use map of July 2015 has been prepared based on the de-facto image of 29 March, 2014 and field survey July, 2015.

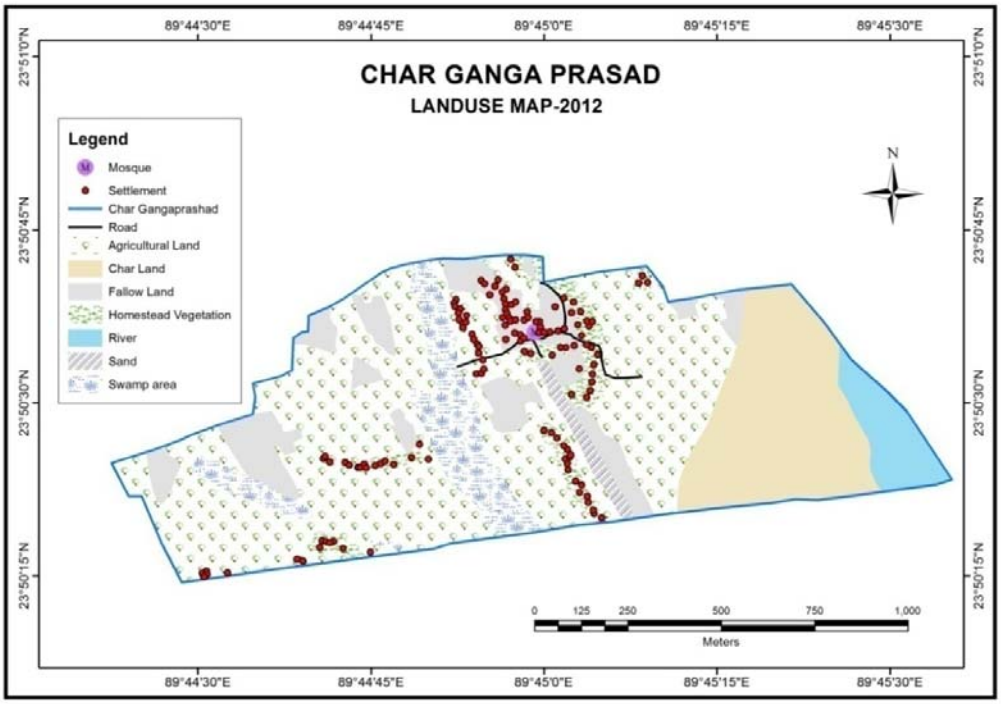
Total land area of this mauza is 273 acres. In December 2006 ‘major portion of the lands i.e. 141 acres were used for agricultural purpose. In the mid western part of the mauza sheet there was 26.30 acres low lying swampy area locally known as “Jula” which was used for Boro rice cultivation during Rabi dry season. 14.40 acres had been used as settlement and homestead vegetation, 72.40 acres area was fallow land and the rest 18.90 acres was occupied by the river Jamuna.

In December 2012, density of population and extent of settlement has increased in comparison with December 2006. In 2006, all the settlement was confined in 27 plots but up to December 2012, the number of plots used for settlement was 43. Amount of agricultural land and homestead vegetation remains more or less unchanged. Fallow land has decreased.



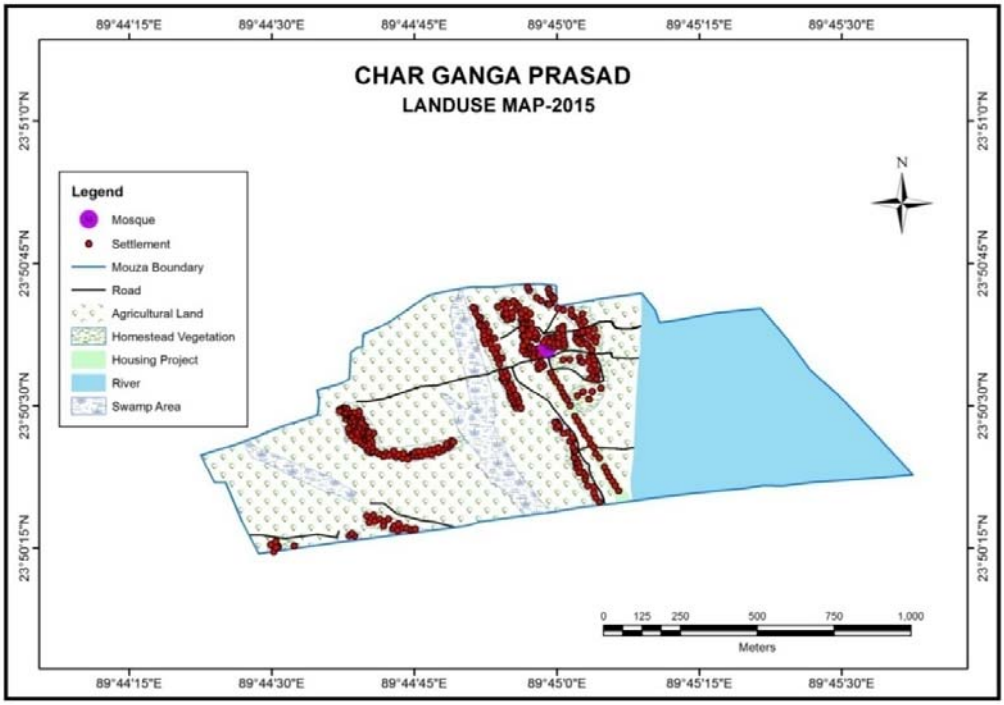
(Source: Google Earth, Compiled by the Author, 2015)

Map 5.31: Digitize map of physical and cultural features of lands of Char Ganga Prasad mauza in December 2006.



(Source: Google Earth, Compiled by the Author, 2015)

Map 5.32: Digitize map of physical and cultural features of land of Char Ganga Prasad mauza in December 2012.



(Source: Google Earth, Compiled by the Author, 2015)

Map 5.33: Digitize map of physical and cultural features of land of Char Ganga Prasad mauza in July 2015.

In the mid-western part of the mauza there was some low lying swampy area locally known as "Jula" remained unchanged and was used for Boro cultivation during Rabi dry season.

The most eye-catching change occurred in plot 138. This plot had been developed and raised with soil to build an Ashrayan project for riverbank erosion displacees.

In July, 2015, an Ashrayan project (Residence Project) locally known as "Ashroy Kendro" is the special and new cultural feature in this year.

Physical and cultural features are a good indicator to reflect the socio-economic and livelihood conditions of an area. In 2012 agricultural land was 138.94 acres. In 2015 total agricultural land is 124.60 acres which is 10% less than 2012. Settlement and homestead vegetation has been doubled, swamp area has decreased by 20% but extent of river is nine fold greater than 2012 because of extreme river erosion in 2014 and 2015.

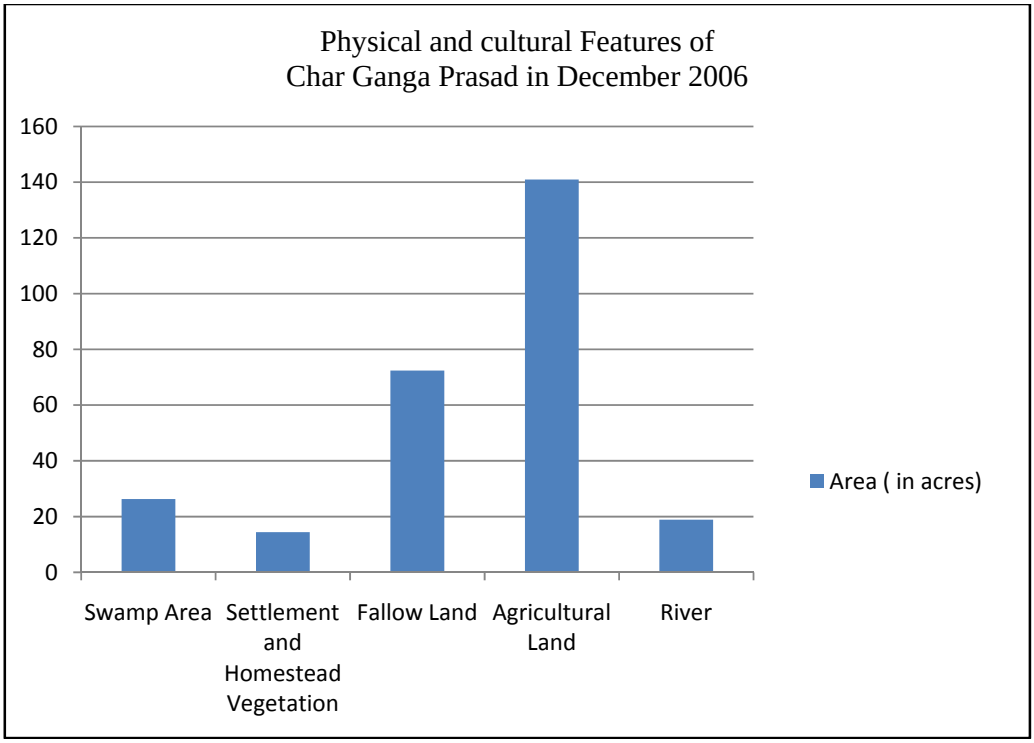
Comparative value of different use of land area of Char Ganga Prasad mauza by December 2006, December 2012 and July 2015 in 2015 has been shown table 5.7.

Table 5.7: Physical and cultural features of lands of Char Ganga Prasad Mauza

Time	Features	Area (in acres)
December,2006	Agricultural Land	141.00
	Settlement and Homestead Vegetation	14.40
	River	18.90
	Swamp Area	26.30
	Fallow Land	72.40
December,2012	Agricultural Land	138.94
	Homestead Vegetation	14.31
	River	11.10
	Char Land	46.90
	Swamp Area	22.30
	Sand	3.65
	Fallow Land	35.80
July, 2015	Agricultural Land	124.60
	Housing Project/ Abason Prokolpo	5.00
	Settlement and Homestead Vegetation	30.58
	Swamp Area	18.18

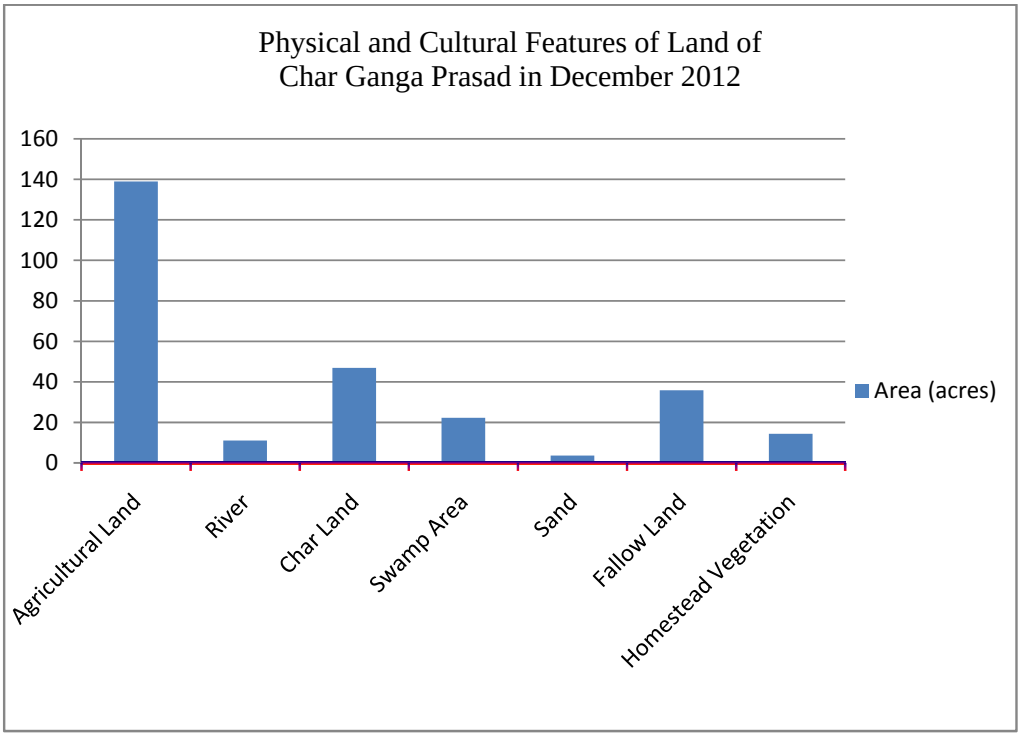
(Source: Field Survey, 2015)

Again, distribution of Physical and cultural features of lands of Char Ganga Prasad mauza by December 2006, December2012 and July 2015 have been plotted in figure 5.16, 5.17 and 5.18 respectively.



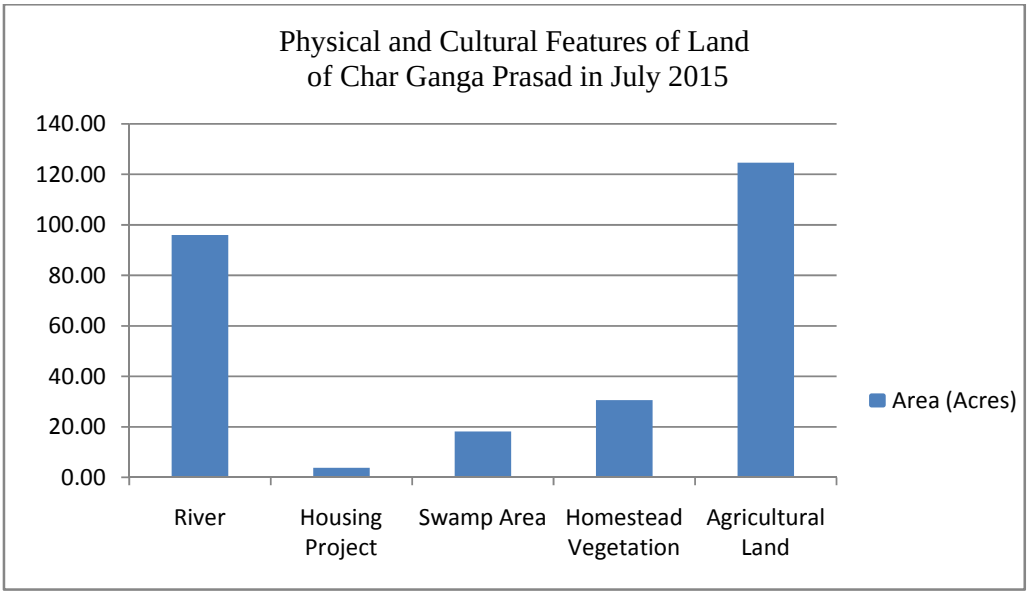
(Source: Field Survey, 2015)

Figure 5.16: Physical and cultural features of lands of Char Ganga Prasad in December 2006.



(Source: Field Survey, 2015)

Figure 5.17: Physical and cultural features of lands of Char Ganga Prasad in December 2012.



(Source: Field Survey, 2015)

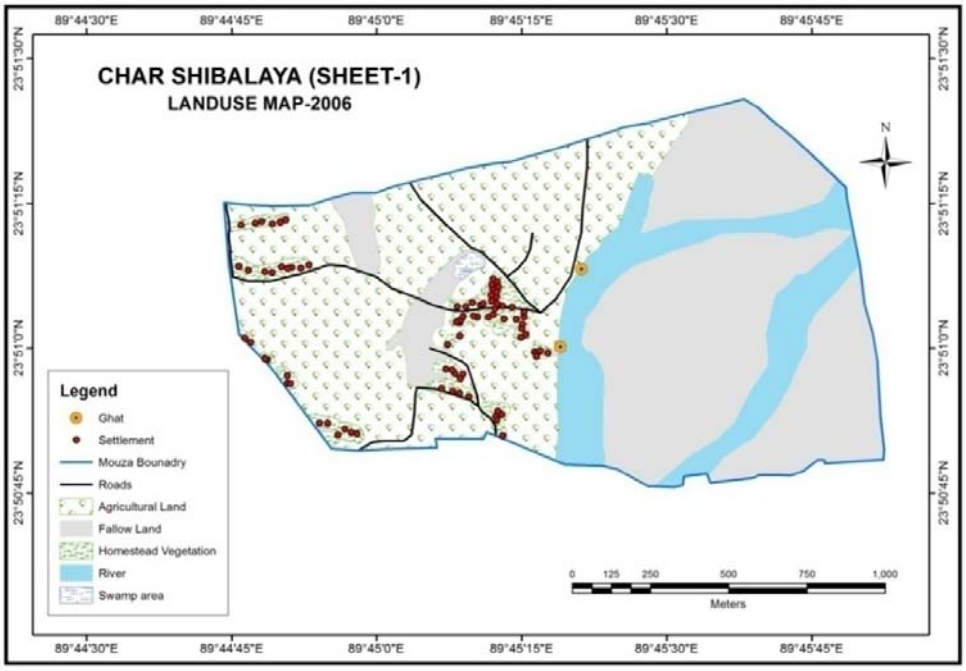
Figure 5.18: Physical and cultural features of Char Ganga Prasad in July 2015.

5.3.2 Physical and cultural features of Char Shibalaya mauza (Sheet-1)

Physical and cultural features or land use map of the Char Shibalaya mauza (sheet-1) for December 2006, December 2012 have been compiled on the basis of Astrium image but land use map for July 2015, Astrium image and field survey data have been used to compiled it.

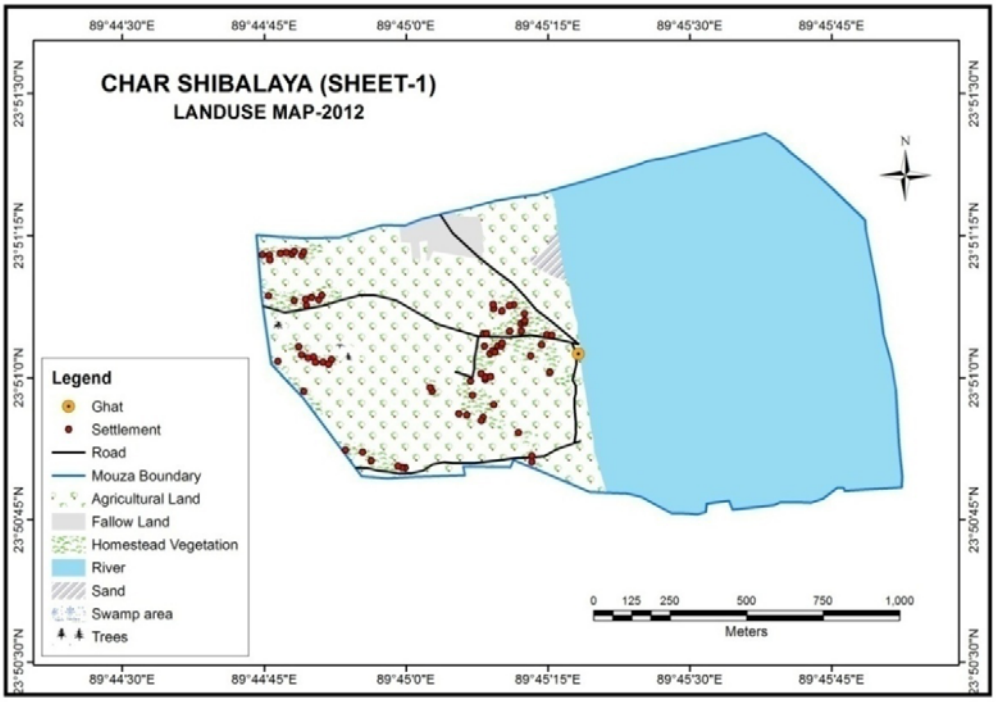
By 2006 about 176 acres was newly accreted sandy soils which were not used for agriculture or any other purpose, that's why it has been shown in the map as fallow land. The next highest amount, about 172 acres of lands had been recorded as agricultural lands. The lands used for agricultural purpose was very fertile and productive. For this reason in spite of repeated riverbank erosion, the people do not want to leave this place and living here decade after decade with their combined families. As this mauza sheet is adjacent to the Jamuna, settlement area is comparatively less than its closest neighborhood Char Ganga Prasad. Very small amount only 1.22 acres of land was swampy area and used for agriculture and keeping boats in the dry season. The third highest amount, 58.36 acres of land was in the river.

In December 2012, comparison with 2006 agricultural lands has reduced 20% with a net amount of 144.12 acres. All the accreted lands shown as fallow lands in 2006 have been eroded widening the area of river. The river Jamuna engulfed about 248 acres of lands from its 428 acres of lands. Percentage wise about 58% land of this mauza was in the river. Settlement and vegetative area increased by 25%.



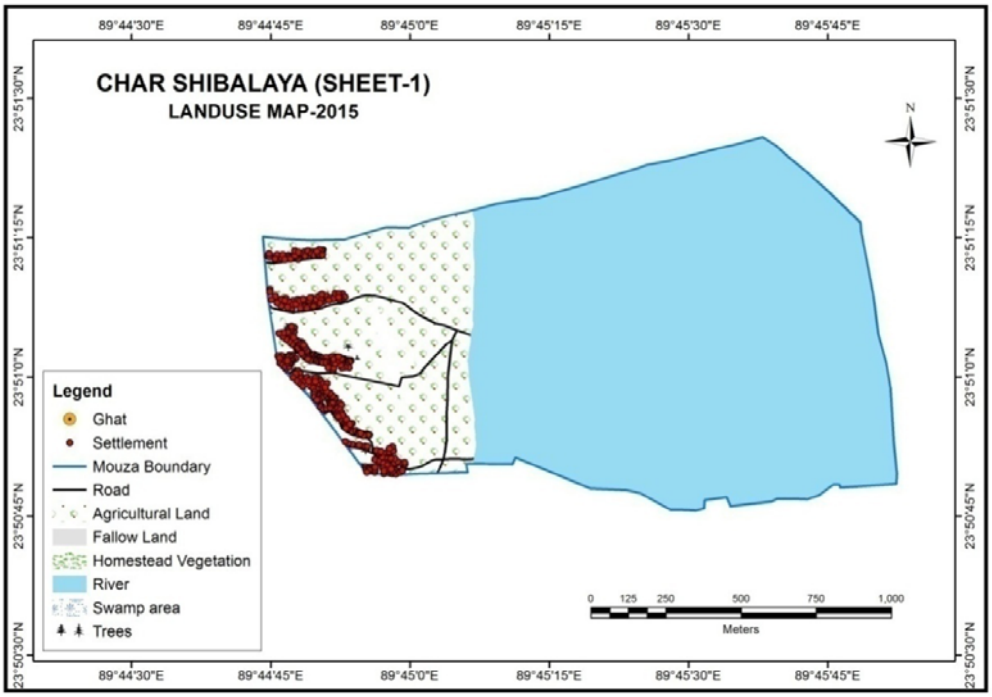
(Source: Google Earth, Compiled by the Author, 2015)

Map 5.34: Digitize map of physical and cultural features of land of Char Shibalaya mauza (Sheet -1) in 2006.



(Source: Google Earth, Compiled by the Author, 2015)

Map 5.35: Digitize map of physical and cultural features of land of Char Shibalaya mauza (sheet-1) in December 2012.



(Source: Google Earth, Compiled by the Author, July 2015)

Map 5.36: Digitize map of physical and cultural features of land of Char Shibalaya mauza (sheet-1) in July 2015.

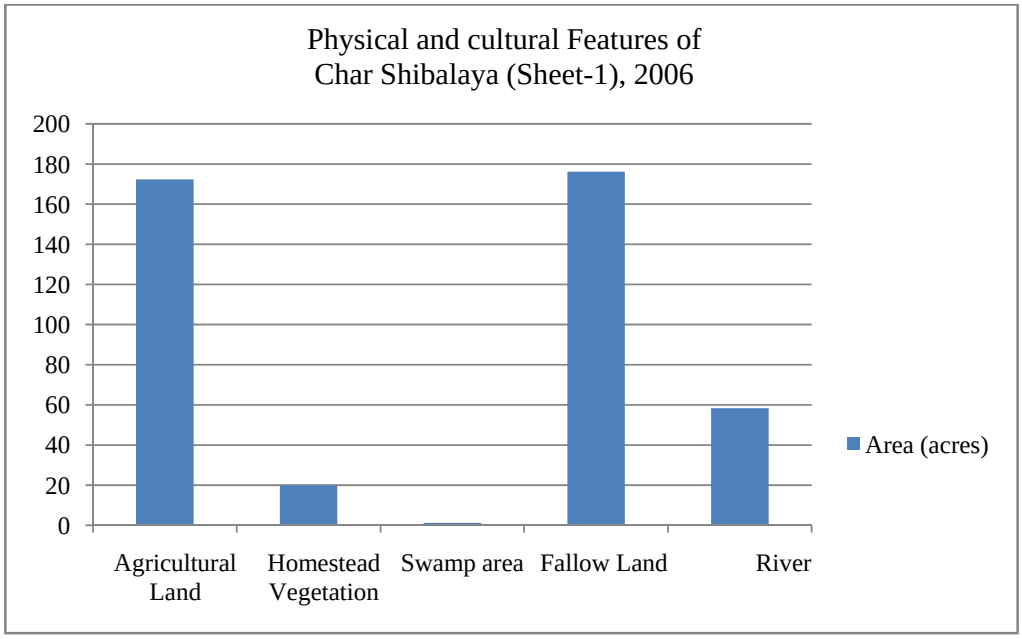
The physical features of this mauza have been drastically changed in July 2015 than the Astrium view of December 2012. By May 2015 a large settlement area has been eroded. Newly eroded area within the period of two and half years is about 50 acres.

Details land use of this mauza sheet in December 2006, December 2012 and July 2015 has been shown in table 5.8 and figure 5.19-5.21.

Table 5.8: Physical and cultural features of Char Shibalaya mauza (sheet-1)

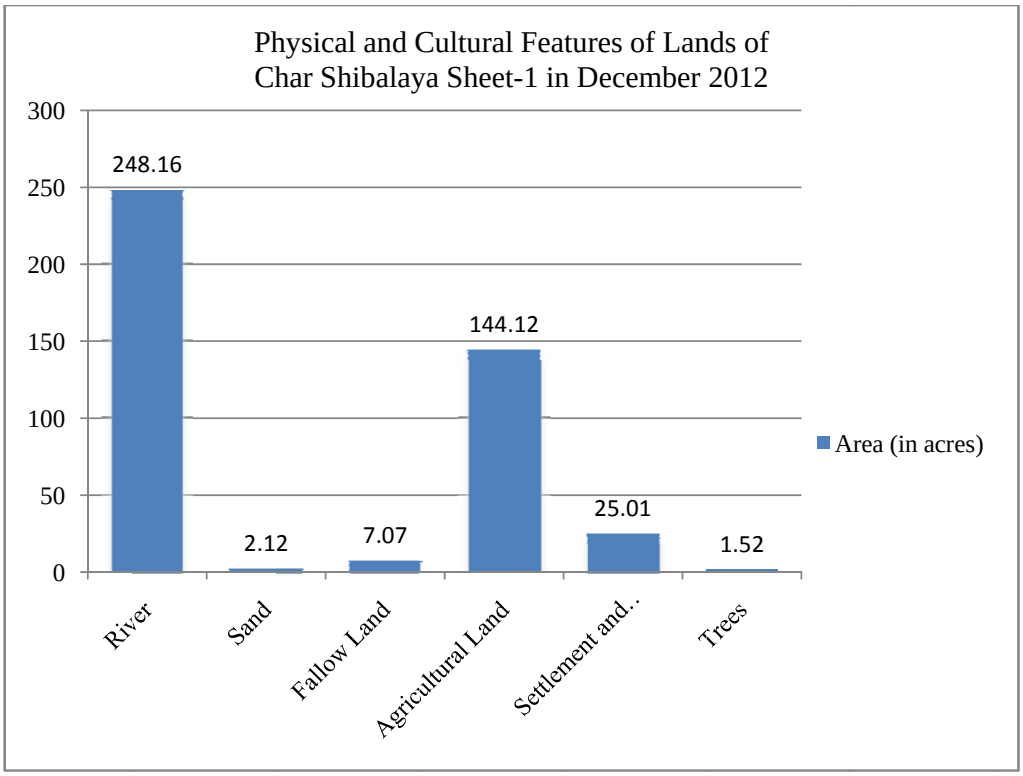
Time	Features	Area (acres)
December, 2006	Agricultural Land	172.34
	Homestead Vegetation	19.95
	Swamp area	1.22
	Fallow Land	176.13
	River	58.36
December, 2012	Agricultural Land	144.12
	Settlement and Homestead Vegetation	25.01
	Trees	1.52
	Sand	2.12
	Fallow Land	7.07
	River	248.16
July,2015	Agricultural Land	74.81
	Homestead Vegetation	16.79
	Swamp Area	3.46
	River	332.94

(Source: Field Survey, 2015)



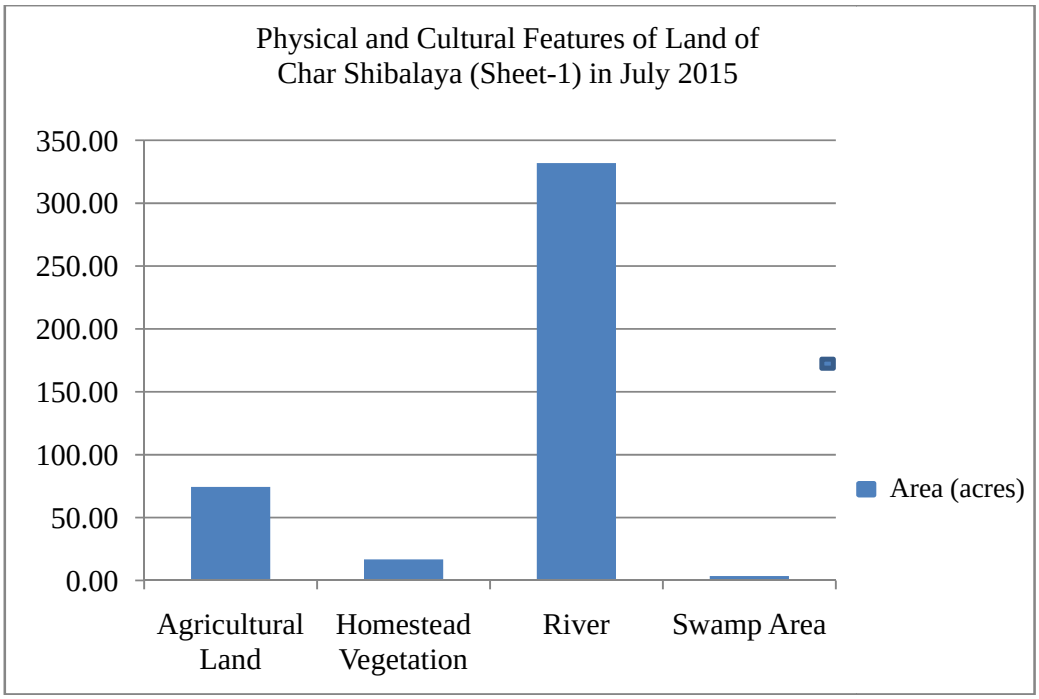
(Source: Field Survey, 2015)

Figure 5.19: Physical and cultural features of Char Shibalaya mauza (sheet-1) in December 2006.



(Source: Field Survey, 2015)

Figure 5.20: Physical and cultural features of Char Shibalaya sheet-1 in December, 2012.



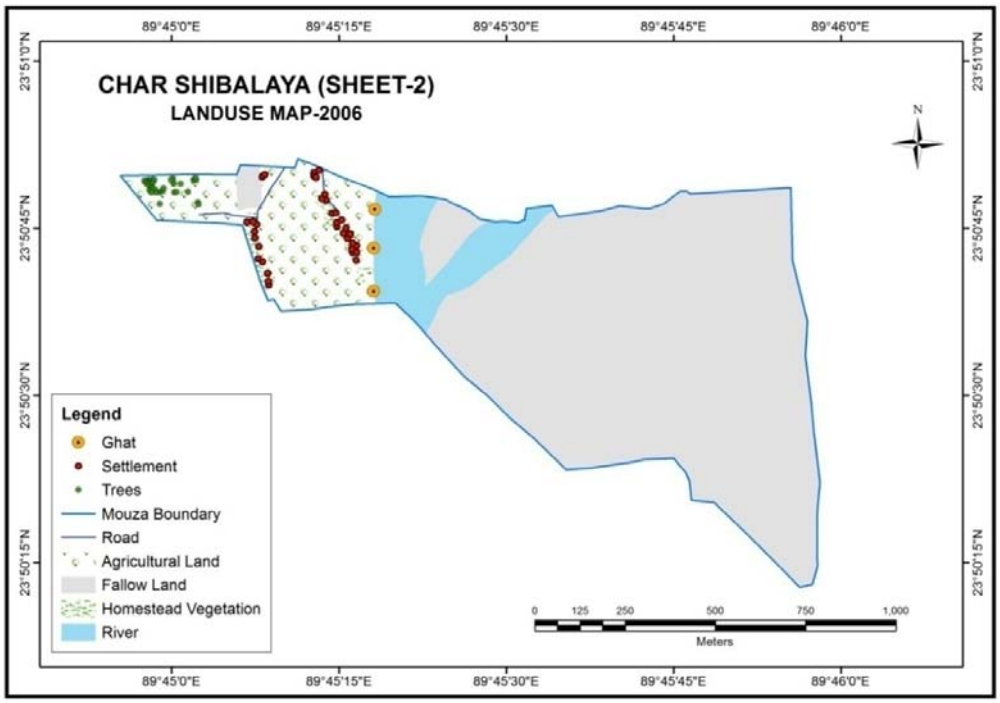
(Source: Field Survey, 2015)

Figure 5.21: Physical and cultural features of Char Shibalaya sheet-1 in July 2015.

5.3.3 Physical and Cultural features of Char Shibalaya Mauza (Sheet-2)

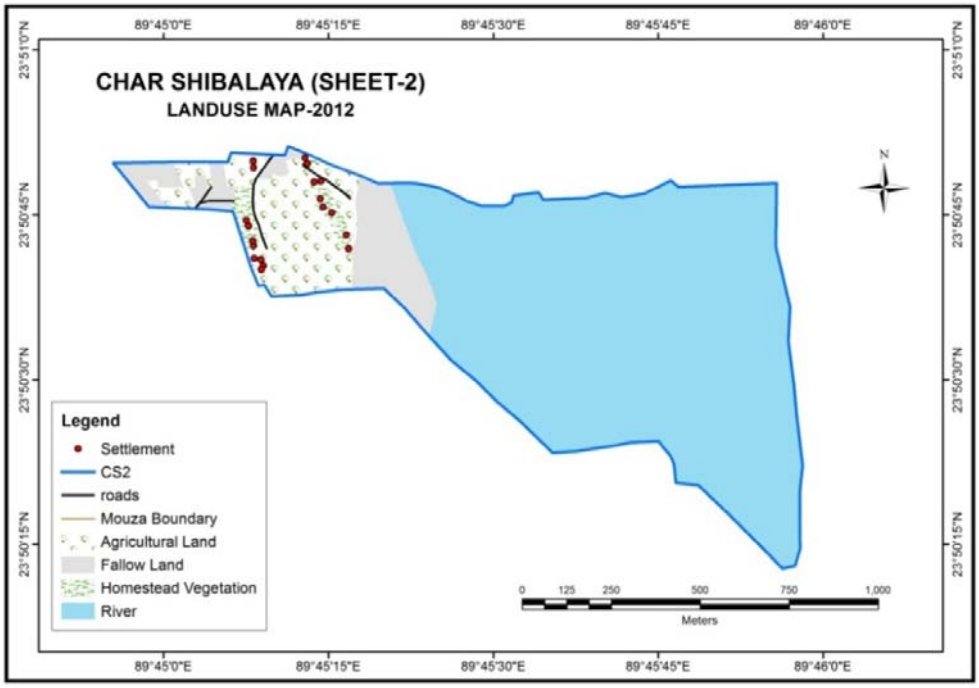
In 2006**,** very little amount of land only 30.84 acres and 4.53 acres of this mauza sheet was suitable for agriculture and settlement unless there was flood. 166.46 acres was newly accreted sandy lands which was not suitable for crops had been shown as fallow land in the digitized land use map. During Rabi monsoon it was used for Boro rice cultivation. Some area was suitable for groundnut cultivation. In 2012, of the 220 acres of land Char Shibalaya only 4.69 acres was used for settlement and homestead vegetation, about 24.51 acres was used as agricultural lands while 171.28 acres was in the river bed. 19.52 acres was fallow land.

Land use pattern of Char Shibalaya mauza (sheet-2) in July 2015 is very frustrating. Lion share of the land of this mauza is in the river bed. The vast area with light blue colored area is in the river. The inhabitants of this mauza do not get the major benefit from this eroded river bed area in exchange of their lost lands. Riverine area is used for fishing and navigation purpose. However, it is mentionable that this riverine portion holds little water in the dry season, which favors them to cultivate rice in this inundated area. Light blue spotted area represents agricultural land. Small sized, branch of vine shaped red part of the western sides of the mauza represents settlement area. Black line in the settlement and agricultural area represents village walk way. Digitized map of physical and cultural features of Char Shibalaya mauza (sheet-2) have been shown in the digitize maps 5.37, 5.38 and 5.39.



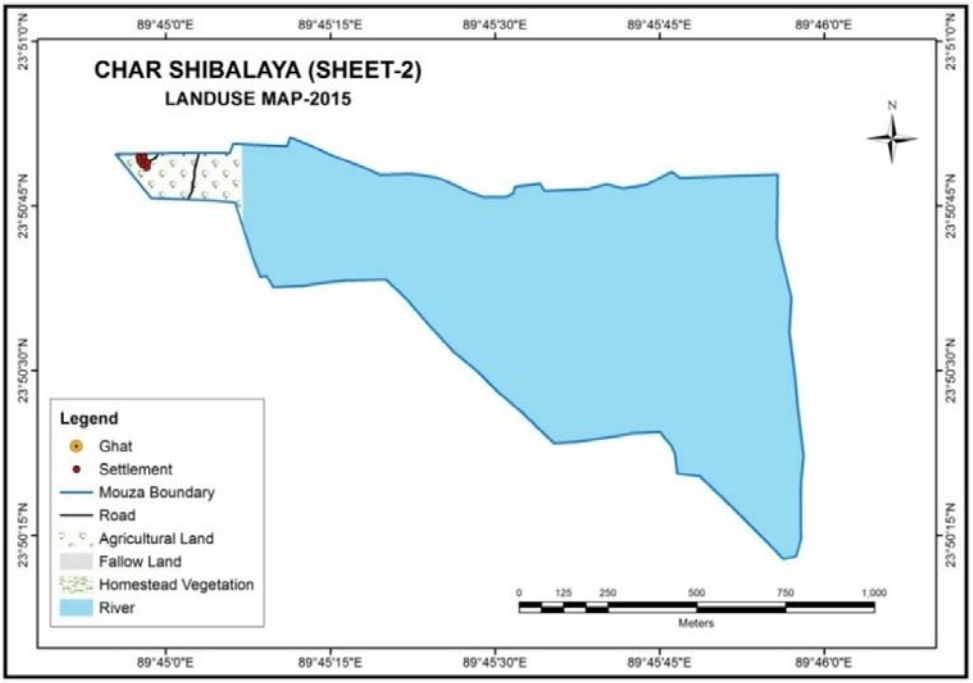
(Source: Google Earth, Compiled by the Author, 2015**)**

Map 5.37: Digitize map of physical and cultural features of land of Char Shibalaya mauza (sheet-2) in December 2006.



(Source: Google Earth, Compiled by the Author, 2015**)**

Map 5.38: Digitize map of physical and cultural features of land of Char Shibalaya mauza (sheet-2) in December 2012.



(Source: Google Earth, Compiled by the Author, 2015)

Map 39: Digitize map of physical and cultural features of land of Char Shibalaya mauza (Sheet-2) in July 2015.

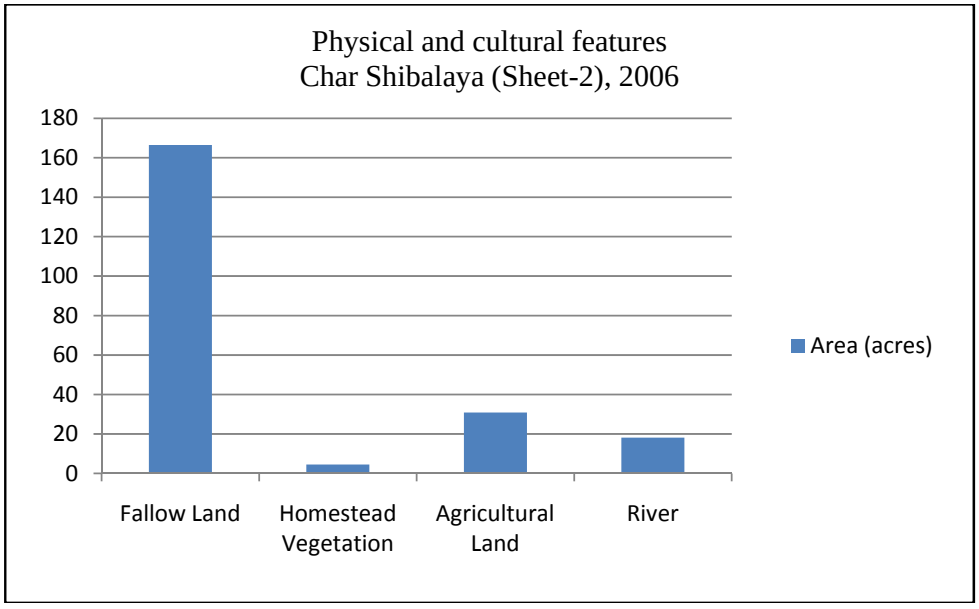
Quantitative analysis of land use of Char Shibalaya mauza (Sheet-2)

Of the 220 acres of land of Char Shibalaya mauza (sheet-2) only 0.42 acres is used for settlement and homestead vegetation, about 5.58 acres is used as agricultural lands while 214 acres is in the river bed. Quantitative distribution of land use pattern of Char Shibalaya sheet-2 for December 2006, December 2012 and July 2015 has been shown in table 5.09 and figure 5.22-5.24.

Table 5.09: Physical and cultural features of land of Char Shibalaya (sheet-2)

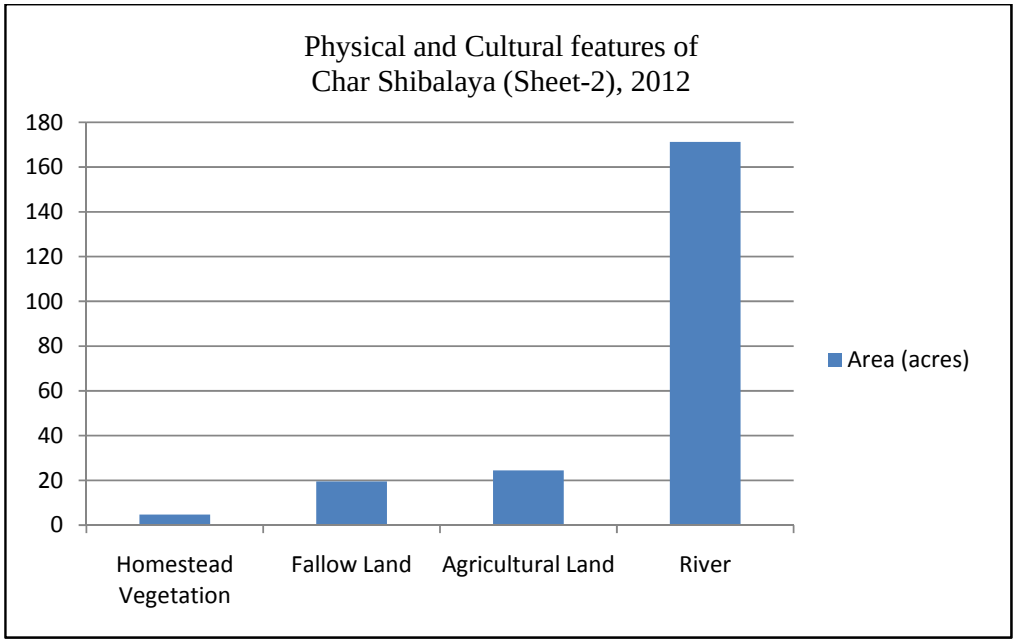
Time	Features	Area (acres)
December, 2006	Agricultural Land	30.84
	Settlement and Homestead Vegetation	4.53
	Fallow Land	166.46
	River	18.17
December, 2012	Agricultural Land	24.51
	Homestead Vegetation	4.69
	Fallow Land	19.52
	River	171.28
July,2015	Agricultural Land	5.58
	Homestead Vegetation	0.42
	River	214

(Source: Field Survey, 2015)



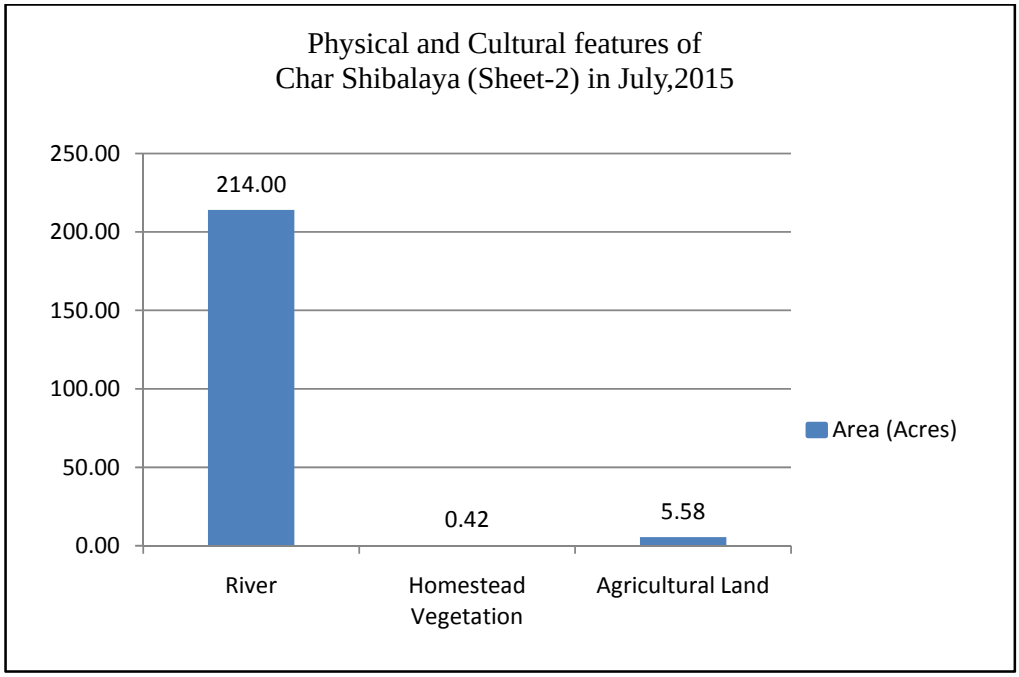
(Source: Field Survey, 2015)

Figure 5.22: Physical and cultural features of land of Char Shibalaya (sheet-2) in December 2006.



(Source: Field Survey, 2015)

Figure 5.23: Physical and cultural features of land of Char Shibalaya (Sheet-2) in December 2012.



(Source: Field Survey, 2015)

Figure 5.24: Physical and cultural features of land of Char Shibalaya (sheet-2) in July 2015.

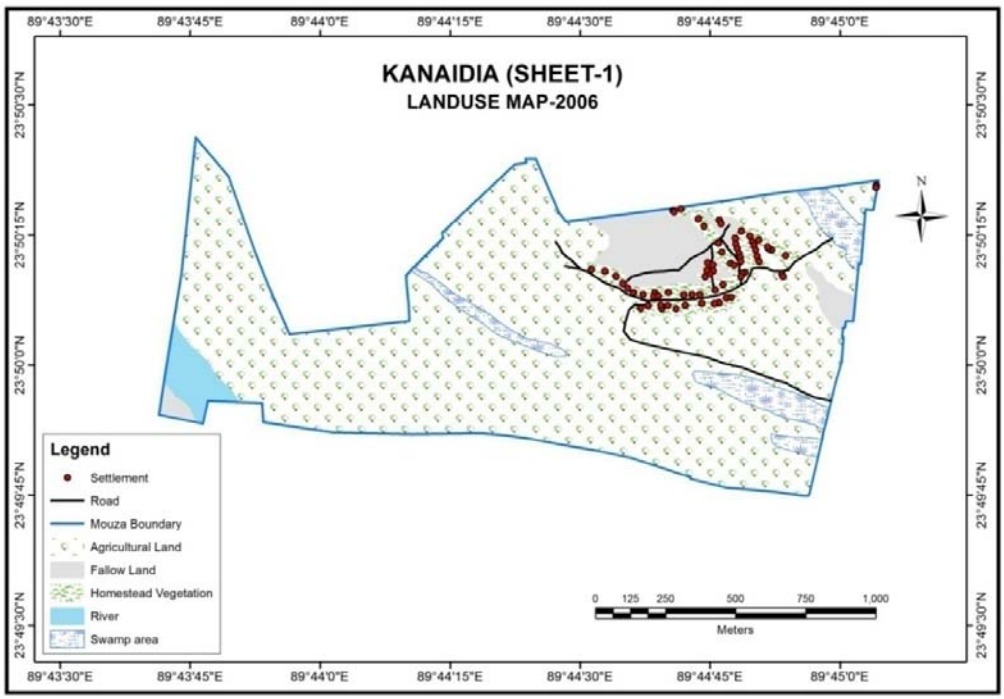
5.3.4 Physical and cultural features of lands of Kanaidia mauza (Sheet-1)

Total land area of this mauza sheet is 421 acres, of which 340.23 acres was agricultural land, A very insignificant amount only 20.72 acres used for settlement purpose, 28.61 acres fallow lands, 22.14 acres swampy lands and 9.30 acres was in the river in December 2006.

In December 2012 there were 240.30 acres of agricultural land. A very insignificant amount only 27.26 acres was used as homestead vegetation, 22.72 acres was swamp area, 32.53 acres fallow land, 20.00 acres sands and 78.11 acres was in the river.

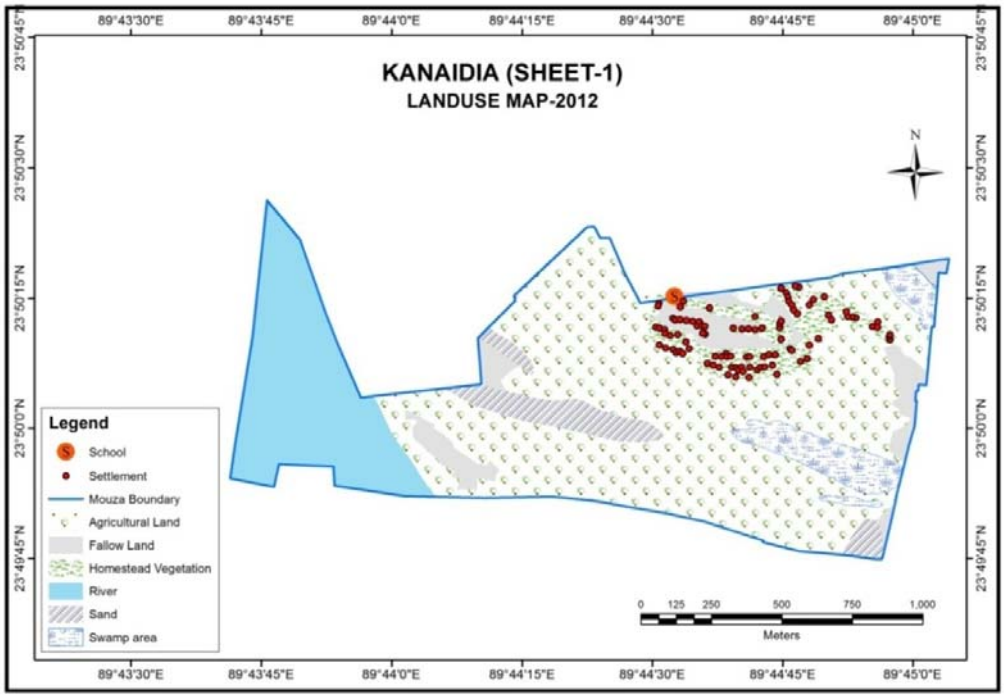
In July 2015, of the total 421 acres of lands of this mauza, 275.38 acres is agricultural land. A very insignificant amount only 28.06 acres is used for homestead vegetation and settlement (Homestead, Mosque, School, Club), 1.26 acres fallow lands, 17.22 acres swamp land and a considerable portion, 99.08 acres is in the river.

Digitize map of features of lands of Kanaidia mauza (sheet-1) in December 2006, December 2012 and July 2015 has been given in map 5.40, 5.41 and 5.42 respectively.



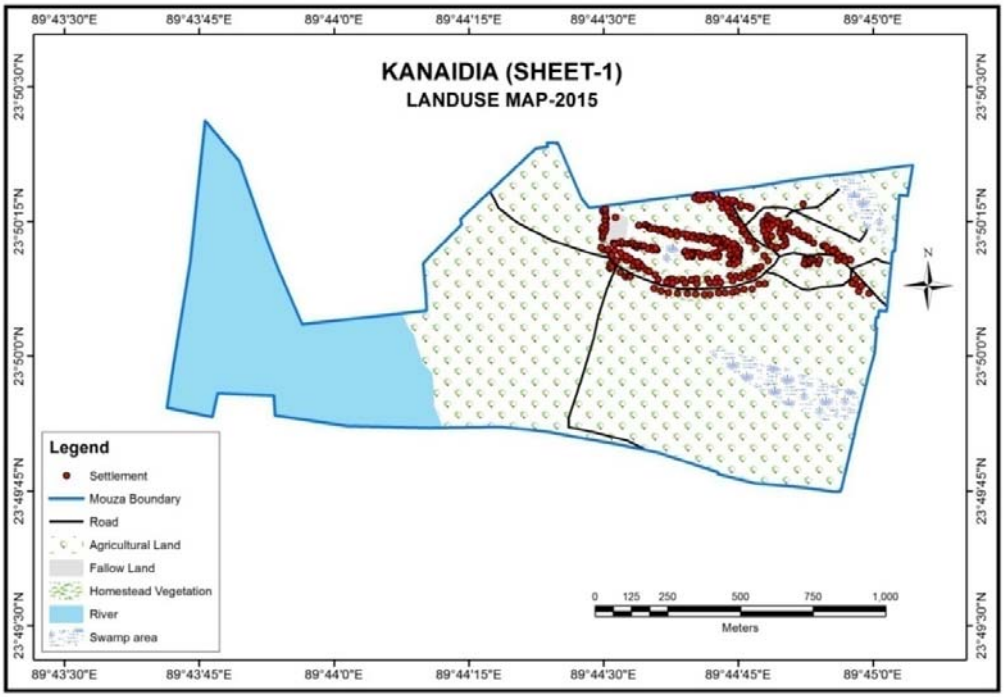
(Source: Google Earth, Compiled by the Author, 2015)

Map 5.40: Digitization of physical and cultural features of lands of Kanaidia mauza (Sheet-1) in December 2006.



(Source: Google Earth, Compiled by the Author, 2015)

Map 5.41: Digitization of physical and cultural features of lands of Kanaidia mauza (Sheet-1) in December 2012.



(Source: Google Earth, Compiled by the Author, 2015)

Map 5.42: Digitization of physical and cultural features of lands of Kanaidia mauza (Sheet-1) in July 2015.

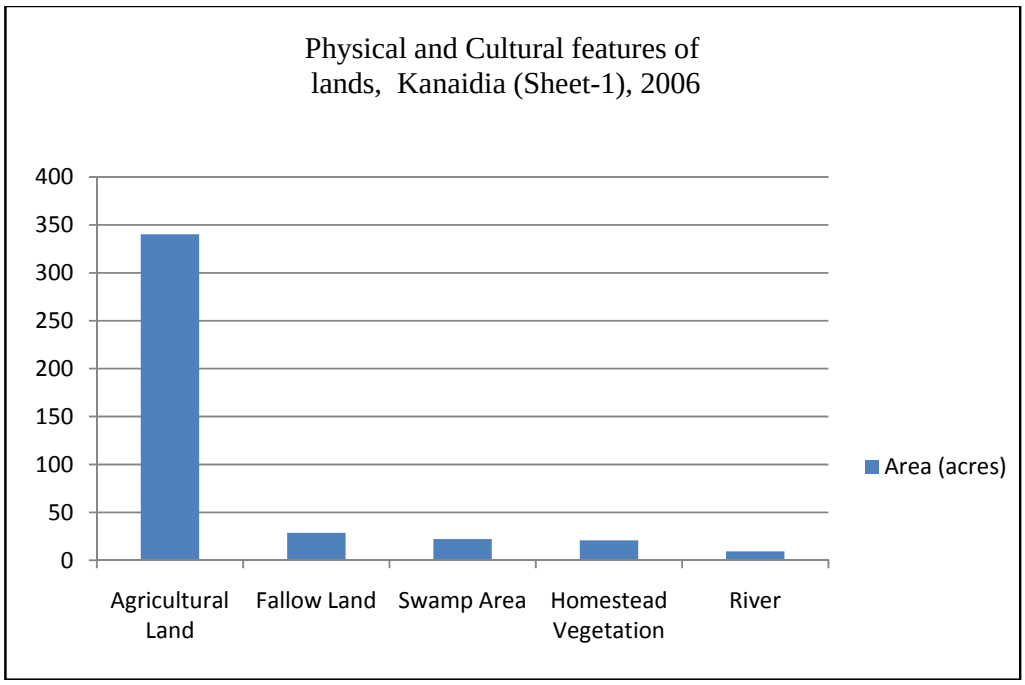
Land Use Pattern

Details physical and cultural features of lands of this sheet of Kanaidia mauza has been shown in table 5.10 and figure 5.25-5.27.

Table 5.10: Physical and cultural features of lands of Kanaidia mauza (Sheet-1)

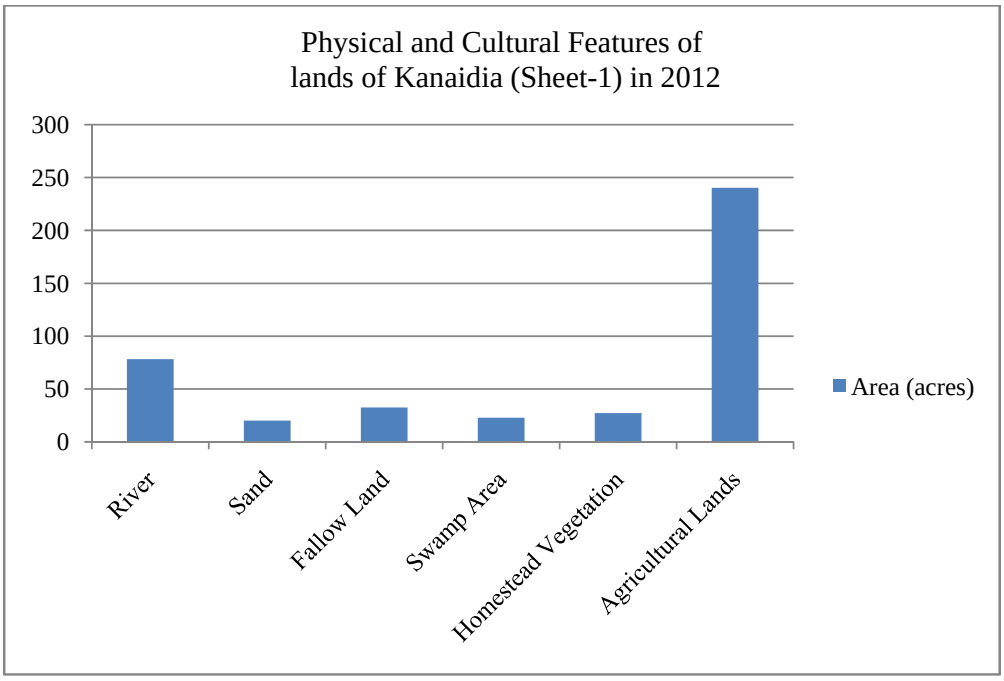
Time	Features	Area (acres)
December, 2006	Agricultural Land	340.23
	Homestead Vegetation	20.72
	Swamp Area	22.14
	Fallow Land	28.61
	River	9.3
December, 2012	Agricultural Land	240.30
	Homestead Vegetation	27.26
	Swamp Area	22.72
	Fallow Land	32.53
	Sand	20.08
	River	78.11
July,2015	Agricultural land	275.38
	Homestead vegetation and settlement	28.06
	Swamp area	17.22
	Fallow land	1.26
	River	99.08

(Source: Field Survey, 2015)



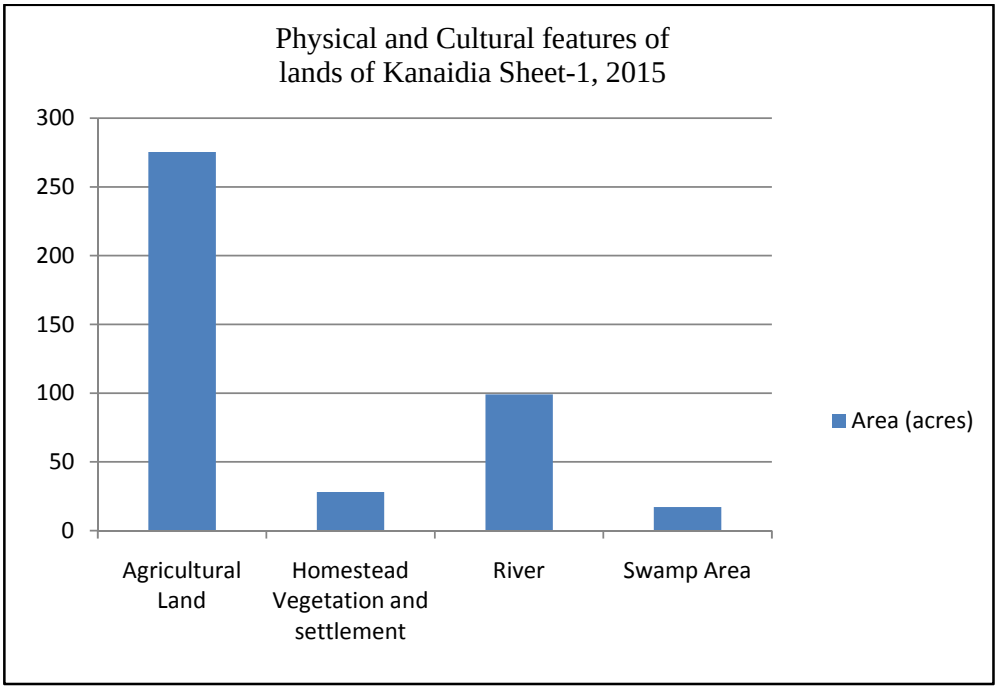
(Source: Field Survey, 2015)

Figure 5.25: Physical and cultural features of lands of Kanaidia (Sheet-1) in December 2006.



(Source: Field Survey, 2015)

Figure 5.26: Physical and cultural features of lands of Kanaidia (Sheet-1) in December 2012.



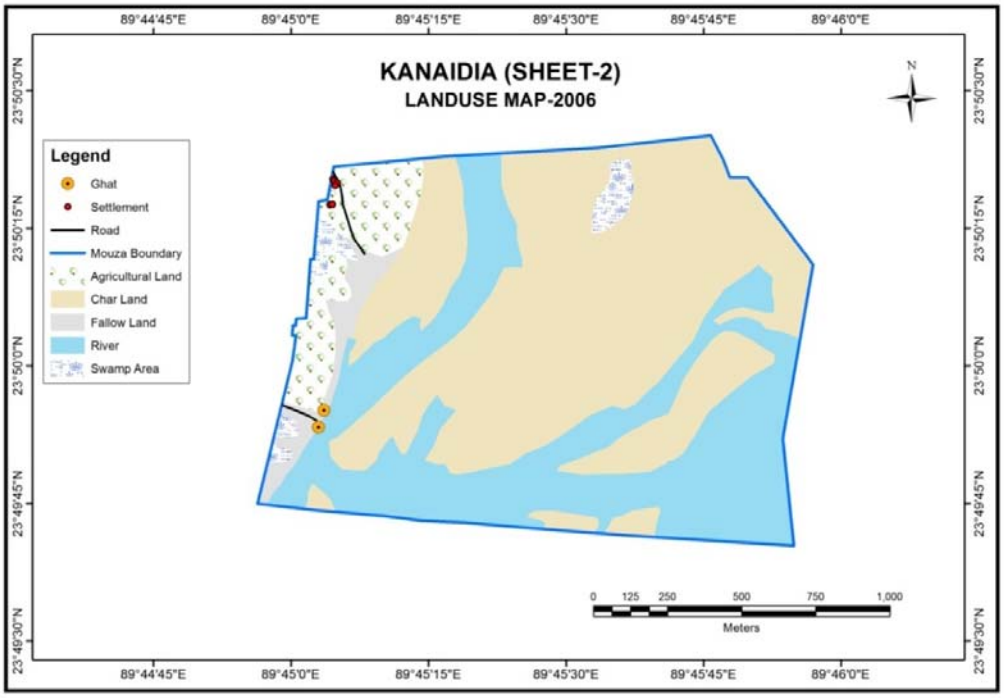
(Source: Field Survey, 2015)

Figure 5.27: Physical and cultural features of lands of Kanaidia (Sheet-1) in July 2015.

5.3.5 Physical and Cultural Features of lands of Kanaidia (Sheet-2)

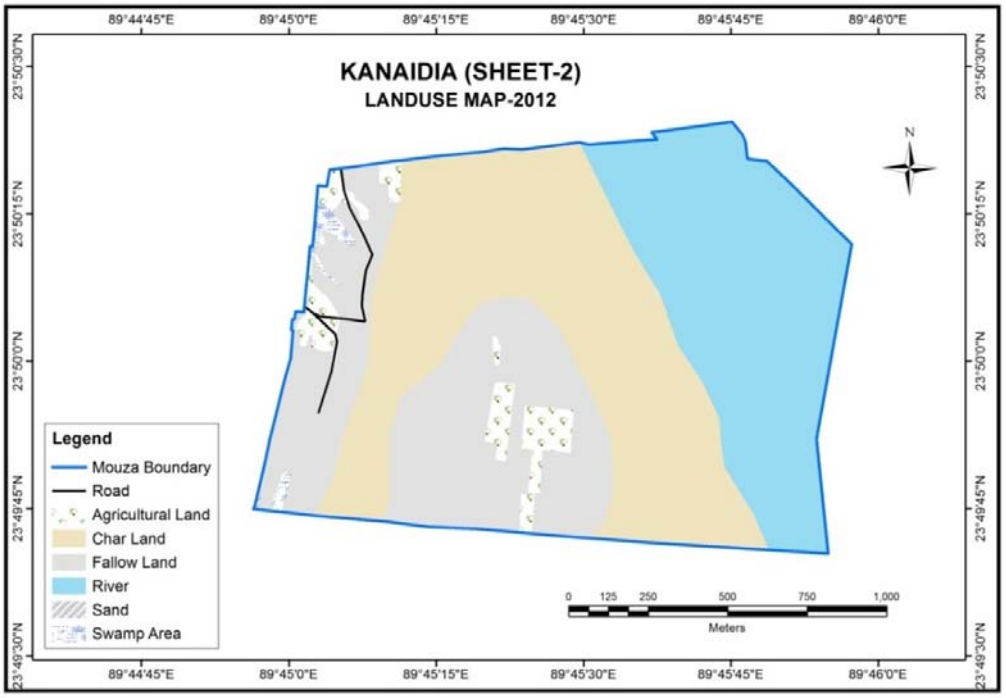
Digitized features map 5.43 of Kanaidia mauza (Sheet-2) in December 2006 indicates most of the land area of this sheet was newly accreted char land. The second largest portion was in the river. The rest of the lands were either fallow or agricultural land.

Based upon the Digital Globe Image of this mauza digitized land use map has been complied. Digitized map of physical and cultural features of land of this mauza in December, 2012 is shown in map 5.44. Cultural features such as agricultural lands, roads, mauza boundary and physical features such as char land, fallow lands, river and swamp area has been shown in this map. Digitized land use map of Kanaidia mauza (Sheet-2) in July 2015 have been shown in Map 5.45. In this map sky blue part indicates riverine area of the mauza. Light pinkish skin colored area is Char land. Spotted area of western part is agricultural land.



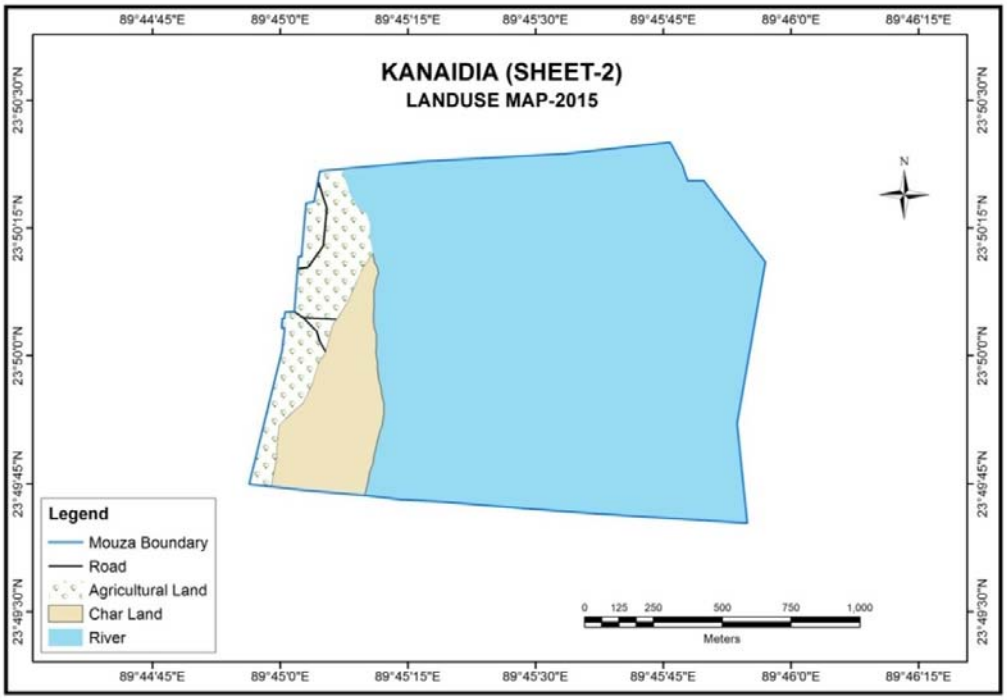
(Source: Google Earth, Compiled by the Author, 2015)

Map 5.43: Digitization of physical and cultural features of lands of Kanaidia mauza sheet-2 in December 2006.



(Source: Google Earth, Compiled by the Author, 2015)

Map 5.44: Digitization of physical and cultural features of lands of Kanaidia mauza (sheet-2) in December 2012.



(Source: Google Earth, Compiled by the Author, 2015)

Map 5.45: Digitization of physical and cultural features of lands of Kanaidia mauza (Sheet-2) in July 2015.

By December 2006 newly accreted char lands comprised 255.86 acres of land. 158.56 acres was in the river. Only 33.02 acres was agricultural lands. Fallow land 13.82 acres, swamp area 9.92 acres and a very insignificant amount only 0.22 acres was used as homestead vegetation.

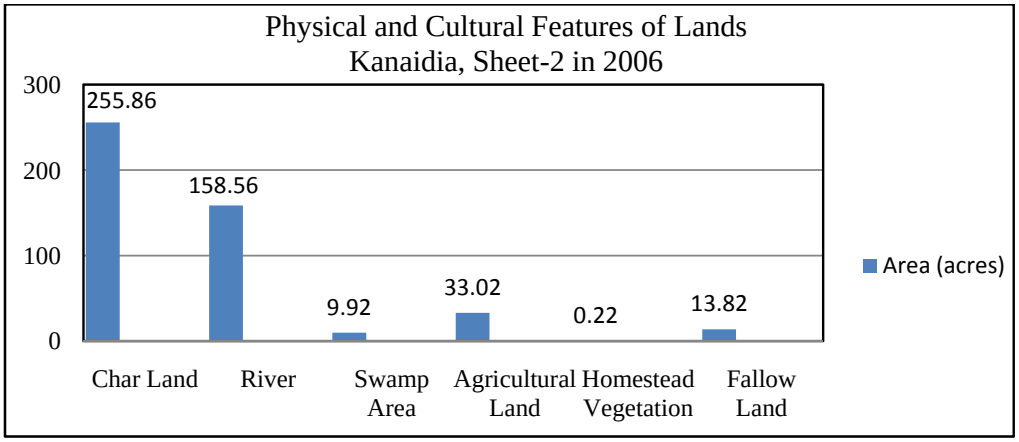
Like December 2006 by December 2012, there was also larger area of newly accreted char lands covering 180.58 acres. Riverine area covering 137.89 acres was in second highest position. Fallow lands covers slightly less than riverine area covering 130.66 acres of lands. There was small amount of swamp area and a negligible, only 0.20 acres sandy soils.

By July 2015, quantitatively 387.97 acres of land is in the river, which is approximately 82% of total lands of this mauza sheet. Char lands 39.73 acres and only 43.70 acres is used for agriculture purpose. Exact features of lands of this sheet of Kanaidia mauza have been quantified in table 5.11 and figure 5.28-30.

Table 5.11: Features of lands of Kanaidia Mauza (Sheet-2)

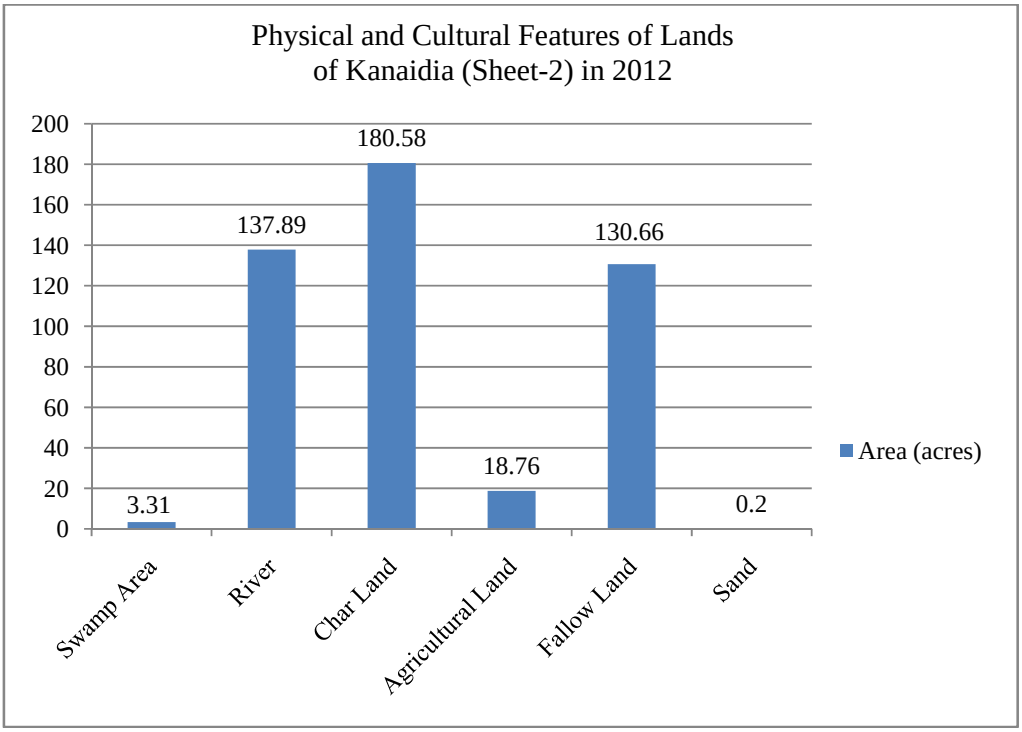
Time	Features	Area (acres)
December, 2006	Agricultural Land	33.02
	Homestead Vegetation	0.22
	Char Land	255.86
	Swamp Area	9.92
	Fallow Land	13.82
	River	158.56
December, 2012	Agricultural Land	18.76
	Swamp Area	3.31
	Fallow Land	130.66
	Char Land	180.58
	Sand	0.20
	River	137.89
July,2015	Agricultural Land	43.70
	Char Land	39.73
	River	387.97

(Source: Field Survey, 2015)



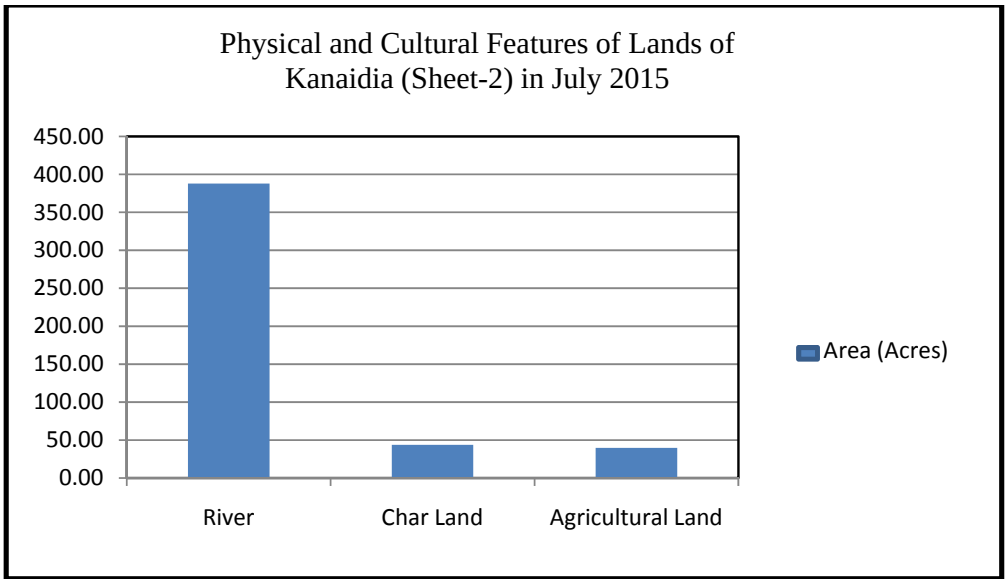
(Source: Field Survey, 2015)

Figure 5.28: Features of lands of Kanaidia (Sheet-2) 2006



(Source: Field Survey, 2015)

Figure 5.29: Physical and cultural features of lands of Kanaidia (sheet 2) in December 2012



(Source: Field Survey, 2015)

Figure 5.30: Physical and cultural features of lands of Kanaidia (Sheet-2) in July 2015.

5.4 Livelihood Scenario in the Context of Riverbank Erosion

Although a number of policies and acts have been formulated with the aim of addressing the needs of marginalized people, the country is far from developing appropriate guidelines for addressing the causes and consequences of riverbank erosion. Unfortunately, riverbank erosion does not draw the attention of the government and non-government agencies as the other disasters do.

The affected people do not have access to institutional support and are not included in any rehabilitation program. When they are displaced from their birth places they become disconnected from their sources of income, lands, food production and other livelihood options, which force them to engage in new livelihood activities. Education of their children is disrupted, and they are deprived of safe water, sanitation and other basic needs.

By the analysis of riverbank erosion in this study area, it has already been mentioned that more than three- fifths of the area has been eroded by the riverbank erosion of the Jamuna. As major earnings of 80% people of this study area is agriculture. So, riverbank erosion contributes immensely to the marginalization process of a large number of people of this study area by loss of agricultural lands and homestead lands and adversely affecting their social and economical circumstances and affecting livelihood of the people of surroundings areas. For elongation the hypothesis let us identify the livelihood system of my study area.

The livelihood system of a community can be better assessed though observing the economic activities seasonal calendar. Seasonal calendar is the sequential list of annual economic activities such as agriculture, fishing etc.

The cropping calendar of an area represents the major cropping pattern of that area as Aus, Aman and Boro. Aus is the pre-monsoon crop that the farmers practice in minor scale because, the pre-monsoon in this study area is very vulnerable due to seasonal flood. Aman is either cultivated by seedlings in the month of March-April or by transplanting just after the rainy season and harvested in the month of November-December.

As the major portions of the study area is in the river, so in some years farmers of this area cultivate Boro rice in the early winter and harvest before rainy season depending on the nature. Moreover, because of inundation of the major portion of the land with deep water more than six months of a year; for the survival the people of this area cultivate varieties of vegetables just after recession of water of a rainy season to next rainy season. Again due to alluvial deposition in most of the year, the area is very suitable to practice vegetable crops like potato, tomato, corolla, cucumber, cabbage, cauliflower, carrot, radish, beans, bottle-gourd (Lau), pumpkin, Parble (potol) Arum, spinach (Palong shak), data shak, lal shak, , etc. Wheat, mastered, pulses,

different kind of peas (Khesari, Motor, Maskolai) sesame (Til), ground nut (*China Badam*), chili, jute, dhaincha (*Sesbania cannabina*), melon, water melon etc, are also cultivated here.

Due to poor socio-economic conditions along with poor soil structure and texture there is no ponds or other artificial water reservoir in this study area. Capturing of fish is observed in the month of May to November by the artisan farmer in the Jamuna by their home made small instruments (Traps) or nets. Some people of this area are engaged as Rickshaw puller, laborer, and garment worker in distance places Aricha, Manikganj, Dhaka, Rajshahi and Faridpur. There is also few primary school teachers, a quack and village veteran. Total livelihood system of the people of this study area has been shown in table 5.12.

Table 5.12: Livelihood System of the study area

Livelihood	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Agriculture												
Wheat												
Corn												
Mustered												
Pulses												
Tomato												
Potato												
Sweet Potato												
Sesbania												
Potol												
Cucumber												
Nut												
Winter Vegetables												
Data shak												
Jute												
Aus												
Aman												
Boro												
Dhaincha												
Fishing												
Rickshaw puller												
Small Trade												
Service												
Others												

(Source: Field Survey, July 2015)

5.4.1 Occupational Status

According to the findings of the field survey, 80% people of the current study area are dependent on agriculture. So, livelihood of the people of this area is largely dependent upon the availability of farming lands and easy access of the people to this land. Because of the recession

of farming lands due to devoured land erosion by the river, livelihood of the people of the study area and its surrounding area is becoming vulnerable day by day. Due to riverbank erosion the number of permanent unemployed people is increasing with the temporary and seasonal unemployed people of this area.

Table 5.13: Occupational Status of the study area

Occupation	No. of respondents	%
Agriculture	40	80
Fishing	2	4
Small Business	2	4
Others	6	12

(Source: Field Survey, July 2015)

5.4.2 Losses due to riverbank erosion

Losses due to riverbank erosion cannot be expressed in words. Loss of lands and loss of homestead is the loss of everything. Loss of homestead losses hearts of the river eroded vulnerable people. From GIS and GPS study current research has already estimated the total amount of lands losses due to riverbank erosion. In addition to this, results have been interpreted with result of the questioner survey of this research. Results of questioner survey are placed in table- 5.14

Table 5.14: Data on losses due to bank erosion in the study area

Losses	No. of Respondents	%	Frequency
Homestead	46	92	1-20 times
Cultivable lands	48	96	
Vegetable Garden	31	62	
Loss of households	45	90	
Loss of cattle and others	10	20	

(Source: Field Survey, July 2015)

Table 5.14 represents type of losses due to riverbank erosion. Total respondents of the questioner survey and Focal Group discussion was 50 in number most of them are living permanently in this study area for more than 20 years and have experienced riverbank erosion 1-20 times in their lives. 96% of the respondents have lost their agriculture lands, 92% of the respondents have experienced homestead loss and 62% of the respondents have experienced loss of vegetable garden in their life. 90% have losses their households and 20% have lost their cattle. Due to these losses income level of the river eroded people has decrease drastically being

the people of this study area in a miserable condition. So the loss due to riverbank erosion in this study area is immense. Women and children are worst sufferer due to riverbank erosion.

5.4.3 Income level of the study area

Low monthly income is the cause of lowering the ability of an individual to maintain a minimum standard of living and to cope with adverse impacts of riverbank erosion. It is evident from the study that respondents of an eroded area are poor. Large number of respondent's monthly income is within the range of Tk.5000-Tk.10000. 70% respondent is in this income group. 24% people of this area have an income level more than Tk.10000 per month, whereas, 10% respondent's income is less than Tk.5000 per month. Due to low income their standards of living including expenditure on food, clothing, healthy life style, safe drinking water and education is minimal.

Table 5.15: Data on income level of the study area

Monthly Income (Taka)	No. of Respondents	%
Less than 5000	3	6
5000-10000	35	70
More than 10000	12	24

(Source: Field Survey, July 2015)

5.4.4 Monthly Expenditure on food

One of the important indexes of measuring poverty is the calorie intake per person. In this study instead of measuring calorie intake amount of food expenditure for each five members family have been calculated.

Table 5.16: Data on monthly expenditure on food

Monthly Expenditure	No. of Respondents	%
Less than 5000	10	20
5000-10000	32	64
More than 10000	8	16

(Source: Field Survey, July 2015)

According to the study findings, 20% families have no ability to expense average Tk. 5000 per month on food expenditure. 64% have ability to expense on an average Tk. 5000- Tk.10000 per month and only 16% of the respondent has the capability to expense more than 10000 per month for their family food consumption. The respondents were asked about whether they can afford sufficient nutritious food for their family members, 94% respondents replied no. Only 6% can afford to provide sufficient balanced and nutritious food for their family members.

5.4.5 Monthly Expenditure on Child Education

Education makes a man competence to serve the nation as well as enjoying his life with full of advantage. An illiterate man, in most of the cases cannot enjoy their life with full potentials. They are engaged in primary economic activities, with little knowledge of how to improve or modify his activities. When river erosion occurs they do not know what to do or how to cope with the losses. Respondents were asked about their expenditure on their children's education, most of them replied that their poor economic condition hinders them to invest in their children education. Due to loss of homestead, they not only displaced from the original living place, in most of the cases their children also dropout from school education. During the field survey, respondent's families have 43 school aged children of them 39 children enrolled in primary school and five children dropout from primary school before completion of primary education. In the study area there was no school before 2013. During the present government a primary school had been established in Kanaidia mauza, there is no any educational institution in Char Ganga Prasad and Char Shibalaya mauza. Of the 34 school going children only 11 children's parents can afford to expense Tk.200 to Tk.500 per months. Although the children have desire to continue study, distance of school plus river between Kanaidia and Char Ganga Prasad and Char Shibalaya hinders them to attend the school regularly specially in the rainy season. Besides these, after the loss of homestead, many children stop to go to school and subsequently dropped from the school.

5.4.6 Expenditure for seeking Healthcare facilities

To maintain a decent life and to perform the economic activities efficiently, health is the prime factor. Lack of proper treatment and sickness cause people to remain unhealthy and this in turn reduces the income level. During riverbank erosion in the study area, different type of health hazard prevails. In addition, after a devastating loss, people bear huge mental shock that need extra long period to recover. Such health related problems make their situation even worse.

Table 5.17: Expenditure on healthcare Facilities

Average Medical Expenditure per month	No. of Respondents	%
< TK.200	29	58
Tk.200 to Tk.500	16	32
>TK.500	5	10

(Source: Field Survey, July 2015)

There is no hospital or community clinic in this study area. In most of the cases community people depends on quake for remedy of diseases. In case of emergency they need to cross 3-4 kilometers wide Jamuna River to reach the Union community clinic. But in most of cases they do not get adequate treatment because of the absence of service provider (Doctor).

To reach the Upazila Health Complex, they need extra five kilometers journey along Dhaka-Aricha high way. Most of the people have no ability to manage boat after evening especially during the rainy season when the river becomes very furious. So, the sufferings of the people of this study area know no bound.

According to the results of this study, 58% respondents expense less than Tk.200 per month for the treatment of their family members. 32% expense on an average Tk.200 to Tk.500 per month for treatment their family members. Only 10% respondents can afford more than Tk.500 per month for medical purpose.

5.4.7 Sanitation

Poor sanitation is one of the main causes of poor health of the people of this study area. Because of continuous shifting of their houses most of the respondents family members use Kacca latrine (Open and unhygienic non-sanitary latrine). Pacca Paikhana and niradad Paikhana are commonly used to describe sanitary latrine in the community. Only 24% respondents have concrete ring slab made partially hygienic latrine.76% respondents use kacca latrine.

5.4.8 Sources of Drinking water

Safe drinking water is one of the vital health issues in our country. This study area is in very good condition in this issue in comparison with many areas of the country. Almost 96% respondents' family use tube well water for drinking. For other household work they either use river water or tube well water depending on the distance of the river from their houses.

5.4.9 Expenditure for Other Purposes

Respondents of the study area are poor in terms of their income and thus they are less capable to expend more money for other purposes such as clothing, strengthening house structure, invest in different income generating sources, savings, recreation etc. Most of them have to spend rest of their monthly expense to combat with the bank erosion.

Table 5.18: Expenditure for Other Purposes

Expenditure for Other Purposes	No. of Respondents	%
<Tk.500	15	30
Tk.500-Tk.700	21	42
>Tk.700	14	28

(Source: Field Survey, July 2015)

The respondents were asked whether they can give new cloths during Eid and other religious festival. Only 10% respondents said, they can provide new cloths during the Eid festival. Others responded negatively. Even they cannot buy warm cloths during winter season. An

almost similar trend of expenditure for other purposes is prevailing in the study areas while most of them (42%) spend Tk.500-Tk.700 per month. Such low amount of spending can neither improve their livelihood nor make a huge change by savings. Overall, the livelihood status of the study area is too low to live a descent life. Furthermore, riverbank erosion makes them spend a large amount of money and eventually they become ultra-poor.

5.4.10 Migration

Migration is the movement of people from one place to another for taking up permanent or semi-permanent residence. Almost one-tenth of the riverbank erosion induced marginalized people migrate in urban centre in searching for livelihood option (Hossain, 1984). Multiple displacements are a common phenomenon of char land settlements, particularly for the marginalized people. The rapid changes in river courses and lateral movement of the bank destroys valuable agricultural land (most often the only option of livelihood), homesteads and other establishments, and they become destitute and landless.

On the other hands, re-emergence characteristics of char lands give the landless people a hope to resettle. The existing power dynamics to take control over a newly emerged char land results in violent fights between groups and hence a considerable proportion of displaced people (10 to 25 percent) determine to migrate. These involuntary migrants become permanent squatter settlers in the cities and towns (Hutton and Haque, 2004).

Riverbank erosion largely affects poor and marginalized people as they have the least capacity to resist and to recover from the natural hazards (Greenberg, 1986; Rogge and Elahi, 1989). The physical, economic, social and political situations of Bangladesh accelerate the rate of marginalization. Most of them try to rely on existing tenancy structures to recommence their livelihoods in rural areas; but widespread erosion destroy the attempt and push the impoverished people to migrate from rural areas to urban centers. However, in the case of riverbank erosion induced displacement, people attempt to stay within the vicinity of their origin. Such intention is rooted in several factors (Hutton and Haque, 2004) that make them more vulnerable to erosion: poor economic condition; not to destroy existing social bonding; and hope of regaining the lost land.

It is evident that temporary migration is prevalent in the study area. People of the study area migrate in temporal scale rather than permanent one. They migrate to distant places most often in search of jobs. Respondents identified that because of the lack of money, they cannot migrate with their family to a place where erosion does not take place. Therefore, they relocate their homestead in a nearby area immediately after the disaster strikes and the people who are able to do laborious job, migrate to distant places in order to cope up with losses incurred from

riverbank erosion. Moreover, they relocated themselves nearly to their destroyed homestead, which they never consider as migration.

The study reveals that people between 20-35 years of age move toward Dhaka. While age groups of 26- 30 and 31-35 were found as the highest long distant migrants in Dhaka. Those who are more than 35 years of age, try to maintain their livelihood by migrating to nearby areas living through different occupation like rickshaw/van puller, day laborer, garment worker etc. Such migration pattern makes them return to their locality after minimum of three days to maximum of 15 days staying. It was also observed that people who are more than 50 years, tried to stay in their household as they are less capable to do hard work.

5.4.11 Remedial Policies of the Problem

The number of riverbank induced population in the country is massive, and the options to improve the conditions of these uprooted populations are severely limited. The detailed survey of the study area has made possible to perceive the extent of erosion hazard and related phenomena of livelihood of community people quite effectively. The control of erosion in fact are in a remote possibility in a short run planning and the opportunities to relocate the homestead lost people in a permanent way are limited.
Therefore, the rehabilitation program for the migrants should be taken immediately and has to be tackled principally within the areas themselves.

On the other hand, the consequences of the erosion hazards are possible to minimize by adopting a number of physical and socio-economic planning measures. If these are not undertaken, the problems associated with riverbank erosion will continue to increase affecting the human habitat and the economy of the area. By knowing the cause and the consequences of river erosion it would be possible to suggest remedial policies which again must be sieved though the particular geographical situation where they are to be implemented. The initial stages of the planning process should be designed in the context of long term planning allowing the involvement of local expertise as well as reflecting aspirations of the affected people.

5.4.12 Existing Survival Strategies of Displacees in the Study Area

It is observed that most of the displacees in the study area are found on their own rest of the land or other’s land on yearly rental basis. Some of them are living in the Ashrayan project, some stayed on land that belonged to other people, while others shared their relative’s dwellings. Only a few had the resources to buy plot of land and start afresh. Usually the neighboring communities provided great help. They gave them space and helped them to build their new shelter. Some voluntarily contributed their labor. In many instances within a short time those who sought shelter in embankment or schools found alternative shelters. On the

other hand, settlement pattern in riverbank erosion-prone areas of this study suggests that some household move to safe zones and build safer settlement, but many merely relocate within the same area that has either been already affected or bears known vulnerable characteristics. Most of the respondents locate their settlement in the erosion prone area and wait to occupy emerging char. Initiation of settlement in the char land usually does not take place before a laps of three years after the emergence of the char. But present field observation indicates that displacees moved into the char as early as one year after their emergence. About 92 percent of the total respondents have relocated their settlement. Physical factors operate as the dominant force for shifting settlement. Sometimes social forces supersede the physical factors. The char environment itself is so uncertain that whenever there is any physical change, it immediately affects the settlements. The first stage is termed as the 'formation stage' and it is the period when a char emerges and displacees wait for occupancy. This is one of the main reasons to settle in the vulnerable area. However, it is important to remember that newly accreted land may take up to 15 years to develop full production potential, whereas the land that was lost into erosion is in most cases, valuable agricultural land.

5.4.13 Resettlement of the homestead lost people

The resettlement of the land and homestead lost people has been the ultimate options supported by the riverbank eroded people. From the study it is revealed that homestead lost people wish to resettle in the areas of newly accreted land or char lands which one belonging to them. These lands had remained beyond their reach as various social and economical circumstances made the river eroded people unable to recover them under the prevailing laws related with char lands reclamation as well as those on land tenure system for the char lands. According to the Bengal Alluvium and Diluvium Regulation of 1825 (Malik, 1985) the accreted land is recognized as the property of individuals of the original ownership; but this gained by gradual accretion from the reaches of river are to be considered an increment to the tenure of the person to whose estate it may be annexed, but the riparian owner's right of accretion were significantly changed by PO no. 135 and 137 of 1972 (Malik, 1983). In essence the accreted lands are to be vested absolutely in the government.

This order was meant to recover char lands from powerful local elites and to redistribute these among landless farmers. Again this declaration was changed in 1978 and the accreted lands came under the holdings of its original owners, which recognize the right of repossession by obtaining settlement of one's old lands. But the experience from the field investigation indicates that the powerful mussel men and morels usually deceive the poor riots by false notice of land deed or by bringing the settlement officers for declaring the land as Khas land. The later take possession of these lands on long-term lease. This eventually deprives the rightful owner of receiving the land. This aspect seriously hampers the resettlement and rehabilitation of the

migrants. Recently the act changed in 1994 and the accreted land treated as Khas lands and should under the control of the government to be distributed among the landless. Finally as soon as possible it should be distributed among the landless migrants.

In reality, even today, larger land owning class dominates the power structure and they determine the possession of re-emerged land from the riverbeds. It is very painful that some 80% of the 50 Lac acres of Khas land is illegally occupied mostly by political and social elites (Association for Land Reforms and Development).

5.4.14 Government Strategies to Improve the Livelihood Status of the Riverbank Erodes

Government response to this problem at local, regional and national levels has been limited to structural measures i.e., embankments, barrages, etc and very little attention has been paid in developing non-structural and self-help strategies. Most often, measures are taken immediately after the disasters and interventions are taken in the form of relief provisioning.

BWDB and CEGIS sources said that at least 1,53,566 hectares of cultivable land along with 50,339 hectares of settlement were eroded due to erosion by Jamuna, Ganges and Padma rivers during the period from 1973 to 2011. According to official sources of CEGIS 2014, the Jamuna alone devoured 90,367 hectares of land along both its bank during this period. BWDB with its limited resources are trying to protect different cities and important locations from riverbank erosion. But it appears to be a tiny effort if we compare it with the extent of erosion vulnerable areas. Several hundred kilometers of riverbank is remained vulnerable to erosion.

Considering the geo-morphological development of the rivers and the prevailing socio-economic context of Bangladesh, it would not be feasible to protect the riverbank erosion fully. In such a situation, non-structural measures, like the prediction of erosion when and where applicable could be an alternative to minimize the suffering of the people and national loses of erosion. Under the framework of EMIN project BWDB is now trying to institutionalize the prediction of erosion.

5.4.15 Ashrayan project

Ashrayan project locally known as “Ashroy Kendra” has enlightened the livelihood of 120 families of this study area. Although sufferings of the river eroded people knows no bound, these 120 family members are lucky enough that at least they have got the shelter to live in a decent house. With the financial and technical assistance from Honorable Prime Minister’s rehabilitation fund Bangladesh army along with other ministry’s and administrative co-ordination have executed the project. Allotment has been given to the homestead lost dwellers of Char Ganga Prasad and surrounding areas in 2013. Ashrayan project has given them residence facility along with facilities of pure drinking water and improved sanitation. According to union information before building the Ashrayan project there were only 29 families in Char Ganga Prasad mauza but after the implementation of the project, many river eroded people from the surrounding areas have gathered to live in and they are living in this village by making temporary houses. As a consequence, population density of this area has increased drastically. According to population census, 2011 total population of my study area is about 2000. But the actual population is more than 3000 because there are many floating people living in temporary house who have no own lands and even are not enlisted in the voter list in the selected mauzas. This Ashrayan project is also in a great threat, as the steep bank of the river Jamuna is very adjacent to this project. As a measure to protect it sometimes geo-textile bags are sunk in the severe erosion phone areas but this step is very limited.

(Source: Field Survey, 2015)

Figure 5.31: Char Ganga Prasad Ashrayan Project

Chapter 6
FINDINGS AND RESULTS

On the basis of the analysis of targeted objective of this research, findings and results have been presented in this chapter very briefly. Findings from mauza map collection to analysis of all objective of my study i.e., mauza map collection, Google Earth Imagery development, quantifying of erosion, features of lands of the current study area and livelihoods impact of riverbank erosion have been given priority in developing this chapter.

6.1 Findings from Mauza Map Collection and Google Earth Imageries

For details study of a small area, mauza map analysis along with GPS and GIS techniques is an effective way to determine Geographic and Social science research. Collection of mauza map is very troublesome and there are lots of hassles. Though RS survey was started in 1966, lack of co-ordination, incorporation with unskilled manpower and corruption of land sector is responsible for not completing the RS survey of all districts within about 45 years after the independence of Bangladesh. However, quality land management is required as a benchmark in civilized societies. Country's land administration system needs to be made stronger and transparent to do this great achievement. To deliver the citizens centric service both efficiency as well as moral ethics is a must. All the land offices from union land office to Directorate of Land Survey and Records need to be digitized. There should be easy access to database on land records especially for the researcher. Current study of mauza map using GPS navigation reading and Google Earth Pro provides Google Earth Imageries that determined status of the study area, findings of which have been shown in table 6.1.

Table 6.1: Findings from Google earth Imageries of the study area.

Mauza	No of Plots having Settlement and vegetation			No of Partially Eroded Plots			No of Completely Eroded Plots		
	2006	2012	2015	2006	2012	2015	2006	2012	2015
Char Ganga Prasad	27	43	42	26	9	9	0	0	26
Char Shibalaya (Sheet-1)	45	50	30	16	16	14	98	198	244
Char Shibalaya, (Sheet-2)	24	21	1	60	33	5	3	114	158
Kanaidia, (Sheet-1)	50	50	58	6	19	11	0	9	23
Kanaidia, (Sheet-2)	0	0	0		24	27		37	120
Total	146	164	131	108	101	66	102	348	571

(Source: Field Survey, 2015)

Plots with settlement and vegetation have decreased by 11% from December 2006 to July 2015. The people of mauza Char Shibalaya (Sheet-2) are the worst sufferer. Partially eroded plots have decreased by 40%, whereas completely eroded plots increased by 560% by July 2015.

6.2. Findings from Riverbank Erosion Analysis.

Findings from analysis of digitized mauza maps of the study area indicate the intensity of erosion of the study area. Findings are very briefly illustrated for each mauza individually and collectively for the whole study area.

6.2.1 Riverbank Erosion of Char Ganga Prasad

The base year 1980, the mauza was completely non-eroded which had been eroded 7% of its area by December 2006. Up to 2006 level of erosion was in a tolerable range; only on an average 0.27% of total area of the mauza per year. After that trends of erosion rapidly increased and reached to 21% by January 2013. Speed of average erosion from January 2007 to January 2013 was about 9 times higher than the time period of 1980-2006. Finally, the next two and half year the process continued more excessively and in July during field survey total eroded area reached to 35.4% which was 21 times faster than that period. Table 6.2 represents status of eroded and non-eroded lands of Char Ganga Prasad from 1980 to July 2015.

Table 6.2: Riverbank erosion of Char Ganga Prasad from1980-2015

Features	31.12.1980	20.12.2006	12.01.2013	07.07.2015
Eroded lands	00%	7%	21%	35.4%
Non-eroded lands	100%	93%	79%	64.6%

(Source: Field Survey, 2015)

6.2.2 Riverbank Erosion of Char Shibalaya

The conditions of the people of Char Shibalaya is very critical as the vast major portions of this mauza area from both the sheet of this mauza have been eroded due to riverbank erosion. From Char Shibalaya (Sheet-1) almost 78% and from Char Shibalaya (Sheet-2) 97% of the total area has been devoured by devastating erosion.

Riverbank Erosion of Char Shibalaya (Sheet-1)

In comparison with the base year 1980, in 2006 eroded land was 27% commencing erosion of approximately 1% of lands of this mauza per year. Whereas, within 6 years i.e. January, 2013 almost 60% of lands of Char Shibalaya mauza (sheet-1) had been eroded. On an average it was 5.5 times severe than the previous time period. By July, 2015 eroded area reached to 78% of total area of this mauza. Average rate of erosion is 7.2% of total mauza sheet area per year.

Table 6.3: Riverbank erosion of Char Shibalaya (Sheet-1) with the base year 1980

Features	31.12.1980	20.12.2006	12.01.2013	07.07.2015
Eroded lands	00%	27%	60%	78%
Non-eroded lands	100%	73%	40%	22%

(Source: Field Survey, 2015)

Riverbank Erosion of Char Shibalaya (Sheet-2)

From 1980 to December 2006 only 9% area of this mauza had been eroded due to riverbank erosion. On an average every year 0.35% of the total area of this mauza had been eroded by this time. For the next 6 years due to infuriated action of the Jamuna, lands of this mauza has eroded very rapidly and up to January 2013, almost 80% area of the mauza had been eroded. The speed of washed out of lands was 33 times higher than the speed of erosion during the time span of 1980-2006 and average12% of total area per year for the time period of 2007-2012. The next two and half years rate of erosion decreased but in July 2015, almost 97% of the area of this mauza had been gone into water. The average speed at that time was 6.8% of total area of the mauza per year. Table 6.4 represents the trends of riverbank erosion of Char Shibalaya mauza from 1980 to July 2015.

Table 6.4: Riverbank erosion of Char Shibalaya (Sheet-2) with the base year 1980

Features	31.12.1980	20.12.2006	12.01.2013	07.07.2015
Eroded lands	00	09	80	97
Non-eroded lands	100	91	20	03

(Source: Field Survey, 2015)

It is noticeable that, when the bank erosion occurs in most of the cases the owner of the lands could not get enough time to remove houses and household properties to safer place. Due to loss of lands and houses their livelihoods become vulnerable.

6.2.3 Riverbank Erosion of Kanaidia

The sufferings of the people of Kanaidia knew no bounds. According to the villager's interpretation, approximately every five to six year maximum of the people of Kanaidia experience river erosion from alternate side of the village. That's why their homestead cannot be permanent. After every massive destructive incident, they transfer their houses to comparatively safe place maintaining a distance from the riverbank. Afterward, before gaining the stable position they become victim of the devastation again and again. Banga (break down) and Gara (build up) are the common phenomenon of their life. God is always playing with their fate. The soil of this mauza is very fertile. Kanaidia (Sheet-1) has settlements but Kanaidia (Sheet-2) has no settlement and homestead at all because of its instability.

Riverbank Erosion of Kanaidia Mauza (Sheet -1)

By 2006, 3% of the area of the mauza sheet had been eroded into the river. Within six years on 12 January 2013, total eroded lands became six fold in compassion of erosion in 2006 of this mauza. Afterwards, with the additional eroded land the total eroded lands became 23% within July 2015.

Table 6.5: Riverbank erosion of Kanaidia (Sheet-1) with the base year 1980

Features	31.12.1980	20.12.2006	12.01.2013	07.07.2015
Eroded lands	00%	03%	18%	23%
Non-eroded lands	100%	97%	82%	77%

(Source: Field Survey, 2015)

Table 6.5 illustrates the land area eroded from Kanaidia mauza (sheet-1) in different time span by the furious action of the river Jamuna.

Riverbank Erosion of Kanaidia (Sheet-2)

In this mauza eroded land was 42.43%, 32.67% and 82.05% in December 2006, January 2013 and July 2015 respectively. Extremely rapid land erosion occurs within a time span of two and half year, from January 2013 to July 2015. The table 6.6 expresses extent of land loss occurred in Kanaidia (Sheet-2) due to riverbank erosion over a time period of 1980 to 2015.

Table 6.6: Riverbank erosion of Kanaidia (Sheet-2) with the base year 1980

Features	31.12.1980	20.12.2006	12.01.2013	07.07.2015
Eroded lands	00	42.43%	32.67%	82.05%
Non-eroded lands	100	57.57%	67.33%	17.95%

(Source: Field Survey, 2015)

6.2.4 Overall Riverbank Erosion of the Study Area

Total land area of my study area is 1813.4 acres. Empirical analysis represents that from the base year up to 2006; average eroded land was comparatively low. From 1980 to December 2006 total eroded land was 369.75 acres; equivalent to 20.39% of the study area, where as this figure doubled within the next 6 years due to catastrophic river erosion and total eroded lands stands to 719.73 acres; equivalent to 39.69%. However, severity of land erosion was more drastic for the last two and half years. In July 2015, total eroded land is1129.72 acres; equivalent to 62.30% of the total study area. Table 6.7 represents total area of eroded and non-eroded lands of my study area according to Astrium image of 20.12.2006, 12.01.2013 and 07.07.2015 respectively.

Table 6.7: Trends of riverbank erosion of the study area with the base year 1980

Mauza	Total Area	31.12.1980		20.12.2006		12.01.2013		07.07.2015	
		Eroded	Non-eroded	Eroded	Non-eroded	Eroded	Non-eroded	Eroded	Non-eroded
Char Ganga Prasad	273	0	273	20.25	252.75	58	215	97	176
Char Shibalaya-1	428	0	428	117.06	310.94	256	172	333.39	94.61
Char Shibalaya-2	220	0	220	20.69	199.31	175.54	44.46	213.89	6.18
Kanaidia-1	421	0	421	11.75	409.25	76.19	344.81	98.64	322.36
Kanaidia-2	471.40	0	471.40	200	271.40	154	317.4	386.80	84.60
Total	1813.4	0	1813.4	369.75	1443.65	719.73	1093.67	1129.72	683.75
%	100%	00%	100%	20.39%	79.61%	39.69%	60.31%	62.30%	37.70%

(Source: Field Survey, 2015)

Analysis of the percentage value indicates that average rate of erosion was less than 1%, more than three percent and about 9% of the study area per year for the period of 1980 to 2006, January 2007 to January 2013 and January 2013 to July 2015 respectively. According to the current scenario of the study area of the three mauza, Char Shibalaya (Sheet-2) and Kanaidia (Sheet-2) are in the worst condition due to riverbank erosion. Char Shibalaya sheet-1 is also in a dire state. Percentage of eroded lands in July 2015 is 92, 82 and 78 in Char Shibalaya Sheet-2, Kanaidia Sheet-2 and Char Shibalaya Sheet-1 respectively.

Findings of the study also indicates that from 1980 to 2015 almost three–fifths i.e., 62.30% of the area has been devoured by the Jamuna riverbank erosion of this study area which have profound effects on the livelihood of the people living in this Char lands covering the study area.

6.3. Findings from Mauza Sheet wise Selected Features Analysis

Summary of mauza sheet wise selected features of the current study area has been shown in table 6.8. Later on, pages selected features of each mauza sheet has been shown in 6.3.1-6.3.5.

Table 6.8: Mauza sheet wise cultural and physical features of the study area

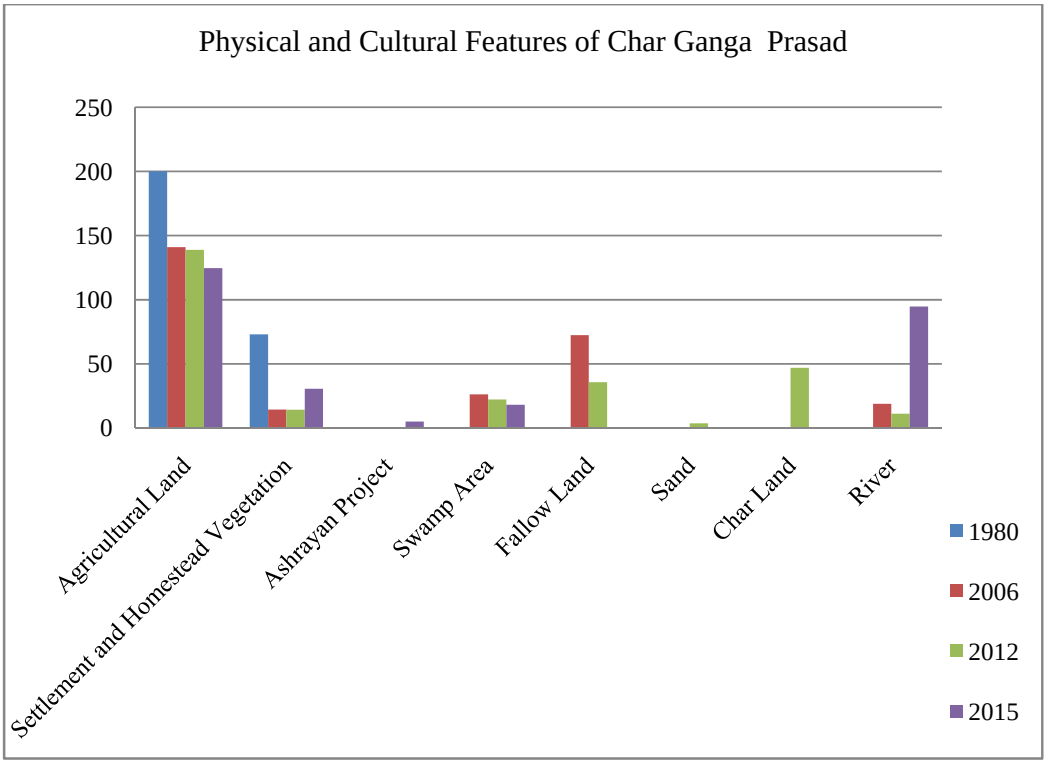
Mauza	Cultural and Physical Features	Year			
		31.12.1980	20.12.06	12.01.13	07.07.15
		Area in Acres			
Char Ganga Prasad	Agricultural Land	200	141.00	138.94	124.60
	Settlement and Homestead Vegetation	73	14.40	14.31	30.58
	Ashrayan Project	-	-	-	5.00
	Swamp Area	-	26.30	22.30	18.18
	Fallow Land	-	72.40	35.80	-
	Sand	-	-	3.65	-
	Char Land	-	-	46.90	-
	River	-	18.90	11.10	95.91
	Total	273	273	273	273
Char Shibalaya ((Sheet-1)	Agricultural Land	300	172.34	144.12	74.81
	Settlement and Homestead Vegetation	128	19.95	25.01	16.79
	Trees	-	-	1.52	-
	Swamp Area	-	1.22	-	3.46
	Fallow Land	-	176.13	7.07	-
	Sand	-	-	2.12	-
	River	-	58.36	248.16	332.94
	Total	428	428	428	428
Char Shibalaya (Sheet-2)	Agricultural Land	170	30.84	24.51	5.58
	Settlement and Homestead Vegetation	50	4.53	4.69	0.42
	Fallow Land		166.46	19.52	
	River		18.17	171.28	214
	Total	220	220	220	220
Kanaidia (Sheet-1)	Agricultural Land	300	340.23	240.30	275.38
	Settlement and Homestead Vegetation	121	20.72	27.26	28.06
	Swamp Area	-	22.14	22.72	17.22
	Fallow Land	-	28.61	32.53	1.26
	Sand	-		20.08	-
	River	-	9.3	78.11	99.08
	Total	-	421	421	421
Kanaidia (Sheet-2)	Agricultural Land	300	33.02	18.76	43.70
	Settlement and Homestead Vegetation	171.4	0.22	-	-
	Swamp Area	-	9.92	3.31	
	Fallow Land	-	13.82	130.66	-
	Sand	-	-	0.20	-
	Char Land	-	255.86	180.58	39.73
	River	-	158.56	137.89	386.7
	Total	471.4	471.4	471.4	471.4

(Source: Field Survey, 2015)

6.3.1 Features of land use of Char Ganga Prasad at a glance

Total land area of Char Ganga Prasad is 273 acres. In 1980, agricultural land was 200 acres and homestead and vegetation area was 73 acres.

In 2006, agricultural land use was limited within 141 acres. In 14.40 acres there were settlement and vegetation, a considerable amount of lands; 72.40 acres was fallow lands, 26.30 acres was swamp area and 18.90 acres was in the river. Although, river eroded land was only 18.90 acres, in association with swamp area and fallow land it comprised almost 43% of this mauza.



(Source: Field Survey, 2015)

Figure 6.1: Physical and cultural features of land use of Char Ganga Prasad from 1980-2015

In 2012, change in the amount of agricultural lands was insignificant, comprising 138.94 acres of lands of this mauza. Settlement and vegetation area was also unchanged, 14.31 acres. Swamp area was 22.30 acres, 16% less than the amount of land of this mauza used as Settlement and vegetation in 2006. Fallow land was almost half the amount of fallow lands of 2006. There were 3.65 acres sandy lands, 46.90 acres char lands and 11.10 acres of land in the river. Fallow land, Char land, Swamp area and river comprised almost 44 % of the total area of this mauza.

In July 2015, total agricultural land is 124.60 acres which is approximately 46% of the total area of this mauza. There are 18.18 acres of swamp area and 94.64 acres of river eroded lands. Homestead and vegetation area have increased remarkably, as the river eroded community people temporary set up their house on other people's land with a hope that they would regain their lost lands soon.

An Ashrayan Project (Residence Project) locally known as "Ashray Kendra" is one of the significant cultural features in this mauza. With the financial assistance from Government of Bangladesh, Bangladesh Army had established this establishment in 5 acres of lands in 2013. This Project comprises 24 big semi pacca tin shed houses. Each house has a capacity for five families. This Ashrayan Project was built for the destitute of homestead and land eroded people of this locality. It is mentionable that this project is the only rehabilitation centre for the homeless and landless people of this study area. This project provided Semi-Pacca Tin shed house for 120 landless people of this area. After receiving the shelter, the landless people have been energizing with new hopes in their life.

Ashrayan Project has not only provided shelter for the landless destitute of this area, but also has created new life for them. They have regained their strength to live here. The People of this area now thought that after the almighty God, only the people oriented democratic and good governance can ensure better life for the river eroded community.

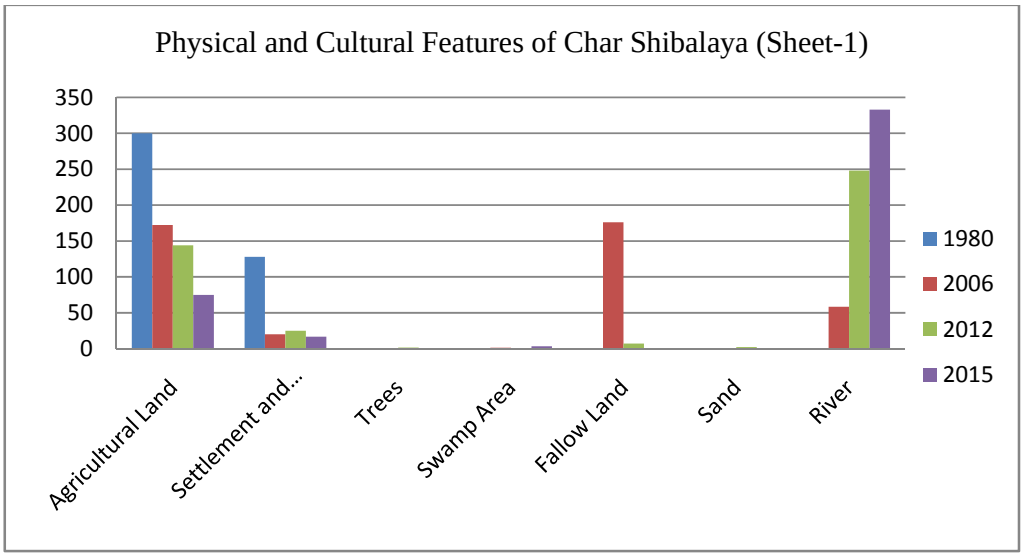
6.3.2 Features of land use of Char Shibalaya (sheet-1) at a glance

Total area of char Shibalaya sheet-1 was 428 acres of which 300 acres was agricultural land and the rest 128 acres was used as settlement and homestead vegetation in 1980. In 1980, there was no eroded land at all.

In 2006, largest portion of land equivalent to 176.13 acres was fallow, 172.34 acres was of agricultural land, 19.95 acres used as settlement and homestead vegetation, 58.36 acres had been eroded into the river and a very little amount; 1.22 acre was swamp area.

In comparison with 2006, agricultural lands had reduced by 20% with a net amount of 144.12 acres in 2012. All the accreted lands shown as fallow lands in 2006 had been eroded widening the area of river. The river Jamuna comprised about 248 acres of lands from 428 acres of lands of this mauza sheet. Percentagewise about 58% of land of this mauza was in the river. Settlement and vegetation area increased by 25% and reached a value of 25.01 acres. The most devastating change occurs with the erosion of all fallow land widening riverine area. In 2006, there was 176.13 acres of fallow lands in Char Shibalaya sheet-1 but in 2012 all the fallow

lands disappeared due to riverbank erosion. In 2012 there were little lands which were used for tree cultivation. Also there were some sandy soils in 2012.



(Source: Field Survey, 2015)

Figure 6.2: Physical and cultural features of Land use of Char Shibalaya (Sheet-1) in 1980, 2006, 2012 and 2015

In July, 2015, total amount of agriculture land was 74.81 acres, settlement and vegetation in 16.79 acres, swamp area 3.46 acres and major portion, about 79% is in the river.

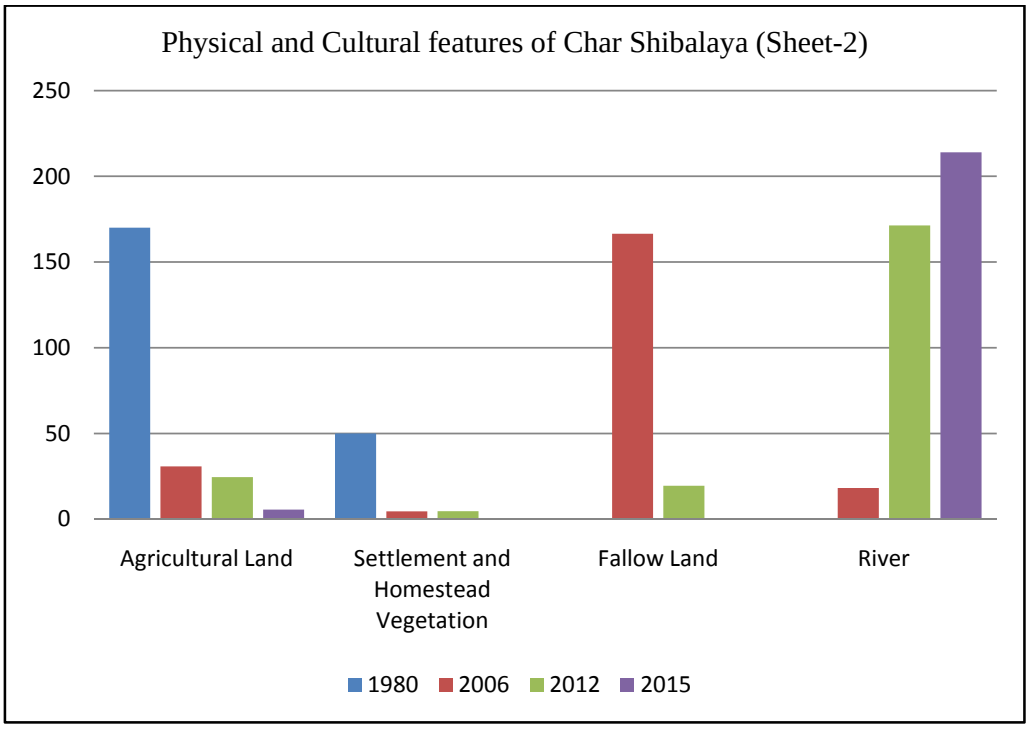
6.3.3 Features of land use of Char Shibalaya (sheet-2) at a glance

Total area of char Shibalaya sheet-2 is 220 acres of which 170 acres was agricultural land and the rest 50 acres used as settlement and homestead vegetation in 1980.

In December 2006 most of the lands was fallow lands which was actually newly accreted low lying unstable char land and was not suitable for successful agriculture practice. Total fallow land was 166.46 acres. 30.84 acres was agriculture lands, 18.17 acres was river and 4.53 acres was used for settlement and vegetation.

By December 2012, more than three-fourth area of this mauza was eroded into the river. Total amount of eroded lands was 171.28 acres. This eroded riverine portion of lands had little use for the homestead and agriculture land lost farmers of the area. Only 24.51 acres was agriculture lands, considerable amount, 19.52 acres was fallow lands and only 4.69 acres of lands was used as settlement and homestead vegetation.

By July 2015, almost 97% of lands of this mauza have been eroded into the river only six acres of land is remains for agriculture and settlement purpose.



(Source: Field Survey, 2015)

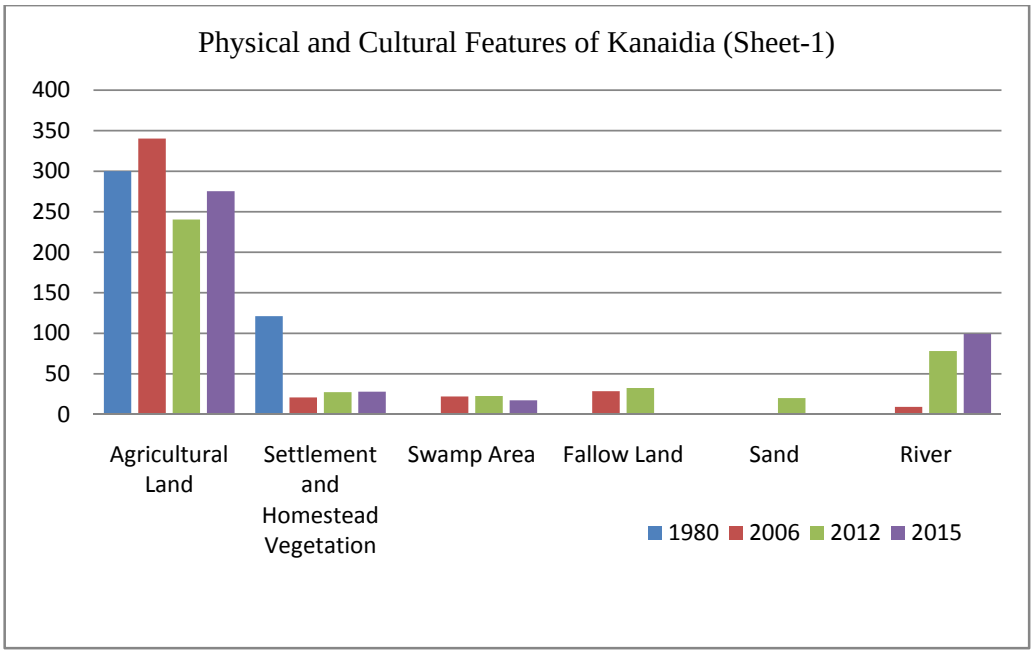
Figure 6.3: Physical and Cultural features of Land of Char Shibalaya (Sheet-2) from 1980-2015

6.3.4 Features of land use of Kanaidia (sheet-1) at a glance

Total land area of Kanaidia mauza sheet-1 is 421 acres. In1980, 300 acres of lands was used as agricultural lands and 121 acres was used as settlement and homestead vegetation. Then there was no eroded land. After about two and half decade latter in 2006, 340.23 acres of lands was used as agriculture purpose. There was Settlement and homestead vegetation 20.72 acres of lands in 2006. In that year also there were 22.14 acres of swamp area, 28.61 acres of fallow lands and 9.3 acres of lands into the river.

In 2012 highest amount of i.e., 240.30 acres of lands was agricultural lands. The second highest amount, 78.11 acres was river eroded. Only 27.26 acres was used for settlement and agriculture. In addition to this there was 32.53 acres of fallow lands, 22.72 acres of swampy lands and 20.08 acres of sandy soils.

In July 2015, there is a slight increase in agriculture lands in comparison to agriculture land use in 2006. Amount of agriculture lands in July 2015 is 275.38 acres. Settlement area remains about unchanged. During field survey of this study, only 28.06 acres of lands of this mauza sheet is used for settlement purpose.



(Source: Field Survey, 2015)

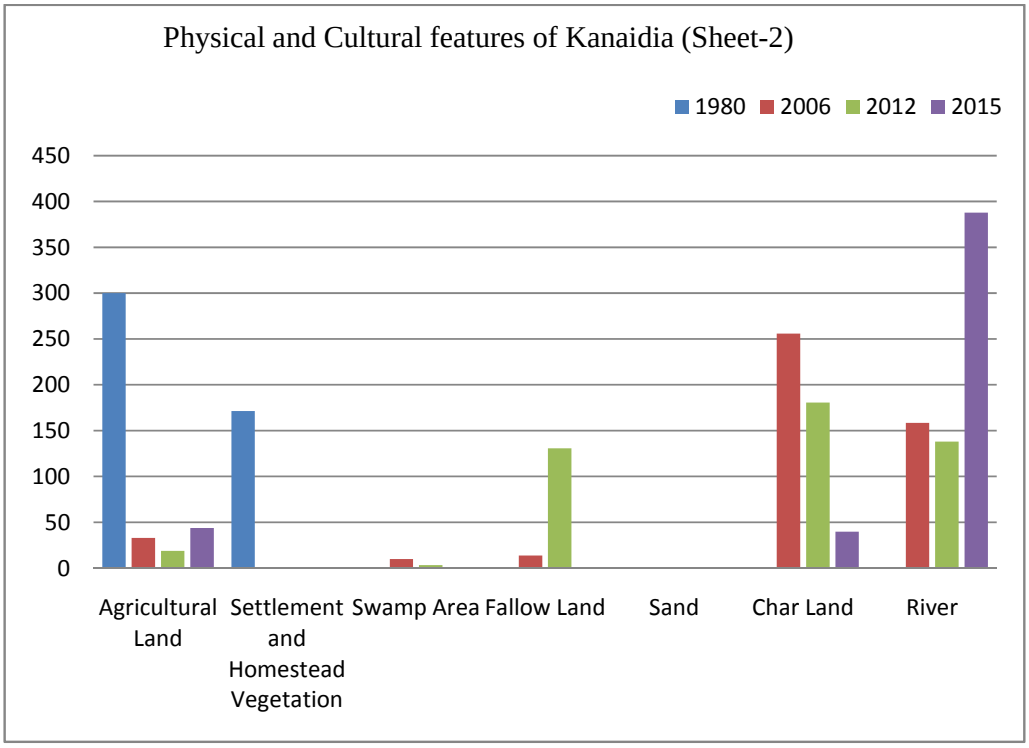
Figure 6.4: Physical and Cultural features of Land use of Kanaidia Sheet-1 from 1980-2015.

In 2015, 28.06 acres of lands is used for settlement and homestead vegetation purpose. 99.08 acres of lands is into the river. Moreover, there are 17.22 acres of swamp land and 1.26 acres of fallow lands. Among five sheets of my study area, Kanaidia mauza sheet-1 is comparatively less erosion phone up to writing this report.

6.3.5 Features of land of Kanaidia (sheet-2) at a glance

Of total 471.4 acres of lands of Kanaidia mauza sheet-2, 300 acres was agriculture land and 171.4 acres was used for settlement and vegetation in 1980. In 2006, only there were 33.02 acres of agricultural lands, 0.22 acres of settlement and homestead vegetation, 9.92 acres was swamp area and 13.82 acres fallow lands. In 2006, also there was 255.86 acres of char lands and 158.56 acres of lands was in the river. Char lands was newly accreted lands and was little use for ground nut cultivation. The riverine portion was eroded lands.

In 2012, the situation of lands was more deteriorating. Only 18.76 acres of lands remained as agricultural land. There was no settlement and vegetation at all. In that year, there was 180.58 acres of char lands; the highest amount of land of this mauza. Moreover, there were vast amount of fallow land and eroded lands in the river. Total fallow lands was 130.66 acres and eroded lands in the river was 180.58 acres.



(Source: Field Survey, 2015)

Figure 6.5: Physical and cultural features of land of Kanaidia (Sheet-2) from 1980-2015

In July 2015, the highest amount 387.97 acres is in the river. It should be noted that this amount ranked highest position as eroded lands of all the year of this study mauza sheet-2 from 1980 to July 2015. There are 43.70 acres agricultural lands and 39.73 acres char lands in Kanaidia mauza sheet-2 in this year.

6.3.6 Features of Total Land of the Study Area

Entire land use of my study area is the sum of land use of five mauza sheets of my study area. Total land use of my study area has been represented in table 6.9 and figure 6.6 individually.

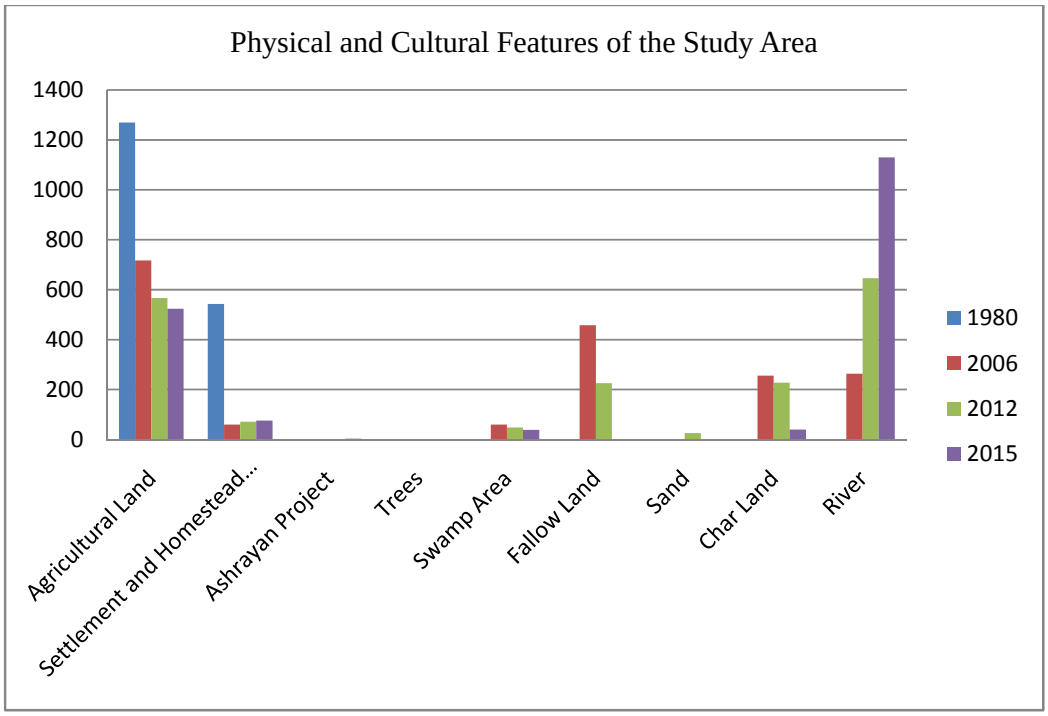
Available information gathered from the study field, especially from conscious older people's opinion and undocumented data from union land offices indicate that during the preparation of RS (Revisional Survey) mauza maps, total area was used for agriculture and settlement. According to the gathered information during field survey of this study, in 1980 of the 1813.4 acres lands in the study area more than two-thirds of the lands was used for agriculture purpose and 543.4 acres for settlement. It should be noted that the people of the char lands are very hard working and active. They used to cultivate various types of vegetables, groundnuts, rice, wheat,

jute, onion, garlic, mustard, sesame and different types of pulses. They got bumper crops in their fields and most of the people were well off and happy.

Table 6.9: Overall land use in 1980, 2006, 2012 and 2015

Features of land	Year			
	31.12.1980	20.12.2006	31.12.2012	07.07.2015
	Area of lands (Acres)			
Agricultural Land	1270	717.43	566.63	524.07
Settlement and Homestead Vegetation	543.4	59.82	71.27	75.85
Ashrayan project				3.73
Trees			1.52	
Swamp Area		59.58	48.33	38.86
Fallow Land		457.42	225.58	1.26
Sand			26.05	
Char Land		255.86	227.48	39.73
River		263.29	646.54	1129.9
Total	1813.4	1813.4	1813.4	1813.4

(Source: Field Survey, 2015)



(Source: Field Survey, 2015)

Figure 6.6: Overall land use in 1980, 2006, 2012 and 2015

Based on GPS (Geographical Positioning System) and GIS (Geographical Information System) analysis of individual mauza sheet, total land use or physical and cultural features of the study area in 2006, 2012 and 2015 has been calculated. According to the calculated value on 20

December 2006, agricultural land was 717.43 acres which is about 43.5% less than the area of lands used in 1980. Settlement and homestead vegetation was in 59.82 acres. This figure is about ten times smaller than the lands used in 1980 for settlement and homestead vegetation. It is remarkable that due to reduction of lands and loss of homestead the inhabitants of this area had been ousted from their original lands and removed their settlement in certain spots. Very densely populated bare houses without trees or houses with only young trees indicate that these are new settlement. Moreover, in the past time the people in the nature dependent riverine area used to built their houses nearest to the river for easy communication and house hold water. Trend of this habit is now changing due to increased consciousness and shortage of available agricultural lands which is their main source of earnings. In 2006, there were 59.58 acres of swamp area locally known as Jula which was used for Boro rice cultivation during Rabi dry season (Mid October- March) and also to plunge (preserve) their boats.

In December 2006 there were 457.42 acres fallow lands and 255.86 acres char lands, together comprising 713.28 acres which was about equal to total agricultural lands in that time. Because of their location and nature of soil, this large amount of land was either fallow or little use for ground nut cultivation. The newly accreted land was sandy and had little capacity to retain sufficient water for other crop cultivation. Although, this type of accreted land creates hopes to the land owners but in most of the cases this is temporary, sometimes due to human intervention and sometimes due to washed out of the lands by extreme flow of water within few years or further deep riverbank cutting by the flow of water before gaining the status of land for full potential agricultural use. Among the human intervention, land ownership is an important issue. When a river eroded, land go into the river, if it does not return as new char land within 25 years, it become Khas land. There is always a controversial role of government and local elites (Matobbor, Morol, Lathial etc). They deprive the rights of actual loser of the lands or landless people. Always new char lands are controlled by the local muscleman and their cohorts. In 2006 also there was a considerable area of lands into the river. Due to Riverbank erosion 263.29 acres of lands was into the river.

In 2012 (exactly 12.01.2013), highest amount of lands 646.54 acres was inside the river. 225.58 acres was fallow lands and 227.48 acres was char lands which were basically non-productive. At that time, 566.63 acres of land of my study area was used as agricultural lands. Reduction of agricultural land, which is the actual means of livelihood of the people of my study area means increasing vulnerability of livelihood due to riverbank erosion. By that time, settlement area was 71.27 acres, swamp area 48.33 acres, sands 26.05 acres.

By July 2015, about two-third area, 1129.9 acres of the land of my study area is in the river. It is mentionable that riverine part is not so useful for the river eroded community people. So the

people of my study area are in worst economic, financial and social position. Less than one-third i.e. only 524.07 acres of lands is used for agriculture. Due to loss of cultivable lands, the number of permanent as well as temporary unemployed has increased among the people of the study area. Settlement and homestead area remains about unchanged. 38.86 acres swamp area; 39.73 acres Char lands and 1.26 acres fallow lands.

The most optimistic cultural features of lands of the study area in 2015 is the existence of a "Ashrayan Project" in 5 acres of lands which provides permanent residence for 120 riverbank eroded family.

6.4 Findings from Livelihood Scenario in the Context of Riverbank Erosion

Agriculture is the main means of livelihood of the people of my study area. So, reduction of agricultural land means the increase in vulnerability of livelihood due to riverbank erosion. On 07 July 2015, about two-third area i.e., 1129.9 acres of the land of my study area was river eroded. The land which has gone into river is not useful for the river eroded community. So the people of my study area are in worst economic, financial and social position. Less than one-third i.e. only 524.07 acres of lands is used for agriculture now. As a consequence of riverbank erosion and loss of cultivable lands, the number of permanent unemployed people is increasing with the temporary and seasonal unemployed people of this area.

According to the findings of this research, 80% people of the current study area are dependent on agriculture. So, livelihood of the people of this area is largely dependent upon the availability of farming lands and easy access of the people to this land. Because of the recession of farming lands due to devoured land erosion by the river, livelihood of the people of the study area and its surrounding area is becoming vulnerable day by day.

So, riverbank erosion contributes immensely to the marginalization process of a large number of people of my study area due to loss of agricultural lands and homestead lands and adversely affecting their social and economic circumstances and affecting livelihood of the people of surrounding areas.

Respondents living in this study area have experienced riverbank erosion 1-20 times in their lives. 96% of the respondents have lost their agriculture lands, 92% of the respondents have experienced homestead loss and 62% of the respondents have experienced loss of vegetable garden in their life. 90% have lost their households and 20% have lost their cattle. Due to these losses income level of the river eroded people has decreased drastically leaving the people of this study area in a miserable condition. So, the loss due to riverbank erosion at present study area is massive.

Respondent's monthly income is within the range of Tk.5000-Tk.10000. Due to low income their standards of living including expenditure on food, clothing, healthy life style, safe drinking water and education is minimal.

94% respondents cannot afford to buy sufficient nutritious food for their family members.
Due to loss of homestead, they not only displaced from the original living place, in most of the cases their children also dropout from school education. After the loss of homestead, many children stop to go to school and subsequently dropped out of school.

Only 24% respondents have concrete ring slab made partially hygienic latrine.76% respondents use kacca latrine.

Respondents of the study area are poor in terms of their income and thus they are less capable to expend more money for other purposes such as clothing, strengthening house structure, invest in different income generating sources, savings, recreation etc. Only 10% respondents can provide new cloths for their children during the Eid and other religious festival.

(Source: Field Survey, 2015)

Figure 6.7: Common People of Kanaidia Mauza.

6.5 Impact Analysis of the Research

Findings and recommendations of this research will have a profound influence on the livelihoods improvements of the riverine community of the country which have been very briefly summarized in table 6.10.

Table 6.10: Impact Analysis of the Research

SL	Design Summary	Performance Targets and Indicators	Data Sources	Risks Assessment
01	**Impact** 1. This thesis report will have a broad effect on the society. 2. Livelihood conditions of the riverine community will be increased. 3. The Government may initiate programs for development of riverine areas of the country depending on recommendations of this study. 4. It will improve socio-economic conditions of the country by creating alternative employment opportunity for the river eroded vulnerable people. 5. Researchers will benefit with current database on riverbank erosion which will be beneficial for further studies.	1. It will create better scope of research on riverbank erosion by encouraging young researchers. 2. The Government will find loopholes in disaster mitigation program and will be able to initiate corrective measures for the betterment of river eroded community.	1. Primary and Secondary Including mauza maps, books, journals, websites, software, GPS and GIS techniques, findings from field survey etc.	1. Increment of livelihoods of riverine community of the country which ultimately improve the socio-economic conditions of the country. 2. Government development initiatives and awareness building programs will reinforce positive role in socio-economic development.
02	**Outcomes** 1. If the development planner can take initiative to develop livelihoods of the riverine people of the country according to	1. Livelihoods improvement of the river eroded people.		1. Development based research database will create better

	recommendations of this research, it will certainly improve the livelihoods of riverine community of our country. 2. If new school can be set up in the study area, dropout rate of primary education will decrease and average rate of literacy will improve. 3. A professional code of conduct for researcher. 4. Findings will improve quality education in the field of environment, geography and riverbank erosion which will create better avenue for higher studies.	2. Increment of household income level. 3. Increment of literacy rate in the riverine area. 4. Improvement of health and sanitation. 5. Enhancement of social awareness and social safety. 6. Gender equality 7. Socio-economic development of the study area.		windows for all research student in the field of Geography and environment, specially who are interested to study riverbank erosion based on mauza maps, GPS and GIS study.
03	**Outputs** The activities of the research have created many outputs. Some of the important findings are enlisted here- 1. Change in number of plots used for settlement and vegetation as well as partially and completely eroded number of plots have been determined. 2. Intensity of riverbank erosion of the study area has been determined. 3. Change in physical and cultural features of lands of the study area has come out. 4. Livelihoods impact of the study	1. Analysis of river bank erosion quantitatively and determination of its impacts both quantitatively and qualitatively on livelihood on the community people of the study area.	1. Analysis of both primary and secondary data using GPS and GIS techniques.	1. Findings will be beneficial for both policy planner and researcher in the field of river bank erosion, environmental and geographic studies.

	area has been determined by analyzing primary data from field survey. 5. Loopholes of Government and Non-government activities for improvement of livelihoods of the riverine areas of Bangladesh have been identified.			
04	**Activities**			**Inputs**
	Component-1: To collect and scan relevant mauza maps. 1. Collection of mauza maps from DLRS. 2. Scanning of the mauza maps with the help of Auto-Cad machine. 3. Preparation of hard copy of scanned mauza map in A3 size paper. 4. Collection of primary data from field survey. 5. Development of Google Earth Imageries for each mauza sheet for different time. 6. Counting the number of eroded, non-eroded and partially eroded plots, plots with settlement, vegetation, special features etc.			1.Supervisor's advice and guidance 2. Mauza Maps 3. Computer and Auto Cad Machine 4. GPS Machine 5. Google Earth Pro, ArcView 3.3, ArcGIS 10.2.1, MS Excel, MS word ….software. 6. Time, labor and money. 7. Soft copies of Mauza maps.
	Component-2 To develop and interpret database on riverbank erosion using GPS and GIS techniques. 1. Development of digitized river erosion maps for each mauza for different time. 2. Determination of percentagewise and quantitatively eroded and non-eroded lands for each mauza Sheet. 3. Development of table and pie-chart of eroded and non-eroded lands of each mauza individually and collectively.			
	Component-3 Mauza sheet wise selected features form overall field context. 1. Development of Land use map for each mauza of the study			

	area. 2. Determination of mauza sheet wise physical and cultural features of the study area. 3. Preparation of table and bar-diagram of physical and cultural features for each mauza sheet of the study area.	
	Component-4 The livelihood scenario in the context of riverbank erosion. 1. Occupational Status of the study area. 2. Losses due to riverbank erosion. 3. Income level of the study area. 4. Monthly expenditure on food. 5. Monthly expenditure on child education. 6. Expenditure for seeking healthcare facilities. 7. Sanitation. 8. Sources of drinking water. 9. Expenditure for other purposes. 10. Migration. 11. Remedial policies of the problem. 12. Existing survival strategies of displacees in the study area. 13. Resettlement of the homestead lost people. 14. Government strategies to improve the livelihood status of the riverbank. 15. Ashrayan project.	1. Field survey 2. Primary and secondary data.

(Source: Compiled by the Author, 2015)

Chapter 7
CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Riverbank erosion contributes immensely to the marginalization process of a large number of people of the country by displacing households and adversely affecting their social and economic circumstances, triggering the flow of displacement which causes many difficulties in the livelihoods of the riverine people. Though a number of policies and acts have been formulated with the aim of addressing the needs of pro-poor people of extreme river eroded area, the country is yet far from developing appropriate strategies and plans for addressing the causes and consequences of riverbank erosion. Unfortunately, riverbank erosion does not draw the attention of the government and non-government agencies as the other disasters do.

The riverbank eroded communities have limited access to institutional support and rehabilitation program. As most of the people of our country are small or marginal peasant particularly in the riverbank area, when they are displaced from their birth places due to riverbank erosion, most of them become disconnected from their sources of income, lands, food production and other livelihood options which compel them to search for new livelihood activities. Education of their children is disrupted and they face deprivation of safe water, sanitation and other basic needs.

As part of their survival mechanism, the affected people depend on indigenous knowledge and strategies. Usually when rainy season and erosion begin at the same time, they start shifting their belongings to safer places. Those who have access to boats and manpower can save their belongings while others are not able to protect everything.

A few of them who have the ability to buy new land shift their houses, while most of them continue to live in temporary shelters for a long time. Most of the households are forced to sell their personal belongings to survive after forceful displacement due to homestead loss. The place of resettlement completely depends on their networks, availability of the options and social kinship. Other factors also impact the choice of destination. As part of long term survival strategy, support from government and NGOs and credit and loans from relatives and neighbors help them a lot to begin a new livelihood. It is not painless for them to gain access to banks or other financial institutions for credit or loans.

7.2 Recommendations

At Present, there is a wide gap in coordination among the various government agencies and also between the government and non-government initiatives with regard to riverbank erosion. The government initiative is limited on some subsidy programs including relief distribution, Vulnerable Group Feeding (VGF), Vulnerable Group Development (VGD), allocation of khas lands, settlement program based on destitute women and public health management. Moreover, these programs are inadequate, disorganized, politically motivated, ad-hoc and often ineffective. So, there are ample scopes for improvement of government initiatives. Close coordination between local governments, administrative institutions and inclusion and participation of riverine community is the prerequisite to reduce the anomalies among different local government institutions. On the other hand, only few NGOs have specific programs targeting riverbank erosion affected people, although they make enormous efforts for addressing the other disasters, both natural and man-made.

1. The government need to made easy accessible and smart database on different types of maps including mauza maps to encourage innovative research on riverbank erosion and a clear vision is urgent for addressing RBE.
2. A National data base is required to assess the magnitude of riverbank erosion and the number of people affected by it.
3. At present there is no appropriate policy to rehabilitation, policy to arrange sufficient habitat for the homestead lost river eroded people. So, a national habitat policy should be formulated that would ensure the need for shelter of thousands of people displaced every year as early as possible.
4. Local Government Institutions must be empowered and decentralized. LGIs should play the lead role and they should have the statistics of possible affected people who live in the risky side of the river. In addition to this, local government agencies should have the capacity to respond quickly and effectively alone with accountability and transparency mechanism with the aim of reducing vulnerability.
5. Setting up early warning systems in all the critical zones and monitoring during critical periods using the local knowledge is very much essential; early preparedness as well as immediate mitigation measures is very much essential on the basis of erosion prediction of the experts.
6. Establishing embankments in the severe erosion prone areas.
7. Generating alternative employment opportunity based on local resources related to fishing and farming industry.
8. Motivation of afforestation program and penalization against deforestation is demanded to reduce river erosion.

9. Natural flow of water should not be hampered by the name of development program.
10. Development program should be participatory and inclusive. Local and affected people should be consulted before taking any development program related to their affairs.
11. Taking initiative to distribute “khas” lands to most vulnerable people. Good governance must be ensured while administering “khas land” distribution program.
12. Innovation of short duration crops and vegetables suitable to grow in sandy char lands and building mechanisms to connect these newly invented technologies can be a smart solution to improve the livelihood of the people of riverine community. The existing agriculture policy needs strategic direction in terms of dealing with the challenges of climate change and river erosion. The farmers of riverine area need adaptive training on riverbank erosion.
13. During rehabilitation of the affected community in the erosion prone areas, there should be a resettlement plan for income generating activities and development of health care facilities, services and education.
14. Politically motivated and interest driven plan for erosion control must be avoided.
15. A National Co-ordination Council may be formed to co-ordinate bank protection works and victims support and development program for improved livelihoods.
16. Both GO and NGOs can come forward with flexible credit schemes to the affected people so that they can immediately restart their income generating activities. Bangladesh is the home to world renowned NGOs like BRAC and ASA who can campaign for rights-based advocacy campaign and awareness building program, so that affected people may be encouraged to demand access to education, healthcare, water, sanitation and work opportunities as part of their rights.
17. Considering the extent and intensity, it is high time to develop national level strategies for better response to riverbank erosion. It is true that, we cannot fight against the forces of nature, but it is not impossible to develop strategies to fight against its consequences.

On the basis of current research work the following important plan of action and their possible implementing authority may be recommended.

Table7.1: Recommendations with Possible Implementing Authority.

Recommendation	Concerned Organizations
1. Country’s land administration system needs to be made stronger, transparent, trustworthy and citizen centric.	1. Ministry of lands, Directorate of Land Survey and Records. District, Upazila and Union land office.
2. There should be easy accessible data base on different Mauza Maps.	2. DLSR, MOL, District, Upazila and Union land Office.

3. Data base of erosion.	3. BBS, MODMR and LGI.
4. There should be a National Habitat Policy.	4. MODMR, Ministry of Law.
5. Decentralization and empowerment of LGIs along with accountability and transparency mechanism. LGI's should preserve the statistics of possible affected people.	5. LGED, MOPA.
6. Setting up early warning systems and national awareness building program in all the critical zones and monitoring during critical periods.	6. Bangladesh Meteorological Department, Bangladesh Betar, Community Radios, TV's, Ministry of Information.
7. Establishment of embankment and spurs.	7. BWDB with finance from Government and development partners.
8. Generating alternative employment opportunity.	8. MOA, MOFL, MOLE, MOI, Ministry of Tourism.
9. Afforestation	9. MOEF, MOA, LGIs.
10. Innovation of short duration crop and vegetables varieties suitable to grow in sandy char land.	10. Ministry of Agriculture, Bangladesh Agricultural University, Agriculture Research Institutions of Bangladesh.
11. Dredging of major river so that natural flow of water could not be hampered.	11. BIWTA
12. Participatory and inclusive Development program.	12. All GO and NGO activities in the river eroded area.
13. Khas land distribution.	13. Ministry of Land, MOPA and MOI.
14. Van on interest driven Politically motivated project.	14. Government
15. A National Co-ordination Council may be formed to co-ordinate bank protection works and victims support and Development program for livelihoods.	15. MOL, MOPA, MOI, MODMR, LGED MOH, MOE, PHED, MOWCA, MSW, MWR.
16. Flexible Credit Policy.	16. Bangladesh Bank, NCBs, NGOs.
17. Right based Advocacy Campaign.	17. MOWCA, MOI, MOL, NGOs, Civil Society.
18. National strategies to better response of RBE.	18. MOFDM, BWDB, MWR, MOHFW, MOE, MOPME, PHED.
19. Inclusion of Riverbank Management as a Subject in all Public Universities.	19. University Grant Commission.

20. Training Program on Riverbank Management and adaptive technology for the farmers and riverine community..	20. BPATC, Disaster Management Cell PM Office, BWDB, MOFDM, RRI.
21. Community people can be trained on better health and sanitation issues.	21. NGOs, MOHFW, MOWCA, MSW.
22. Establishment of primary school and one High school in the study area.	22. MOE, MOPME.
23. Resettlement Plan	23. Ministry of Food and Disaster Management

(Source: Compiled by the Author, 2015)

Finally, it should not only be the role of GO and NGO to improve the livelihoods conditions of Bangladesh. In order to improve the livelihood conditions of the people of river eroded people of Bangladesh we ourselves must play our very own roles. From our individual standpoint, we need to do our small, bit right. We need to focus more on what we as individuals can do for improvement of livelihood of the river eroded community of the country. Our collective belief, action and positive energy will answer the negativity that exists; it will work as a strong influence for even the government to do the right thing. In today's world of social media and interconnectivity, driving this change is easier than ever. We should always remember the force behind us is always stronger than the challenges ahead of us. If we care about Bangladesh and its image, if we believe it needs to be changed, then the responsibility lies with us.

References

1 Ahmed, Q.K. Verghese, B.G. Iyer, R.R. Pradhan, B.B. and Mallah, S.K. (1994), 'Converting Water into Wealth: Regional Cooperation in Harnessing the Eastern Himalayan Rivers'. Academic Publishers, Dhaka.

2 Aktar Most. Nazneen 2013,'Historical Trend of Riverbank Erosion along the Braided River Jamuna', International Journal of Sciences: Basic and Applied Research (IJSBAR) (2013) Volume 11, No 1, pp 173-180; accessed July 2015from http://gssrr.org/index.php

3 Ali A. 2000, 'Vulnerability of Bangladesh to Climate Change and Sea Level Rise'; Paper Presented in the International Day for Disaster Reduction Seminar, 11October 2000, Dhaka, Bangladesh.

4 ALRD-2014, 'Annual Report: Association for Land Reform and Development 2013-2014', ALRD Team, Dhaka, Bangladesh. Retrieved 25 July 2015 from https://drive.google.com/file/d/0B2ZFilaTEOZKd2pwbW9uYjBQMmc/view?pref=2&pli=1

5 A.t.m. Abdullahel Baki 2014, 'Socio-Economic Impacts of Gorai Riverbank Erosion on People: A Case Study of Kumarkhali, Kushtia'. Accessed on 12 July 2015 from http://dspace.bracu.ac.bd/bitstream/handle/10361/3532/13372004.pdf

6 Bangladesh Water Development Board 2015, Retrieved 15 July 2015 from http://www.bwdb.gov.bd/index.php

7 Bangladesh Bureau of Statistics 2011, 'Bangladesh Population Census 2011', Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka

8 Banglapedia: National Encyclopedia of Bangladesh 2015, 'Brahmaputra-Jamuna River and Drainage System of Bangladesh'. Retrieved 23 July 2015 from http://en.banglapedia.org/index.php?title=Bangladesh_Water_Development_Board

9 Brouwer Roy, Sonia Aftab and Luke Brander 2007, 'Socioeconomic Vulnerability and Adaptation to Environmental Risk: A Case Study of Climate Change and Flooding in Bangladesh Risk Analysis'. Vol. 27, No. 2, 2007; accessed from https://www.researchgate.net/publication/6320196_Socioeconomic_Vulnerability_and_Adaptation_to_Environmental_Risk_A_Case_Study_of_Climate_Change_and_Flooding_in_Bangladesh on 12 June 2015.

10 Burger, J., Klaassen, G.J. and Prins, A., 1991; Bank erosion and channel processes in the Jamuna River, Bangladesh, in: Riverbank Erosion, Flood and Population Displacement in Bangladesh, Elahi, K.M., Ahemd, K.S., and Mofizuddin, M. (eds), pp. 13-29, Publ. by Riverbank Impact Study, Jahangirnagar University, Dhaka.

11 BWDB 2015, Bangladesh: Flood and Riverbank Erosion Risk Management Investment Program, Prepared by the Bangladesh Water Development Board for the Asian Development Bank. Accessed from http://www.bwdb.gov.bd/tender_doc/4429.pdf on 29 June 2015

12 Center for Environmental and Geographical Information Services (CEGIS), 2014, Ministry of Water Resources Bangladesh. Retrieved 29 July 2015 from http://202.53.173.179/cegisweb/Services.aspx

13 Chambers, R. and Conway, G.R. 1992, 'Sustainable Rural Livelihoods: Practical Concepts for the 21st Century' IDS Discussion Paper 296 Publisher IDS. Retrieved 12 July 2015 from http://www.ids.ac.uk/publication/sustainable-rural-livelihoods-practical-concepts-for-the-21st-century

14 COAST Trust 2007, 'River erosion in Bangladesh; Campaign Brief: Impact of Climate Change in Bangladesh', Dhaka. Retrieved 28 July 2015 from http://www.unisdr.org/files/4032_DisasterBD.pdf

15 Coleman, J. M. 1969, 'Brahmaputra River channel process and sedimentation'. In: Sedimentary Geology, 3 (2-3): 129-239.

16 'Community Report: Manikganj District' 2015, Bangladesh Population and housing Census 2011, Statistics and informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka. Accessed on 15 June from http://www.bbs.gov.bd/WebTestApplication/userfiles/Image/PopCen2011/C_Manikganj.pdf

17 Das, S. K. (2010), "'People without Shadows': Ethnographic Reflections on Identity and Justice in Contemporary India", Peace Prints: South Asian Journal of Peace building, 2(3). URL (accessed 18 September 2014): Retrieved 25 June 2015 from http://wiscomp.org/pp-v3-n2/peaceprints4.htm

18 Das T.K., Haldar S.K., Das Gupta I., Sen Sayanti 2014, "Riverbank Erosion Induced Human Displacement and its consequences", Retrieved 15 June 2015 from http://lrlr.landscapeonline.de/Articles/lrlr-2014-3/download/lrlr-2014-3BW.pdf

19 Das T. K. and Haldar S. K. and Das Gupta Ivy and Sen Sayanti 2014, 'Four Riverbanks Erosion in the World', Living Rev. Landscape Res., 8 (2014), 5. Accessed from http://lrlr.landscapeonline.de/Articles/lrlr-2014-3/articlese4.html on 15 June 2015.

20 Department of Disaster Management, 2012, Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh. Retrieved 13July 2015 from www.ddm.gov.bd/erosion.php

21 Dhaka, Tribune, 2015, 'Riverbank erosion may make 26940 landless this year', Retrieved 3 April from http://www.dhakatribune.com/bangladesh/2015/apr/03

22 Edwards, M. 2000, Community Guide to Development Impact Analysis. Retrieved 25 February 2015 from

www.lic.wisc.edu/shapingdane/facilitation/all_resources/impacts/analysis_socio.htm

23 Elahi K.M. 1991, Riverbank Erosion, Flood Hazard and Population Displacement in Bangladesh: An Overview. In Elahi, K. M., Ahmed, K. S., and Mafizuddin, M. (eds), Riverbank Erosion, Flood Hazard and Population Displacement in Bangladesh. Dhaka, Riverbank Erosion Impact Study (REIS), 364 pp [From Khalequzzaman].

24 Elahi, K. M., Ahmed K. S. and Mofizuddin M. (eds) 1991, Riverbank Erosion, Flood and Population Displacement in Bangladesh, Dhaka, Riverbank erosion Impact Study (REIS), Savar, Jahangirnagar University.

25 Elahi, K. M. and Rogge, R.J. 1991, Riverbank erosion, flood and population displacements in Bangladesh: A Report on the Riverbank Erosion Impacts Study, Jahangirnagar University, Savar, Dhaka.

26 Erosion (n.d.). Online Etymology Dictionary. Retrieved July 19, 2015, from Dictionary.comwebsite: http://dictionary.reference.com/browse/erosion

27 E.U. Pahlowan and A.T.M.S. Hossain, 2015, 'Jamuna River Erosional Hazards, Accretion & Annual Water Discharge—A Remote Sensing & GIS Approach', The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-7/W3, 2015 36th International Symposium on Remote Sensing of Environment, 11-15 May 2015, Berlin, Germany.

28 FAP – Flood Action Plan 21, 1993, The dynamic physical and human environment of riverine charlands: Meghna, Dhaka: Floods plan coordination organization. Ministry of Irrigation, Water Development and Flood Control, Dhaka, pp 1-63.

29 FAO, 2011; Ganges-Brahmaputra-Meghna River Basin. Accessed on 16.06.2015 from http://www.fao.org/nr/water/aquastat/basins/gbm/index.stm

30 Greenberg, C., 1986, The Adaptation Process of Riverbank Erosion Displacees in an Urban Environment: A Case Study of Squatters in Sirajganj, Bangladesh, Unpublished thesis, University of Manitoba, Winnipeg.

31 Haggart Kelly1994, Rivers of Life, Bangladesh Centre for Advanced Study (BCAS), Dhaka.

32 Halli, S.S. 1991, Economic Impact of Riverbank Erosion in Kazipur. *In* K.M. Elahi, K.S. Ahmed and M. Mafizuddin (eds.), Riverbank Erosion, Flood and Population Displacement in Bangladesh, Dhaka: REIS, JU.

33 Haque, Chowdhury Emdadul (1986) Impacts of river bank erosion on population displacement in the lower Brahmaputra (Jamuna) floodplain. Population geography: a journal of the Association of Population Geographers of India 8(1-2):1-16

34 Haque, Chowdhury Emdadul 1991, Human Responses to Riverbank Erosion Hazard in Bangladesh: Some Lessons from Indigenous Adjustment Strategies. *In* K.M. Elahi, K.S. Ahmed and M. Mafizuddin (eds.), Riverbank Erosion, Flood and Population

Displacement in Bangladesh, Dhaka: REIS, JU.

35 Haque, C. E. and Zaman, M. 1989, Coping with riverbank erosion hazard and displacement in Bangladesh: Survival strategies and adjustments. In: Disasters, 13 (4): 300 -314.

36 Haque, C. 1997, Hazards in a fickle environment: Bangladesh, Kluwer Academic Publishers, Boston.

37 Haque, M. 1999, Indigenous knowledge and practices in disaster management in Bangladesh, In: Grassroots Voice, Volume II, Issue II and III. Dhaka.

38 Hassan, M., Haque, M. S., and Saroar M. 2000, 'Indigenous knowledge and perception of the Char land people in cropping with natural disasters in Bangladesh'. In: Grassroots Voice: A Journal of Resources and Development, III (I-II): 34- 44.

39 Hossain, M.Z. 1984, Riverbank Erosion and Population Displacement: A Case of Kazipur in Pabna. M.Sc. Thesis (mimeo), Department of Geography, JU, Dhaka.

40 Hutton D. and Haque C.E. 2004, Human Vulnerability, Dislocation and Resettlement: Adaptation Processes of River-bank Erosion-induced Displacees in Bangladesh, Published by Blackwell Publishing, 9600 Garsington Road, Oxford, 0X4 2DQ, UK. Retrieved 22 July 2015 from http://www.ncbi.nlm.nih.gov/pubmed/15016105

41 Irrigation Support Project for Asia and the Near East (1993), Ministry of Irrigation Water Development and Flood Control, Flood Action Plan-21(FAP 21): The Dynamic Physical and Human Environment of Riverine Char-Lands: Meghna, Dhaka: Floods plan coordination organization, ISPAN. EGIS Press, Dhaka, pp 1-32.

42 Islam M. and Islam A (1985), 'A Brief Account of Bank Erosion, Model Studies and Bank Protective Works in Bangladesh'. REIS Newsletter, 2, 11-13.

43 Islam and Islam 1985, Cited in Hutton D. and Haque C. E. 2004, Human Vulnerability, Dislocation and Resettlement: Adaptation Processes of River-bank Erosion–induced Displacees in Bangladesh, Disasters, 2004, 28(1): 41-62.

44 Islam A. 1995, Environment Land use and Natural Hazards in Bangladesh, University of Dhaka, Dhanshiri Mudrayan (Press), Dhaka, pp 227-276.

45 Islam and Rahman 1987, 'Bank Erosion of the river Meghna: Population displacement and socioeconomic impacts', Indian Journal of Power and river valley Development.

46 Islam, MD F. Ph.D. and Rashid A.N.M. Bazlur, Ph.D. (2011), 'Riverbank Erosion Displacees in Bangladesh: Need for Institutional Response and Policy Intervention', Bangladesh Journal of Bioethics, 2011:2(2): 4-19.

47 Islam M. F. and Rashid A.N.M. B. 2011, 'Riverbank erosion displaces in Bangladesh: Need for institutional response and policy intervention', Bangladesh Journal of Bioethics, 2(2); P4-19. Retrieved 23 July 2015 from file:///C:/Users/User/Downloads/9540-35048-1-PB%20(4).pdf

48 Islam MS, Sultana S, Saifunnahar Mr. and Miah MA, 2011, 'Adaptation of Char Livelihood in Flood and River Erosion Areas through Indigenous Practice: A Study on Bhuapur Riverine Area in Tangail', J. Environ. Sci. & Natural Resources, 7(1): 13-19. Retrieved 24 July 2014 from http://www.banglajol.info/index.php/JESNR/article/view/22138

49 Islam, N. 1993, Rural housing in Bangladesh: an overview in search of new strategies. In: Oriental Geographer, 37 (2): 47-59.

50 Islam, M. and Islam, A. 1985, 'A brief account of bank erosion, model studies and bank protective works in Bangladesh', REIS Newspaper Vol. 2: pp 11-13.

51 Islam, S.N. 2011, Char-lands Development Policy for Livelihoods Sustainability in the Padma River Basin in Ganges Delta in Bangladesh, 2011 KAPS International Conference, pp 349-370.

52 Islam S.N. 2011, 'Char-lands Development Policy for Livelihoods Sustainability in the Padma River Basin in Ganges Delta in Bangladesh'. Accessed on 17 March 2015 from http://www.academia.edu/2152265/CharLands_Development_Policy_for_Livelihoods_Sustainability_in_the_Padma_River_Basin_in_Ganges_Delta_in_Bangladesh

53 ISPAN-Irrigation Support Project for Asia and the Near East (1995). The dynamic Physical Environment of Riverine Char-Lands: Padma River, Prepared for Flood Plan Coordination Organization (Unpublished technical report), Dhaka, Bangladesh, pp 5 -8. Retrieved 25 February 2015 from http://pdf.usaid.gov/pdf_docs/PNABW817.pdf

54 IUCN - International Union for Conservation of Nature and Natural Resources (1993). People, Development and Environment Complex Interlink in Bangladesh. In: Proceedings of National Symposium held in Dhaka, Bangladesh. Dyna Print Ltd, Bangkok, pp 31-153.

55 Joint River Commission of Bangladesh 2015, Ministry of Water Resources, The People's Republic of Bangladesh. Retrieved 10 February 2015 from http://www.jrcb.gov.bd/basin_map.html

56 Kazi Rajib, 2015, Panaromio Photographs of Jafarganj, Shibalaya. Retrived 25 December 2014 from http://www.panoramio.com/photo/115364608

57 Kuehl, S.A., Hariu, T.M., and Moore, W.S., 1989; Cited in Shelf sedimentation of the Ganges-Brahmaputra river system: evidence for sediment by passing to the Bengal Fan. Geology, 17: 1132-1135.

58 Mahmud, K.H. 2013, "Introductory GIS", Nabarun Publication, Dhaka.

59 Malik, S., 1983, 'Land Reclamation', Bangladesh Today 1(1): 25-28.

60 Meade, R.H. 1996, River sediments input to major deltas. In: JD, Milliman and BU Haq (eds), Sea-level Rise and Coastal Subsidence, Kluwer Academic Pub., P 63-85.

61 Milliman, J.D., Rutkowski, C., and Meybeck, M., 1995, River Discharge to the Sea: A Global River Index (GLORI). NIOZ, Texel. P125.

62 Ministry of Disaster Management and Relief, People's Republic of Bangladesh. Retrieved 10 December 2014 from http://old.ddm.gov.bd/erosion.php

63 Ministry of Water Resources 2000, Government of the People's Republic of Bangladesh.

64 Morgan, IP. and McIntire, W.G. 1959, Quaternary Geology of the Bengal Basin, East Pakistan and India. Bull. Geol. Soc. Amer; 70 (3): 319-342.

65 Mutton and Haque 2004, 'Human Vulnerability, dislocation and Resettlement: Adaptation Process of Riverbank Erosion-induced in Bangladesh', Scholar articles; Publisher Blackwell Publishing Ltd. Retrieved 15 July 2015 from http://onlinelibrary.wiley.com/doi/10.1111/j.0361-3666.2004.00242.x/abstract

66 Oldeman, L. R. 1991-92, Global Extent of Soil Degradation, ISRIC Bi-Annual Report, pp 19-36.

67 Rahman, M. R. 2013, 'Impact of Riverbank Erosion Hazard in the Jamuna Floodplain Areas in Bangladesh', Journal of Science Foundation, 8(1-2). Retrieved 7 July 2015 from http://lrlr.landscapeonline.de/Articles/lrlr-2014-3/articlese4.html

68 Rahman, S. U. 2014, 'Impacts of flood on the lives and livelihoods of people in Bangladesh: a case study of a village in Manikganj district'.

69 Raju Md. N. A. and Taznin. A. 2015,"Coping with Riverbank Erosion: What should we focus on"? retrieved 15 September 2014 from http://www.thedailystar.net/coping-with-river-bank-erosion-what-should-we-focus-on-43199

70 Raju, Md. N. A. 2015, 'Coping with Riverbank Erosion', *Financial Express*, Dhaka, Bangladesh.

71 Risk mapping of natural hazards in Shibalaya upazila of Manikganj district. Retrieved 24 June 2015 from http://www.assignmentpoint.com/arts/sociology/risk-mapping-of-natural-hazards-in-shibalaya-upazila-of-manikgonj-district.html

72 Ritter, J. 2012, Soil erosion-causes and effects, Retrieved 10 March 2015 from http://www.omafra.gov.on.ca/english/engineer/facts/12-053.htm

73 Rogge, J. and Elahi, K. M. 1989, 'The Riverbank Impact Study, Bangladesh', University of Manitoba, Winnipeg, Canada. pp 1-32.

74 Siddiqui, T. 2002, Beyond the Maze: Streamlining Labor Recruitment Process in Bangladesh, RMMRU, Dhaka.

75 Siddiki et al., 2014, 'Mauza based mapping and quantitative analysis of small Water bodies using GIS in a flood prone area of Bangladesh', Int. Journal of Applied Sciences and Engineering Research, Vol. 3.

76 Soil Resources Development Institute (SRDI), 2000: Land and Soil User Manual, Shibalaya, Manikganj.

77 Taleb Md. Abu, Kabir Md. Humayun and Muhibbullah Md. 2009, 'Survival Strategies Among Erosion- Induced Displacees at Haimchar Upazila, Chandpur District, Bangladesh', The Chittagong Univ. J. B. Sci., Vol. 4(1&2),2009, pp 25-39.

78 The Char Development and Settlement Project Phase IV (CDSP IV). Retrieved 20 June 2015 from http://www.cdsp.org.bd/

79 The Daily Star, Bangladesh 2015, retrieved March, 2015 from http://www.thedailystar.net/jamuna-devours-homesteads-markets-at-jafarganj-33650

80 The Financial Express, Bangladesh 2014.

81 The Financial Express, Bangladesh 2014.

82 Uddin A.F.M.A and Basak J. K. 2012, 'Effects of Riverbank Erosion on Livelihood', Unnayan Onneshan, Dhaka. Retrieved 10 October 2014 from http://www.bdresearch.org.bd/home/attachments/article/758/Effects_of_Riverbank_Erosion_on_Livelihood.pdf

83 Wiest, R.E.1991, Domestic Group Dynamics in the Resettlement Process Related to Riverbank Erosion in Bangladesh. In K.M. Elahi, K.S. Ahmed, and M. Mafizuddin (eds), Riverbank Erosion, Flood and Population Displacement in Bangladesh. Dhaka: REIS, JU.

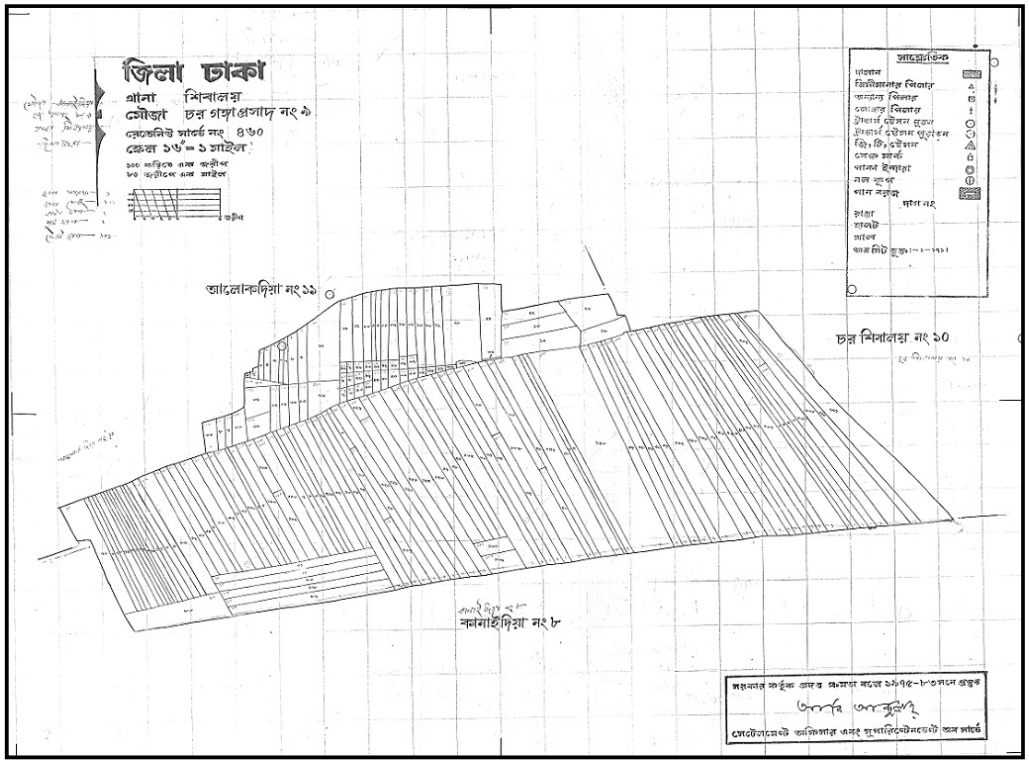
84 Yeasmin and Islam 2011, 'Changing trends of channel pattern of the Ganges-Padma river', International Journal of Geometrics and Geosciences, volume 2, no 2. Retrieved 15 June 2015 from http://www.ipublishing.co.in/jggsvol1no12010/voltwo/EIJGGS3057.pdf

85 Zamman, M. Q. 1989, 'The Social and Political context of adjustment to Riverbank Erosion Hazard and Population Resettlement in Bangladesh', In: Human Organization, 48 (3):196 -205.

86 Weist, R.E. and Zaman, M.Q. 1991, 'Riverbank erosion and population resettlement in Bangladesh', Practicing Anthropology 13(3):29-33.

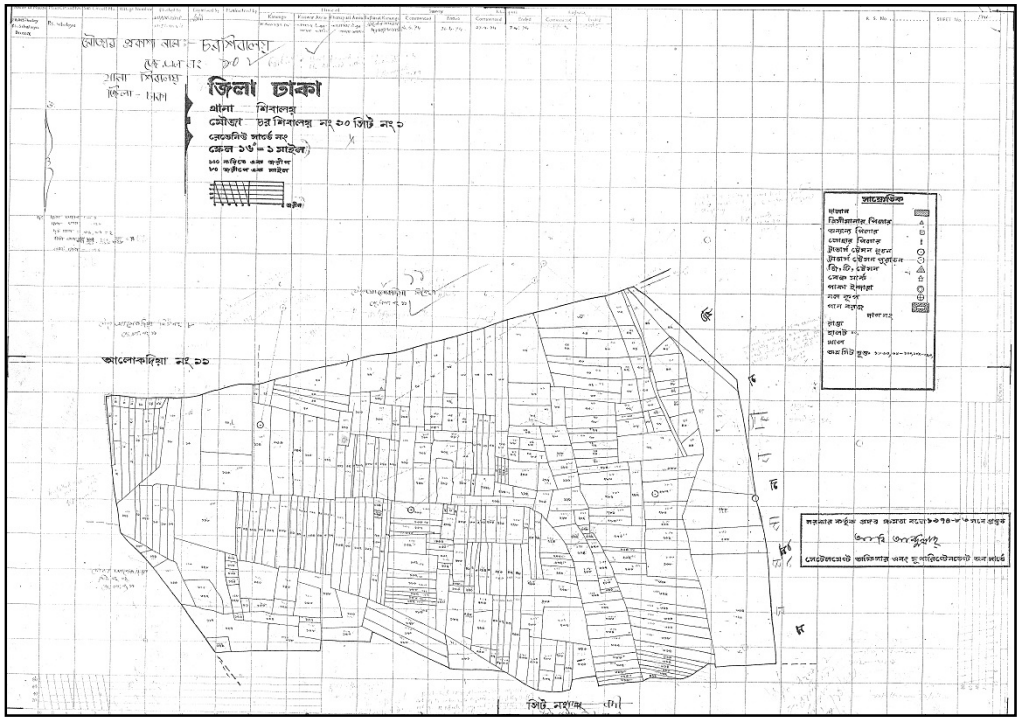
Appendices

Appendix 1.1: Mauza map: RS Mauza Map of Char Ganga Prasad



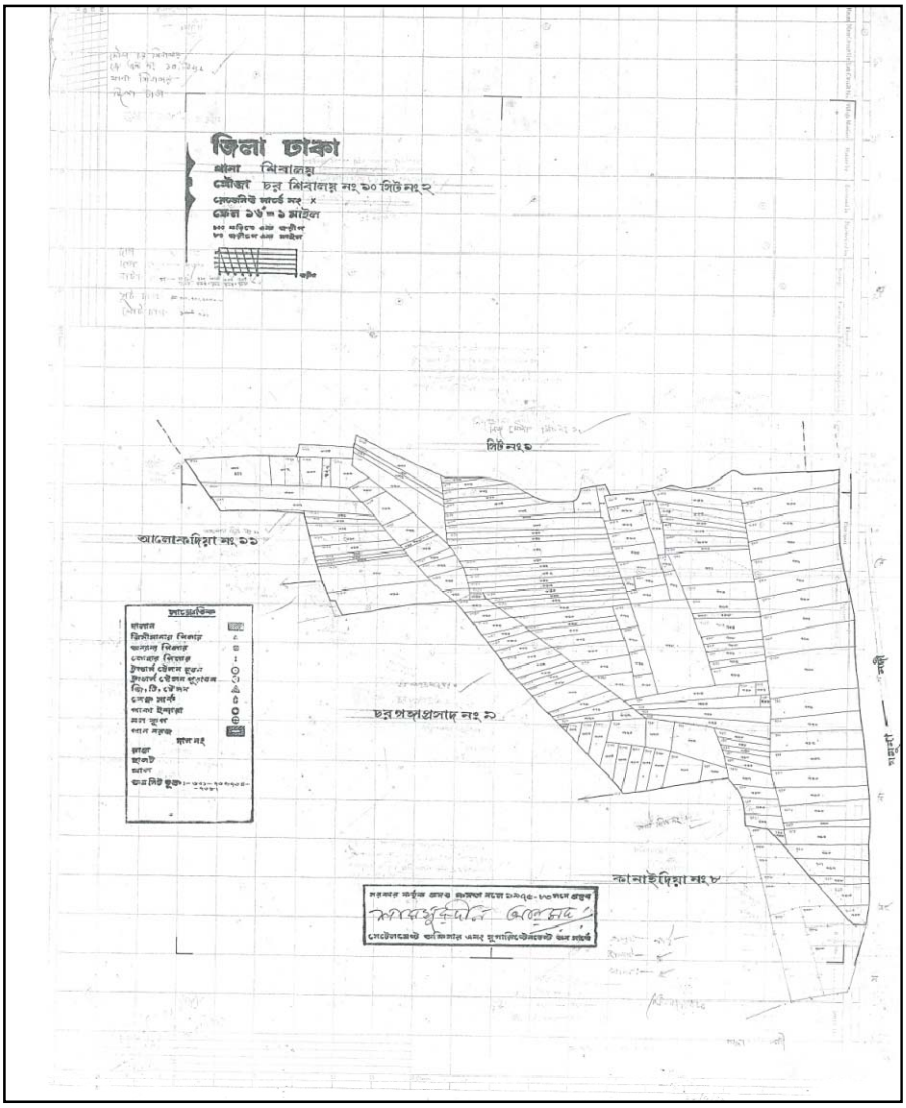
(Source: Mauza map of Char Ganga Prasad compiled by the author, 2015 by scanning original mauza map with Auto CAD machine); Resolution 200 DPT (Dot per inch); format: JPG

Appendix 1.2: RS Mauza map: Char Shibalaya Sheet-1



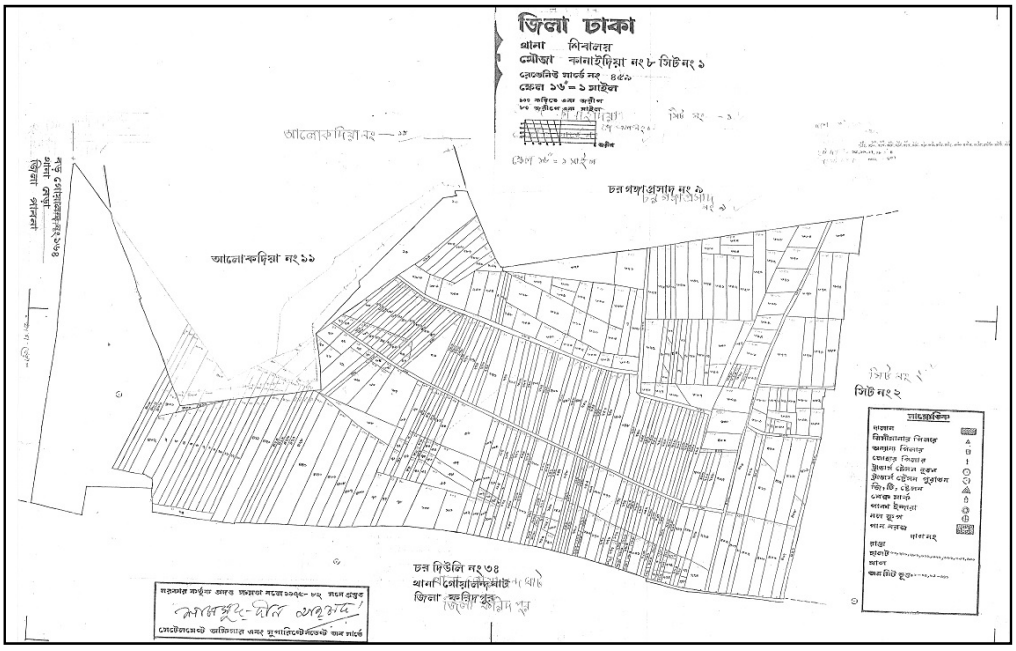
(Source: Mauza map of Char Shibalaya Sheet-1, compiled by the author, 2015 by scanning original mauza map with Auto CAD machine); Resolution 200 DPT (Dot per inch); format: JPG

Appendix 1.3: RS Mauza map: Char Shibalaya Sheet No.2



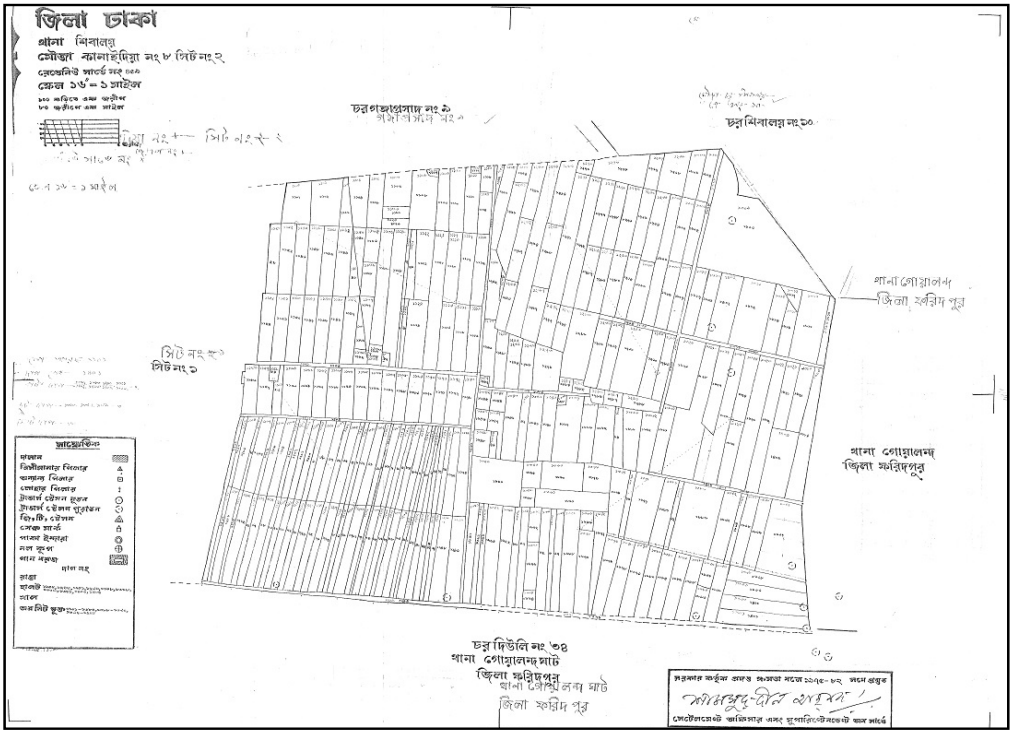
(Source: Mauza map of Char Shibalaya Sheet No.2, Compiled by the Author, 2015 by scanning original mauza map with Auto CAD machine.); Resolution 200 DPT (Dot per inch); format: JPG

Appendix 1.4: RS Mauza Map: Kanaidia Mauza, Sheet No.1



(Source: Mauza map of Kanaidia, Sheet -1, Compiled by the Author, 2015 by scanning original mauza map with Auto CAD machine.); Resolution 200 DPT (Dot per inch); format: JPG

Appendix 1.5: RS Mauza Map: Kanaidia Mauza, Sheet No.2



(Source: Mauza map of Kanaidia, Sheet -1, Compiled by the Author, 2015 by scanning original mauza map with Auto CAD machine.); Resolution 200 DPI (Dot per inch); format: JPG

Appendix 1.6: Few Photographs of the study

(Source: Field Survey, 2015)

Photograph: Professor is nurturing the student with his scholastic views and ideas of the Research

(Source: Field Survey, 2015)

Photograph: Extreme Erosion Prone Area of Char Shibalaya Mauza

(Source: Field Survey, 2015)

Photograph: Char Ganga Prasad Ashrayan Project which now very close to Jamuna Riverbank

(Source: Field Survey, 2015)

Photograph: Densely populated river eroded people's house in Char Shibalaya. These houses are also verge of erosion.

(Source: Field Survey, 2015)

Photograph: Moment of Field Survey in Kanaidia Mauza

(Source: Field Survey, 2015)

Photograph: Extreme Erosion Prone Kanaidia Mauza (Sheet-2)

(Source: Field Survey, 2015)

Photograph: Union Land Office Shibalaya

(Source: Field Survey, 2015)

Photograph: BIWTA Office, Aricha, Shibalaya taken while visiting this office during Field Survey