King Fahd University of Petroleum & Minerals

CITY & REGIONAL PLANNING DEPARTMENT

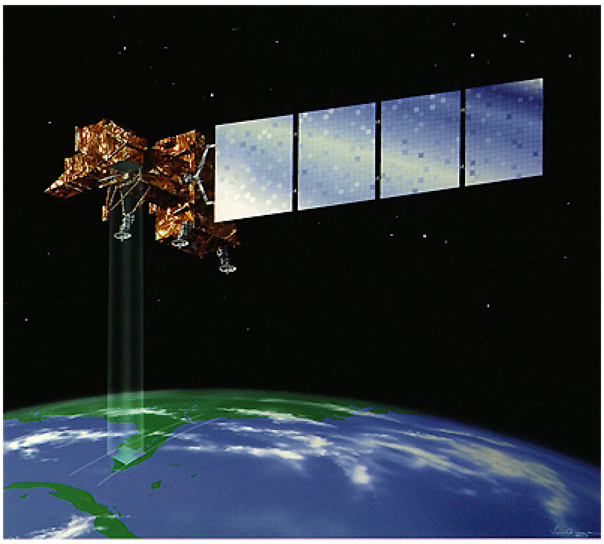
Introduction to GIS
CRP 514 – (101)

Term Paper on

Tracking the morphological change of a river extent of Bangladesh using satellite images in ArcGIS

Submitted to
Dr. Baqer Al-Ramadan

Submitted by
Imran Reza
Student ID: 201003280



January 23, 2011

ABSTRACT

River shapes surrounding landscapes by continuous change in hydrodynamic and subsequent morpho-dynamic processes. The part of the course of River Padma and the Lower Meghna drained through the central part of Bangladesh has been taken as the study area. In Chandpur the lower course of Meghna flows on a very gently sloping area with low elevation which reduces rather stops the process of valley incision (deepening) but lateral erosion process and valley widening continues. Such processes develop wide floodplain over which the river Meghna gradually and continuously changes its course that reshaped channel morphology and developed several landforms. In this paper, an attempt has been made to consider such shifts and to evaluate the micro level morphological changes that have taken place in last several years. The changes have also been quantified and analyzed by the application of different tools of GIS software. This study estimates the severity of the river shifting process of this region and subsequent micro level morphological changes, which may help in the holistic management plan to protect the river including the cultural landscapes.

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CHAPTER 1

Introduction

1.1 General

A close relationship always exists between man and rivers since the beginning of civilization, because water has always been an integral part of man's development. Most of the early civilizations were survived as well as developed near the river valleys. The most ancient commercial places have been developed along river banks. Bangladesh is a riverine country with hundreds of rivers overlaying its landscape. Because of its inherent alluvium nature, the rivers of Bangladesh are morphologically dynamic characterized by erosion and sedimentation, which results in changes in hydraulic geometry; plan form and longitudinal profile of the rivers (Habibullah, 1987). Aggradations, degradation or change in plan forms; change in river bed and meandering characteristics are most common features in the rivers of Bangladesh, affecting the major rivers as well as the medium and the minor rivers. When bank erosion of a river takes place the drainage capacity of the river and navigation is hampered and consequently a large number of populations are directly or indirectly affected. Erosion could be mitigated through local protective measures for the time being but properly designed river control and training structures are required to reduce the loss of lands. A detailed study of hydraulic geo morphology can help controlling rivers in an effective manner.

This study demonstrates how GIS can be used for describing spatial and temporal trends of physical river data, including geomorphic trends and features associated with the local environmental condition of the study area. This study will aid in understanding physical changes in channel form that are linked to essential habitat features. Geomorphic trends are assessed through an examination of spatial physical data in ArcMAP (v 9.3, a GIS application).

Coastal Zone accounts for about 23% of the land area of Bangladesh. Per capita land availability is very low (Singh, 2000). Above this substantial amount of land is lost due to erosion in coastal region. Although land is also accreted in some other locations that land does not become useful and productive immediately. Inhabitants living in areas subjected to erosion become landless. Their sufferings can be minimized by identifying eroded zone and land accretion opportunities. Being a small country, Bangladesh needs to extend land areas which can be done only by accretion in coastal region. Therefore, the **GIS technology** to this fatal problem can be effectively used to find out the land eroded or accreted along the river Bank.

1.2 Background of the Study

The Padma-Meghna estuary is a very dynamic estuarine system. Meghna Estuary extends from Chandpur to the northern end of the Bay of Bengal which is a coastal plain estuary on the coast of Bangladesh. The coast of Bangladesh is exposed to extreme meteorological and hydrological conditions. Occasional cyclone surges in combination with high tides always have devastating effects on the southern part of Bangladesh, causing loss of human life, crops and livestock as well as the destruction of property (MES, 2001). The lower Meghna River drains the flow from Ganges Valley and the southern part of the Himalayas (Ganges River), the Tibet and the north-eastern part of India (Brahmaputra River) and the north-eastern part of Bangladesh (Lasarte et al., 1991). The discharge varies from 8,000 m^3/s during dry season to 1,20,000 m^3/s during the wet season. The flow starts rising sharply in June, it assumes peak flow sometime in July-September and assumes minimum values in March-May. The total discharge of the lower Meghna River is diverted through the Tutulia River, the Shahbazpur channel, the Hatia Sandwip cross sections and the Sandwip channel. The main flow is emptied into the sea through the Shahbazpuar channel and part of it is emptied through the south-central region in the Meghna Estuary. The discharges of the Ganges and the Jamuna are collectively known as the Padma River, these three major rivers dominate the river inflow in the Meghna estuary study area. The Meghna Estuary lies between 90°20′0″ to 92°0′0″ Easting and 21°40′0″ to 22°40′0″ Northing (Figure 1.3.1).

Erosion and accretion rate is very high in Meghna Estuary system. The sediment discharge from the Meghna River is the highest (Coleman, 1969) and water discharge is the third highest of all river system in the world (Milliman, 1991). The river borne sediment load of lower Meghna River amounts to more than a billion tons annually and carried by the combined flows of the Meghna, Brahmaputra and Ganges to the estuary of Bangladesh (Eysink, 1983 and Nishat and Alam, 1987) are deposited in the coastal areas which is dominated by silt to fine sand (Hossain, 1992).

The important driving force for the flow in the Meghna Estuary are the bathymetry, oceanographic conditions outside the estuary (tides), hydrology of the adjacent watershed (river discharge) and meteorological condition (MES, 2001). Considering bathymetrically, the estuary can be considered as a sudden dramatic widening of the Meghna River, which is shallow and followed by a deep land, wide opening towards the Bay of Bengal.

The knowledge about the physical processes and morpho-dynamic behaviour of the lower Meghna Estuary system still creates complex pattern of sediment displacement and erosion in the estuary. The river influence becomes progressively larger in an upstream direction as friction drains tidal energy in the funnel shaped Meghna Estuary (Akhter and Mahmud, 2007).

Considering the dynamic situations prevail in the Meghna Estuary a Morpho-dynamic study has an utmost necessity to identify the morphological changes of the River.

1.3 The Padma and the Meghna River

Part of the Padma and the Meghna River one of the major rivers in Bangladesh, specially famous for its great estuary that discharges the flows of the Ganges-Padma, the Brahmaputra-Jamuna and the Meghna itself. The downstream of Surma River from Ajmiriganj is often referred to as the Meghna. The matter would be simpler but for the fact that from Madna downstream for about 26 km (in a straight line) one of the two Channels of the Surma-Meghna is known as the Dhaleswari. The channel from Ajmiriganj down to the confluence with the Dhanu is referred to as the Surma. This confluence is five kilometers east of Kuliarchar and north of Bhairab Bazar. Downstream from this point, the river is referred to as the Meghna (Figure 1.3.1).

The Meghna has two distinct parts.

The Upper Meghna: Down to Chandpur from Kuliarchar to Shatnol, Meghna is hydrographically referred to as the Upper Meghna

The Lower Meghna: Sixteen kilometres from Shatnol, the combined flow of the Ganges and Brahmaputra-Jamuna, known as the Padma, meets the Meghna at 11 km wide confluence near Chandpur. From this point southwards the Meghna is marked as the Lower Meghna, becoming one of the broadest rivers and largest estuaries in the world. The Lower Meghna is at times treated as a separate river. The Meghna receives the Old Brahmapurta on its right at Bhairab Bazar. A little above the confluence, the Meghna has a railway bridge-'Bhairab Bridge'-and a road bridge-'Bangladesh-UK-Friendship Bridge over it. The width of the river there is around 750m. Several small channels branching off from the Meghna and meandering through the lowland bordering the Tippera Surface receive the flow of a number of hilly streams and rejoin the main river downstream.

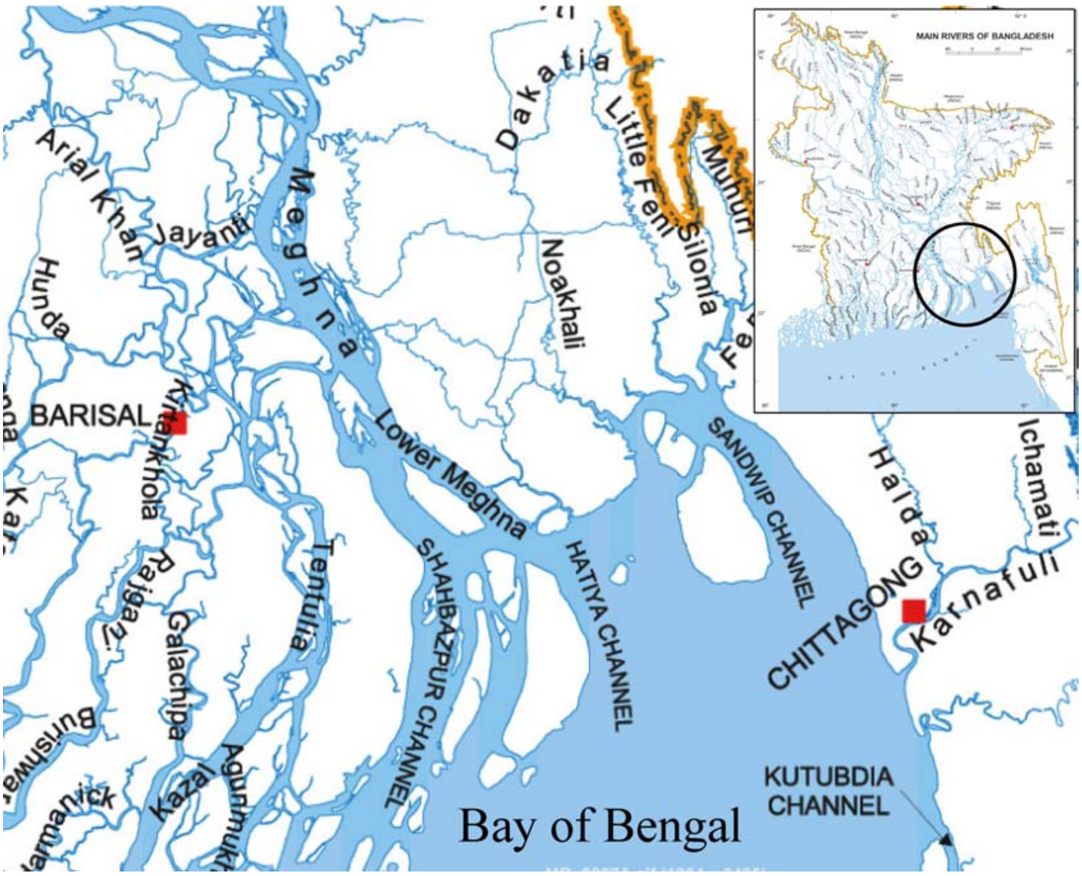

Figure 1.3.1: Lower Meghna River from Chandpur to Swandip Channel

The most important of these offshoots is the Titas, which takes off south of Ghatalpar and after meandering through two long-bends extending over 240 km rejoins the Meghna through two channels in Nabinagar upazila. Other offshoots of the Meghna are the Pagli, Kathalia, Dhonagoda, Matlab and Udhamdi. The Meghna and these offshoots receive water of a number of hilly streams from the Tripura Hills. The important hill streams are the Gumti, Kakrai, Kagni, Dakatia, Hawrah, Sonaiburi, Harimangal, Pagli, Kurulia, Balujuri, Sonaichhari, Handachora, Jangalia and. All of these are liable to flash floods. The Meghna receives Tippera Surface streams from the east and flows from the enlarged Dhaleshwari from the west.

Figure 1.3.2: Satellite image of the Padma River and Meghna Estuary (Source: LANDSAT, 1977)

At the confluence, just north of Shatnol, the Meghna is about five kilometers wide (Nath, 2004). Dhaleshwari comes down in a brown stream and meets the clear blue-green Meghna. For many kilometers the waters do not seem to mix, for half the river water remains brown and the other half blue-green.

Salient features of Padma and Lower Meghna River

Off take:

a) River : Meghna Upper

b) Location	: Upazila (Sub-District)- Motlob
	: District – Chandpur
Physical Description	: Length- 180 km
	: Width – 13000 meter
	: Depth – 27.00 meter
	: Catchments Area – 1595 sq. km
Flow	:
a) Seasonal/Perennial	: Perennial
b) Month without flow	: N/A
c) Low flow (dry season)	: February and March
Approx. flow	: 10,500 m^3/s
Depth	: 20 meter
d) High flow (monsoon)	: July and August
Approx. flow	: 1,050,000 m^3/s
Depth	: 27 meter

Reference: (BWDB, 2002), Figure 1.3.1

1.4 Objectives of the Study:

The proposed study will be carried out with a view to attain the following objectives

- To identify the trend of Bank line shifting (Morphological change) of The Padma-Meghna River System over the past 20 years by analyzing Satellite Image of the respective 1989, 1999 and 2009 years in ArcGIS.
- To Identifying the possibility of development of new channels (bifurcation) in the next 10 years by analyzing the past trends.
- To find out the development of new islands in the area.

CHAPTER 2

Literature Review

2.1 General

Rivers erode landmasses and carry the water sediment to the ocean. A well-controlled system of physical and hydraulic features is maintained in water and sediment transport processes. The inter relationship between the attributes and their details in this organized system are highly complex and it is hard to visualize many of them simultaneously. However these interrelationships from the typical characteristics of rivers and some knowledge of the basic types of rivers are necessary before complex relationships can be understood.

2.2 Channel Patterns

The pattern of a river is described as the appearance of a reach in a plan view. Observing plan views of most of the major rivers, they can be classified broadly into three major patterns- a) straight, b) meandering and c) braided (Leopold and Wolmen, 1957). Figure 2.2.1 shows the illustrations of the basic type of rivers.

Straight Channel

A straight channel is one that does not follow a sinuous course. Straight channels are rare in nature according to Leopold and Wolman (1957). A stream may have moderately straight banks but the thalweg or path of greatest depths along the

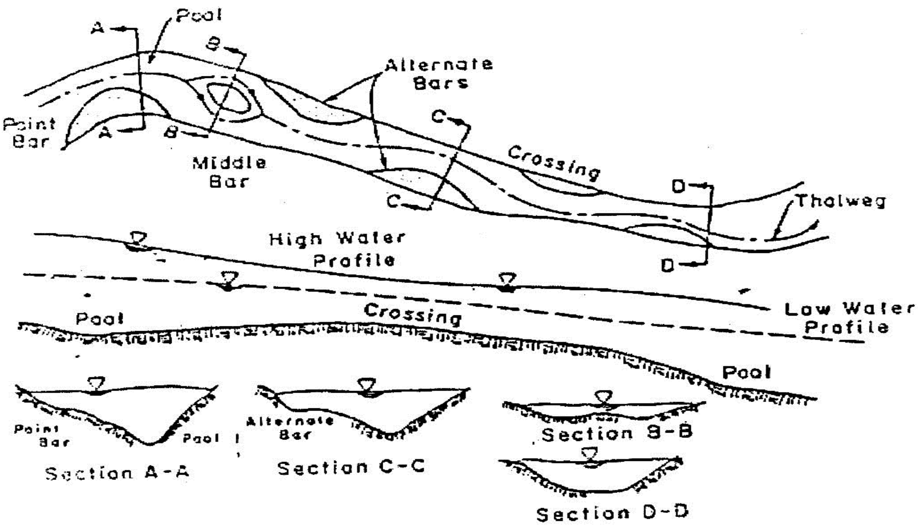

Figure 2.2.1: Channel patterns (Source: Schumm, 1977)

Channel is usually sinuous. Straight channels with prismatic cross-section are not typical in nature. It is only feasible for artificial channel.

To differentiate between straight and meandering channels and sinuosity of a river, the relation between thalweg and length to down valley distance is most frequently used. Sinuosity varies from 1 to 3. Sinuosity of 1.5 is taken as the division between meandering and straight channels by *Leopold et al.*(1964). A series of shallow crossings and deep pools is formed along the channels in a straight channel with a sinuous thalweg developed between alternate bars (Figure 2.2.1).

Depending on the regime of the river, the erodibility of the banks, a straight channel can remain as such, if a river is dredged as a straight channel. Seldom only part of a river is straight, typically as stretch of a few miles in between two meander bend.

Meandering River

A meandering channel is one that consists of alternating bends, creating as S-shape to the top-view of the river. In particular Lanne (1957) showed that a meandering

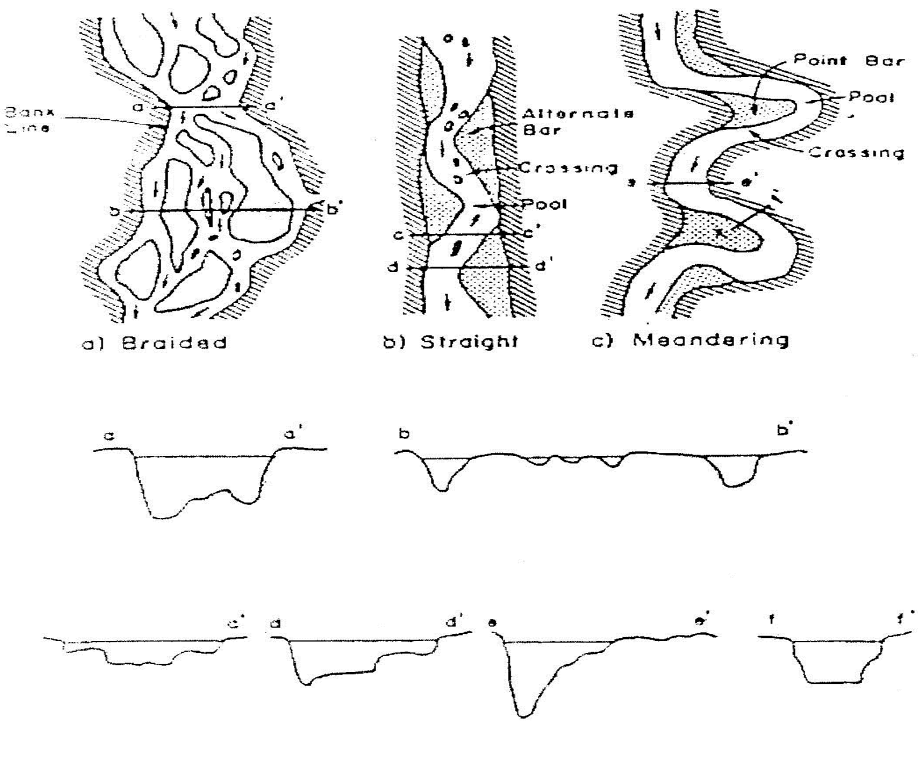

Figure 2.2.2: Various features of channels (Source: Schumm, 1977)

channel is one where channel alignment consists mainly of distinct bends, the shape of which have not been established principally by the varying nature of the topography through which the channel flows. The meandering river contains a sequence of deep pools in the bends and shallow crossings in the short straight reach connecting the bends. The thalweg flows from a pool through a crossing to the next pool forming the typical S-curve of a single meander loop at higher stages. In the severe case, the changing of the flow causes chute channels to develop across the point bar at high stages.

Braided Channel

A braided river is one with generally wide and poorly delineated unstable banks, and is depicted by a steep, shallow route with multiple channel divisions around alluvial islands (Figure 2.2.2 (a)). Leopold and Wolmen (1957) studied braiding in a laboratory flume. They deduced that braiding is one of many patterns that can maintain quasi-equilibrium among the variables of discharge, sediment load and transporting ability. The two primary reason that may be accountable for the braiding is stated by Lane (1957) as: (1) Overloading, that is the channel may be full with more sediment than it can transport consequently accumulating part of the load, deposition occurs, the bed aggrades and the slope of the channel increases in an effort to maintain a graded condition and (2) steep slopes, which generate high velocity, multiple channels develop resulting the overall channel system to widen with rapidly forming bars and islands. The multiple channels are generally unstable and change position with both time and stage.

2.3 Factors influencing river geometry

Factors governing the geometry and roughness of an alluvial river are numerous and interconnected. Their characteristic is such that it is difficult to single out and study the function of a specific variable. Assessing the consequence of average velocity by increasing channel depth will affect other correlated variables as well. Again, not only will the velocity respond to change in depth, but also the form of bed roughness, the position and shape of alternate, middle and point bars, the shape of cross-section, the magnitude of sediment discharge and so on. Therefore, the study of the mechanics of flow in alluvial channels and the response of channel geometry is incessant.

Variables influencing the geometry of alluvial rivers are numerous and some of the important ones according to Simons (1971) are as follows:

$V, D, S, \rho, \mu, g, d, \sigma, \rho_s, S_P, S_R, f_S, C_T$

Where,

V= Velocity

D= Depth

S= Slope

ρ = Density of water

μ = apparent dynamic viscosity of the water sediment mixture.

g = acceleration due to gravity

d = grain size of the bed materials

σ = measure of size distribution of bed materials

ρ_s = density of sediment

S_P = shape factor of the reach of the stream

S_R = shape factor of the cross-section of the stream

f_S = seepage force in the bed of the streams

C_T = concentration of the bed material discharge

Simons and Richardsen (1962) has described the role of the variables on resistance and bed form. Simons (1971) also partially explained their significance on the channel geometry.

2.4 Aggradation and Degradation of Channels

Aggradation (i.e. rising of the river bed by deposition) occurs in a river if the amount of sediment coming into a given reach of a stream is greater than the amount of sediment going out of the reach. Part of the sediment load must be deposited and hence, the bed level must rise (Ranga Raju, 1980). In alluvial channels or streams bed aggradation evolves primarily form the passage of flood events. The bed profile consequently reduces the section factor of the channel. Sediment deposition along streams or in reservoirs is a complex and troublesome process. It creates a variety of problems such as, rising of river beds and increasing flood heights, meandering and over flow along the banks, chocking up of navigation and irrigation canals and depletion of the capacity of storage reservoir (Hossain, 1997).

Bed degradation (i.e. lowering of the bed by scouring) occurs when the amount of sediment coming into a given reach of a river is less than the amount of sediment going out of it (Ranga Raju, 1980). The excess sediment required to satisfy the capacity of the river will come from erosion of the bed and there will be lowering of the bed level, which will result in shifting of thalweg line of the river. If the banks are erodible material can be picked up form the banks and widening of the river will also result. Hence the whole process of aggradation and degradation of rivers have potential effects on various hydraulic and geometric features of rivers such as cross-sectional area, section factor, shifting of thalweg line etc.

2.5 Selection of study area

The study area has been selected from the confluence of the Bhrahmaputra and Padma river to the lower end of Meghna river where the Meghna meets the bay of Bengal. The study area is depicted in the following figure:

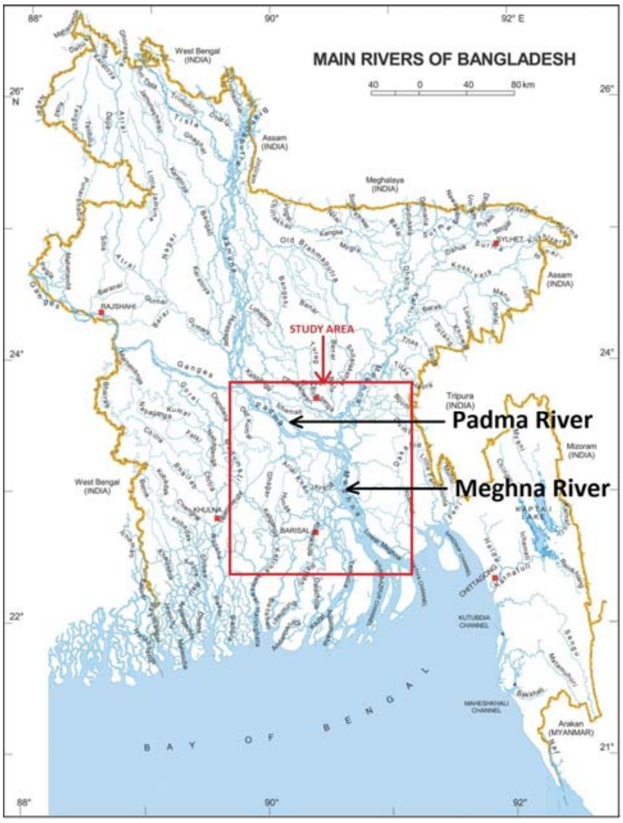

Figure 2.5: Study area selection

2.6 Environmental Condition of the Study area

The process of natural development of the selected islands of Meghna Estuary is governed by the environmental conditions. Rainfall in the catchment is drained by the rivers to the Bay of Bengal. Heavy monsoon rains causes high water levels in the rivers that flood the land, while very high discharge brings enormous amounts of sediments down the rivers to the estuary. The processes of accretion and erosion are strongly influenced by the changes in the river flow, but also by waves. Winds drive the circulation of water in the estuary while cyclones cause high storm surges and (sometimes catastrophic) floods. Tide coming from the Indian Ocean determines the variation in water levels and the flow in the estuary. Saline seawater penetrates through the estuary up to Chandpur during the dry season, while during monsoon the estuary is merely filled with fresh water. Changes in salinity contribute to flocculation and deposition of silts in the estuary (Ali, 1996).

Knowledge of environmental conditions in the Meghna Estuary is therefore of crucial importance for understanding the morphological processes. These conditions are described in the following articles.

2.6.1 Precipitation

The climate of Bangladesh is tropical, with a hot, humid summer (March to June), a rainy monsoon (June to September) with predominantly south-westerly monsoon winds, and a dry, relatively cool winter (September to June) with predominantly north-westerly monsoon winds. The catchment of Brahmaputra,

Jamuna-Meghna receives annually an average of 1,500 mm of rainfall, most of which falls during the monsoon months but there are great variations in rainfall across the basin. The average rainfall in the coastal area of Bangladesh is about 2000-3600 millimeters per year.

2.6.2 Wind

The wind regime along the Bay of Bengal shows a typically seasonal variation between the dry season (November-March) and the monsoon season (June

September). During the dry season the prevailing winds are calm and offshore. The prevailing winds during the monsoon season are from the S-SE direction, with an average velocity of about 8-12 m/s. During severe storms and cyclones, very high wind velocities can occur. The highest wind speed, reported during the April 1991 cyclone (CERP-II, 2000), is 62.5 m/s, corresponding to 225 km/h. Most cyclones occur during April-May and October-November, which are the transitional periods between the dry season and the monsoon season. The highest wind speed recorded in the recently (November 7, 2007) occurred devastating cyclone SIDR was 250 km/h that swept in from the Bay of Bengal.

Monthly average wind speed data as recorded at the study area of Lower Meghna River, the coastal stations are presented in Table 2.5.1

Table 2.6.1 Average monthly wind speed in coastal stations (m/s)

Station	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bhola	0.3	0.4	0.7	1.2	1.0	0.9	0.9	0.8	0.5	0.2	0.2	0.2
Sandwip	0.6	0.9	1.7	2.6	2.3	2.7	2.6	2.4	1.5	0.8	0.5	0.6

(Source: CERP II, 2000)

The tidal wave from the Indian Ocean travels through the deep Bay of Bengal and approaches the coast of Bangladesh approximately from the south. It arrives at Hiron Point and at Cox's Bazar at about the same time. The extensive shallow area in front of the large delta causes some refraction. Also some reflection of the tidal wave occurs contributing to a significant amplification of the tidal wave in Hatiya and Sandwip Channels. North of Sandwip Island and Urir Char occurrence of tidal bores has been observed (Akhter and Mahmud, 2007).

2.6.3 Waves

No wave heights have been recorded during severe storms until now. In the dry season the waves are generally less than 0.6 m with peak periods of 3 - 4 seconds. During the monsoon season wave heights exceed 2 m with periods greater than 6 seconds.

Table 2.6.2: Offshore Significant Wave Heights (m)

Return Period (years)	**Wind Speed** (m/s)	**Wave Heights in different Water depth**		
		20(m)	**15(m)**	**10(m)**
5	46.6	7.6	6.1	4.5
10	53.2	8.2	6.6	4.9
25	60.9	9.0	7.2	5.3
70	68.5	9.6	7.8	5.7
100	71.0	9.9	7.9	5.9

The maximum wave height is limited by the water depth. Depth of water is co-related to the wave height. Water depth of 20m is representative for a deeper part of the continental shelf. In the estuary, depths are generally lower than the other part. The water depth in the estuary is less than 5-l0m when the cyclone surge is taken into account. Waves higher than 0.6-0.8 times of the local water depth will break due to insufficient water depth. Still, waves higher than 5m may be expected in the outer part of the estuary during a cyclone (IWM, 2005).

2.6.4 Sediment transport processes

Sediment transport processes form a crucial control in the estuarine processes and evolution of the Meghna Estuary. The estuary is the route by which sediments are transported from the major rivers to the Gulf of Bengal. On their way down the river, continuous deposition, re-erosion and transport alter the composition of sediments. Much of the coarser sediments become trapped on the floodplains of the rivers, only being released at times of flood (Alam et al.,1998). The finer fractions are transported into the estuary. There, the estuarine processes act as a filter on the sediment input, and mixing can take place with sediment brought in from the sea. Additionally, chemical alterations can occur within the estuary that can cause the surface properties of some of the constituent particles to alter, affecting their potential deposition.

2.6.5 River profiles, bank erosion and bed material

Materials comprising the beds of alluvial have an important influence on river geometry. Bed slopes at the headwaters of rivers are steep and the bed material is relatively course. In general, both the bed material size and river slope decrease in the downstream direction. Tractive force is not sufficient to move the longer materials down stream, but the smaller material is transported out to the point where hydraulic sorting essentially paves the bed with coarse materials characteristic of a reach eventually partially decomposed with time due to abrasion and weathering so that, in general, a continuous supply of material capable of being transported is available (Mukherjee, 1995).

The river boundary in a given reach is constantly changing with such interacting flow variables as velocity, depth, slope, density and viscosity of the water-sediment mixture, concentration of bed-load discharge, concentration of suspended load discharge and characteristics of the bed material. River bank stability depends on these interrelated stream variables as well as on channel geometry (Rahman, 1980).

Bank erosion and retrogression or retreat occurs in many ways, primarily as a result of one or a combination of the following:

1. Removal of soil particles from the bank surface either continuously or intermittently over a period of time;
2. Sequential failures of small segments of bank material
3. Failure of a single large segment of bank material

2.7 Hydro-morphological studies of the rivers of Bangladesh

In Bangladesh there have been many studies done on the hydro-morphological aspects such as hydraulic geometry, erosion/deposition and bed level variations in many rivers. Most of these studies were carried out in the major rivers like the Ganges, the Brahmaputra, the Meghna and the Teesta River.

2.7.1 Hydro-morphological studies carried out in Meghna River and Meghna Estuary

MES, 1999 studied that several interventions were proposed at different locations of the Estuary in order to reduce the loss of valuable existing land and infrastructure from erosion. The interventions proposed for erosion control were made of permeable spurs and bottom screens.

The locations identified for interventions under this study include the northeast coast of Bhola in the Lower Meghna (12 km coastline between the villages of Ilisha in the north and Chowkighata in the south), the east coastline of Bhola (about 50 km between the villages of Chowkighata in the north and Betua in the south), the right bank of the Upper Tetulia River (between Ilisha and Dasmonia), the Mehendigamj-Hizla-Bhedarganj (about 40 km on the right bank of the Lower Meghna), the Lakshmipur-Ramgoti (about 40 km riverbank on the left bank of the Lower Meghna between Haimchar and Char Bouy), the North Hatiya (about 12 km shoreline), and the west coast of Sandwip island (about 15 km in length).

MES-022 studied the long-term hydraulic and morphological process in the Meghna Estuary can be stirred by gravitational circulation due to salinity gradients in the pre-and post monsoon period.

The study estimated the strength of the gravitational circulation for the Shabazpur main channel of the Meghna Estuary. The gravitational circulation was estimated based on LRP measurements of salinity collected during pre- monsoon over the period 1983-1986.

MES, 2001 The Meghna Estuary Studies (MES I and MES II) were the supporting studies under FAP 5B of the Flood Action Plan (FAP). The FAP was initiated after the disastrous floods in Bangladesh in 1987 and 1988, and it was a co-coordinated action to study the flood problems of Bangladesh.

The main goals of the MES were as follows:

- To collectively gather hydrological and morphological data;
- To increase knowledge of the hydraulic and morphological processes in the Meghna Estuary system;
- To develop appropriate techniques (or efficient land reclamation and effective riverbank protection;
- To provide a Master Plan and Development Plan for the estuarine area

- To enhance the knowledge of the complex morphological process in the Meghna Estuary, a morphological study was carried out within the framework of the Meghna Estuary Studies in the period 1995 to 2001.

2.7.2 Hydro-morphological studies in the river around the world

Over the past decades several studies have been made to evaluate morphological changes of the major rivers in and outside of Bangladesh. Although the list provided is not exhaustive, yet it provides some information in this respect.

Ranga-Raju (1980) did a study on the practical computation of degradation and aggradation on alluvial river based largely on the works carried out in India. He presented semi-empirical methods for computation of bed and water surface profiles for some of the commonly encountered cases of aggradation.

Jain (1989) proposed a guide for estimating river bed degradation. The rate and extent river bed degradation resulting from sediment interruption were determined by means of computer based numerical experiment. He presented the results in the form of algebraic relations that can be easily applied by practicing Engineers to estimate the temporal and optimal river bed degradation during the preliminary phase of the engineering designs. The proposed relationship for the bed degradation has been verified with the field data of Missouri river.

Ramez, P., Paquier, A. and Bonnet, F. (2002) carried out a study on Influence of sediment transport on the computation of water in the river Rhone. The showed that the increase of the head losses due to bed forms is interpreted in the U-curves (ratio of Strickler coefficients versus ratio of bottom shear stresses) and of S-curves (Strickler coefficient versus discharge). This effect is stronger at dominant discharge. It can lead to a rise of water level much higher than the final topographical change. For the presented example of a reach of River Rhône near Bourg lès Valence, this rise is estimated over 1 m for the dominant discharge of about 1200 m^3/s.

CHAPTER 3

Data Collection and Methodology

3.1 General

In Chapter-2 the different theories and terminologies that are used in this study have been discussed. In this chapter, the detailed methodology of analysis for determining morphological changes of the selected Padma and Lower Meghna River under this study will be presented.

3.2 Data Collection

In this study, the hydraulic geomorphology of the Padma and lower Meghna River will be investigated with the help of GIS technology. To identify the trend of Bank line shifting (Morphological change) of The Padma-Meghna River System over the past 20 years by analyzing Satellite Image of the respective 1989, 1999 and 2009 years in ArcGIS. The study would also determine the possible appearance of new lands and loss of lands with the help of GIS maps drawn with geo reference scale. Satellite raster images will be collected for selected 3 different years from the United States Geological Survey (USGS) websites. The images were taken from LANDSAT-II. The images used in this study are shown below:

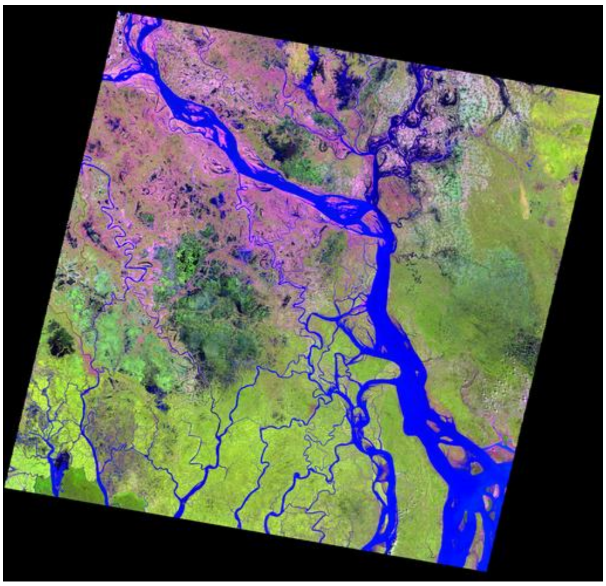

Figure 3.2.1: Satellite map of 1989 of the study area

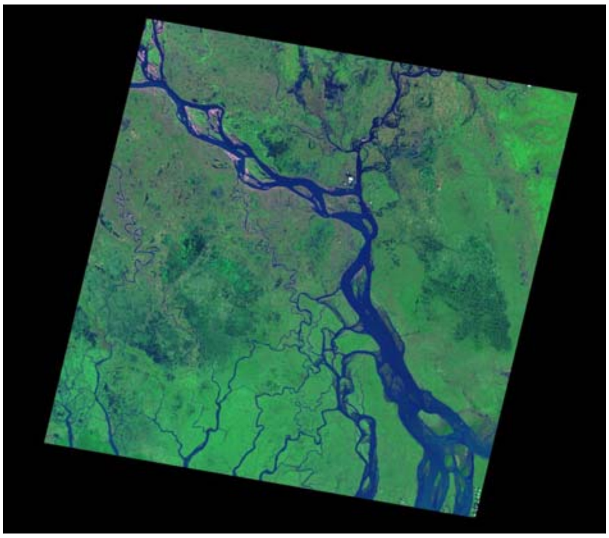

Figure 3.2.2: Satellite map of 1989 of the study area

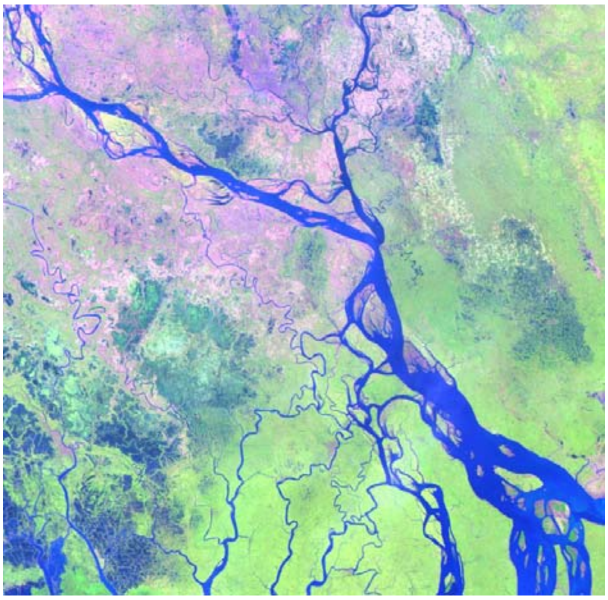

Figure 3.2.3: Satellite map of 1989 of the study area

3.3 Methodology

The collected satellite images of the Padma and Lower Meghna River (for 3 different years) will be put in ArcMap and the geo-referencing will be done using another map which is previously geo referenced. With the geo referenced point all the maps will be converted to a common scale. Then all the maps will be superimposed to observe the deviation of the bank line of the river in different years.

- Superimposition of the map of 1989 and 1999 in **ArcMap** will show the erosion or deposition along the river bank and the net area will be calculated to find the actual Erosion or Deposition. Eventually appearance of new lands will show up for further use. Similarly all the maps of 1999 and 2009 will be superimposed all together to get the net erosion or accretion from 1989 to 2009.
- The pictorial depiction of the whole process are shown below:
- Step-1: Geo-Referencing the Map of study area with another geo-referenced map.

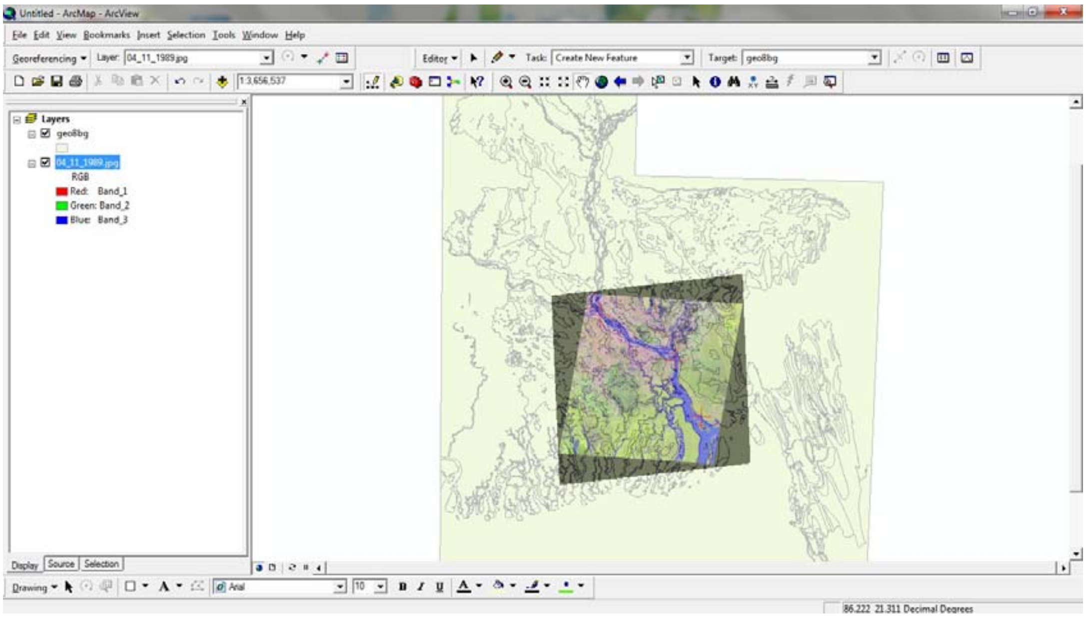

Figure 3.3.1 Map geo-referencing

- Step 2: Digitizing the map

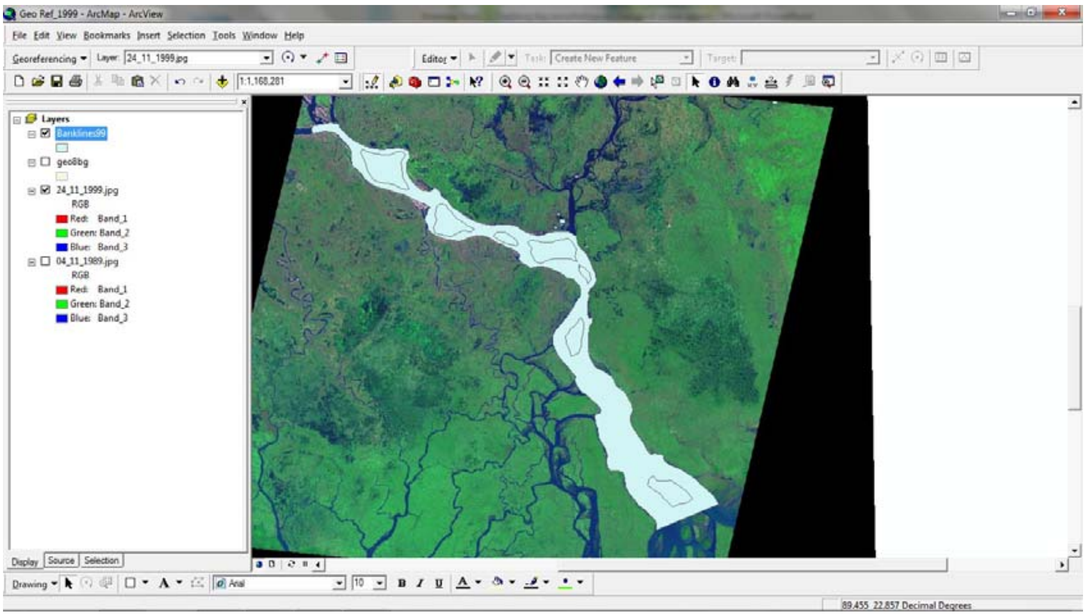

Figure 3.3.2 Map Digitization

- Step 3: Overlapping the maps one over another

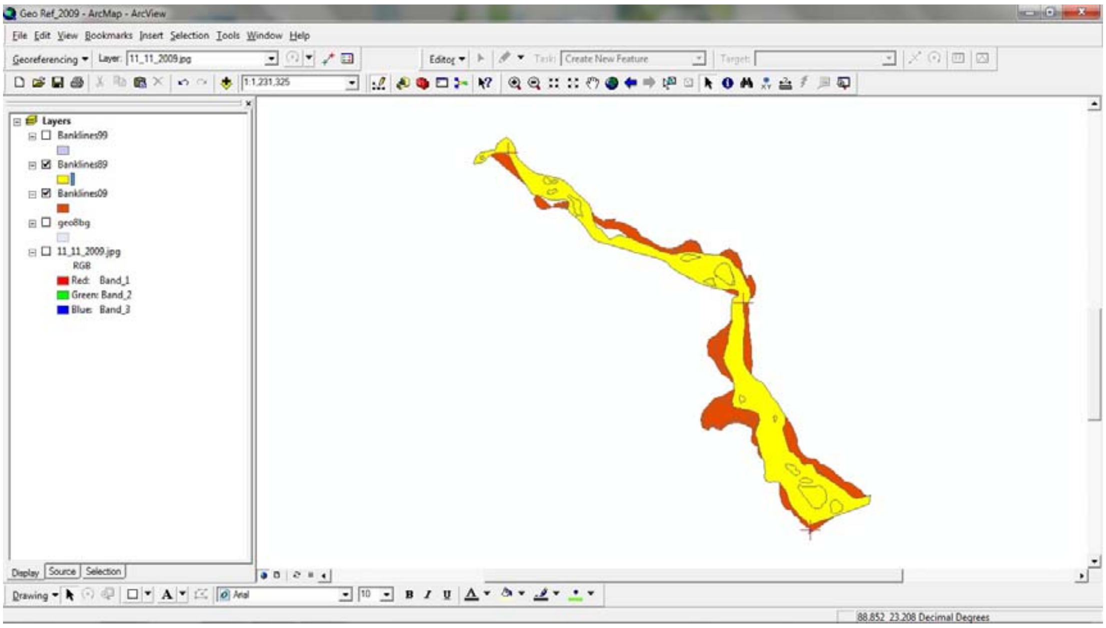

Figure 3.3.3 Map overlapped

The whole process will show the land area eroded or accreted within this 20 years span thereby it would also show the shifting of bank line of the rivers. The islands inside the rivers would also be calculated to carry further analysis.

Chapter 4

Results and Discussion

4.1 Results Discussion:

In the present study, the shifting of river course was estimated within the temporal window 1989 and 2009. In the course of river Padma after Aricha an island called Alir char was developed and the flow was divided into two broad channels. Now the river is flowing mainly through western channel, as eastern channel has dried up due to siltation. Few cross section lines have been drawn on the superimposition of courses of Padma of different years to estimate the distance and direction of the shifting of river course made by Padma. The following database depicts that, in most places in most of the years the left Bank of Padma has shifted towards east.

	1989 (Sq. Kilometer)	**1999 (Sq. Kilometer)**	**2009 (Sq. Kilometer)**
River area with Islands	2908	3548	3926
River area without Islands	2603	3026	3213
Area of Islands	305	522	713
% River area increase/decreased (Base year 1989)		+ 0.22%	+ 0.35%

However, the resultant shifting of river Padma shows a trend of eastward within the study area. The width of the river valley also has increased in most of the cross sections. The river stretch between Aricha Ghat and Munshiganj has badly affected by the continuous channel widening process throughout the given period. The whole river stretch under study has experienced high rate of valley widening during the period of 1989 to 2009 than the previous time span.

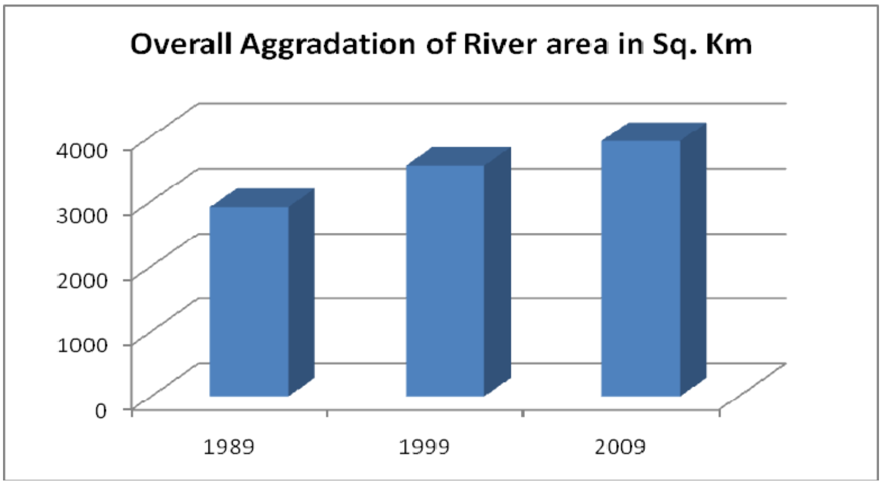

Figure 4.1 Degraded area in Sq. Kilometer

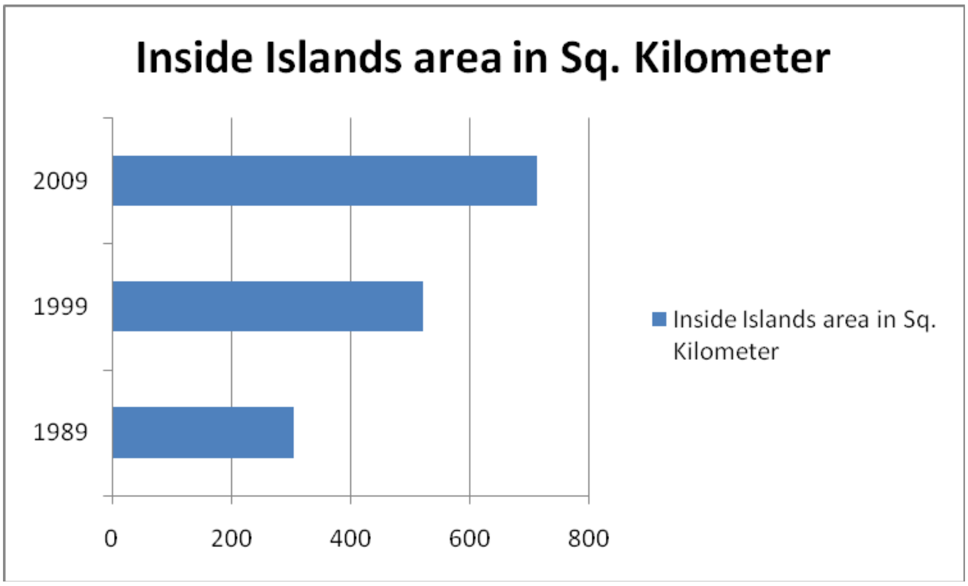

Figure 4.2 Inside Island area in Sq. Kilometer

CHAPTER 5

Conclusion and Recommendation

The following conclusion can be drawn from the study carried out:

- All the Channel Morphometry Indices show a rising trend within the time span considered in the study which actually indicates the severity of the changes in river course and its morphology in coming future.

- Analyzing the data it was found that the river area was increased from 2908 sq Kilometer to 3926 sq. kilometer in a span of 20 years from 1989 to 2009.

- The area of inward Islands also increased significantly which means that the river system has lost the sediment carrying capacity over the years.

- The shifting process of river course and its subsequent erosion and accretion processes cause the loss and newly formation of land simultaneously. But problem is occurred when the amount of loss increases.

- The digitized files can be used as a useful tool for the water resources engineer to find the optimum location for embankment for flood protection.

So the trend and severity of the change in channel morphology made by Padma and Lower Meghna creates a vulnerable situation at present, which requires a good management plan specially to protect the cultural landscapes.

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