STUDY OF MORPHOLOGICAL CHANGE OF RIVER OLD BRAHMAPUTRA AND ITS SOCIAL IMPACTS BY REMOTE SENSING

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ABSTRACT
Old Brahmaputra River is one of the main rivers in Bangladesh. In this study, the part of the old Brahmaputra River, offtaking from Jamuna is located under the district of Mymensingh and partially under the district of Tangail, Jamalpur, Sherpur and Netrokona. Analyzing the image of part of the old Brahmaputra River among the year 1997 and 2004, it is found that Significant changed has been occurred in north east part of Mymensingh sadar upazila and less change is found in the lower part which is close to the Mymensingh town where China Bangladesh Friendship Bridge (Shambhuganj Bridge) has been constructed. Transportation of sediment is the major contributing factor of morphological changes.

Key words*: meandering, remote sensing, sediment transport, morphological changes, river protection.*

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1. INTRODUCTION

Bangladesh stands on a thick alluvial deposit. It is the result of deltaic activity of the Gangas and the Brahmaputra. These main rivers, their tributaries and distributaries control its hydrological and morphological behavior. The Padma, the Megna, the Jamuna are the big and wide rivers of Bangladesh. The Buriganga, the Surma, the Kushiyara, the Monu, the Sitalakshya, the Dhaleswari, the Teesta, the Gumati and the Karnafuli are small rivers. Rivers differs from one another in their physical characteristics and general behaviors. Among these small rivers, the Old Brahmaputra is an active river and play important role in changing morphological changes in the others rivers of downstream [1]. Constant changes of the river's course constitute a significant factor in the hydrology of the Brahmaputra; the most spectacular of these changes was the eastward diversion of the Tista River and the ensuing development of the new channel of the Yamuna, which occurred in 1787 with an exceptionally high flood in the Tista. The waters of the Tista suddenly were diverted eastward into an old abandoned course, causing the river to join the Brahmaputra opposite Bahadurabad Ghat in Mymensingh district. Until the late 18th century the Brahmaputra

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flowed past the town of Mymensingh and joined the Meghna River near Bhairab Bazar (the path of the present-day Old Brahmaputra channel). At that time, the course of the Yamuna River (now the main Brahmaputra channel) was a minor stream called the Konai-Jenai, which was probably a spill channel of the Old Brahmaputra.

After being reinforced by the Tista flood of 1787, the Brahmaputra began to cut a new channel along the Konai-Jenai and gradually converted it after 1810 into the main stream, now known as the Yamuna. So, the study is strictly focused on the Old Brahmaputra river. This study provides the finding of morphological change, its cause, its effect by using remote sensing and GIS.

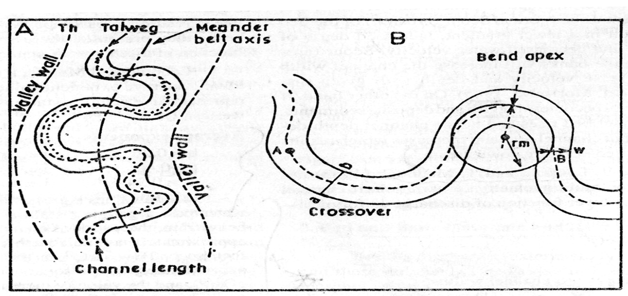


Fig. 1. ***Channel form-valley walls, channel length, channel thalweg, meander belt axis, crossover, curvature of radius (rm) and channel width***

Channel morphology is the result of mutual interactions of four broad categories of variables such as fluid dynamics (which include velocity, discharge, roughness and shear stress), channel character or channel configuration (e.g. channel width, channel depth, channel slope, channel shape, channel pattern etc.), sediment load and Bed and bank materials (composition and character i.e. coarse, fine, medium etc.). Fig. 1 shows its different variables of channel morphology [2, 3, 4, 5]. Fig. 2 shows the different types channel pattern. The rivers studied are meandering rivers in pattern. Different types of meander changes are shown in fig. 3.

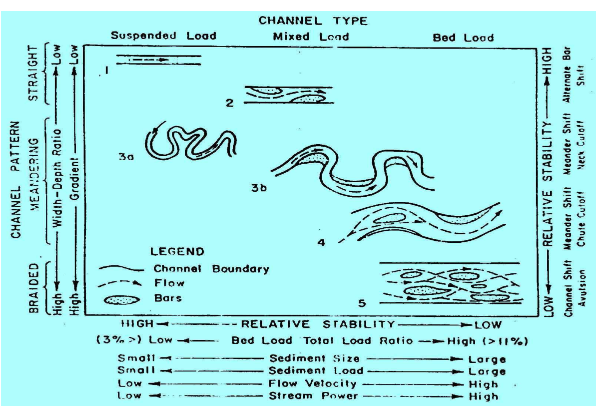


Fig. 2 ***Channel classification based on pattern and type of sediment load, showing types of channels, their relative stability and some associated variables [6]***

Many researchers use remote sensing technology in studying channel pattern study which is a part of morphological change study [7, 5]. Alam and Hossain [7] studied identifying the morphological changes of a distributary of the ganges in response to the declining flow using remote sensing. In response to the changes of the hydraulic regime, morphological characteristics of the river have been changing as well. Remote Sensing and Hydrologic Data Satellite images are mainly used to identify the morphological changes. Kolejka J. (2006) was realized an application of digital landscape model in crisis management (intensity and frequency of occurrence of extreme atmospheric and hydrological phenomena; erosion, land sliding, subsidences etc.)

On the other hand hydrologic data are used to show the relation between the changes of morphological parameters with the change of hydraulic regime. For planning and sustainable development, identification of morphological change is essential. So, in this study, an attempt has been taken to present the pattern of morphological change of one of the main river of Bangladesh (Old Bramaputra) and its social impact for future planning to protect agricultural land, ecology of the surrounding area.

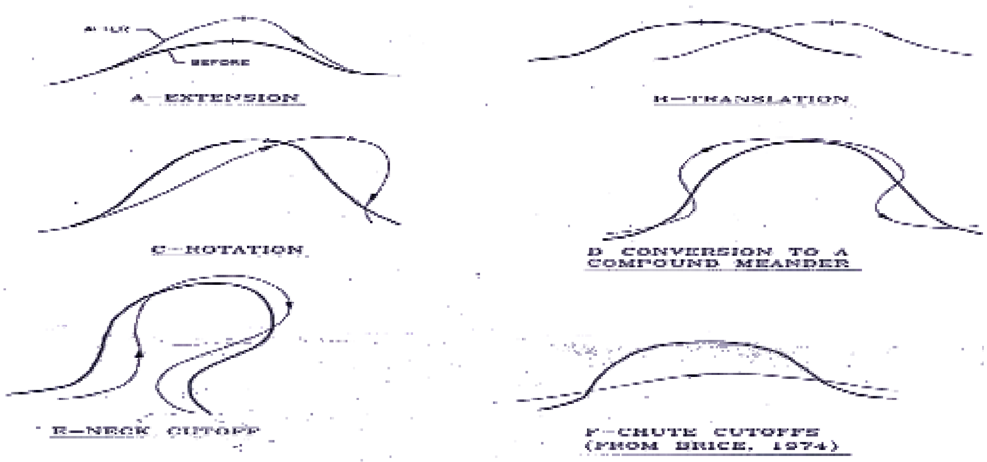


Fig. 3. Different types of meander changes [6]

2. STUDY AREA

The main part of the study area is under the district of Mymensingh and partially under the district of Tangail, Jamalpur, Sherpur and Netrokona. Fig. 4 shows (inside the rectangle) the study area along with the major river networks. Geographically the study area is situated within 90^{0} $03^{'}$ $34.34^{''}$ to 90 41 08.93 E longitude and 24 28 43.64 to 24 59 48.83 N latitude. The climate of the study area is tropical monsoon. Figure 5 shows typical monthly minimum and maximum temperatures and rainfall variation characteristics in Bangladesh over the year (Mymensingh district).

The general soil types of the area are Non-calcareous gray flood plain soils. The landuse / land cover of the area is categorized in to cultivated land, forest, plantation and barren land. The inhabitants of the study area are mainly dependent on agricultural production. The main occupation is agriculture. Most of the farmers practice non-mechanized conventional agriculture. In general, the inhabitant of the area is in lack of knowledge of soil conservation.

3. METHODOLOGY

Input Data Used

Landsat TM data has been used for the present study. To detect the changes of two images data were used and those are:

January 10, 1997 and

January 25, 2004.

In both cases Band 2, 3 and 4 has been chosen for the present study.

Unsupervised Classification shows how to create a thematic raster layer by letting the software identify statistical patterns in the data without using any ground truth data. ERDAS IMAGINE uses the ISODATA algorithm to perform an unsupervised classification. The ISODATA clustering method uses the minimum spectral distance formula to form clusters. It begins with either arbitrary cluster means or means of an existing signature set. Each time the clustering repeats, the means of these clusters are shifted. The new cluster means are used for the next iteration [8].

The ISODATA utility repeats the clustering of the image until either a maximum number of iterations have been performed, or a maximum percentage of unchanged pixel assignments have been reached between two iterations. Performing an unsupervised classification is simpler than a supervised classification because the signatures are automatically generated by the ISODATA algorithm.

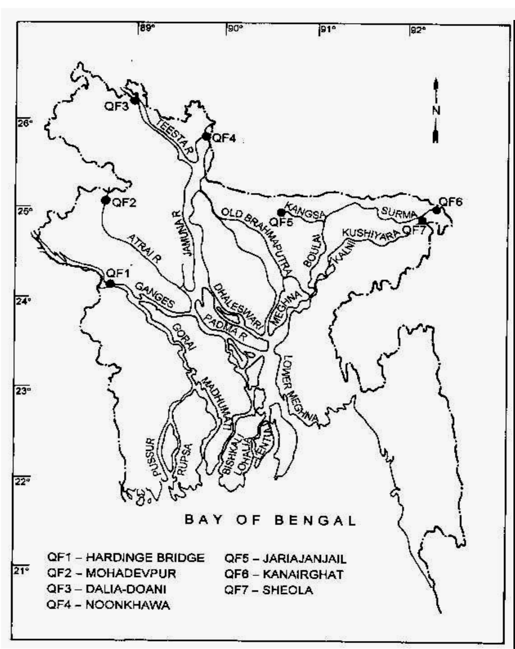


Fig. 4. ***Location Map of the study area map***

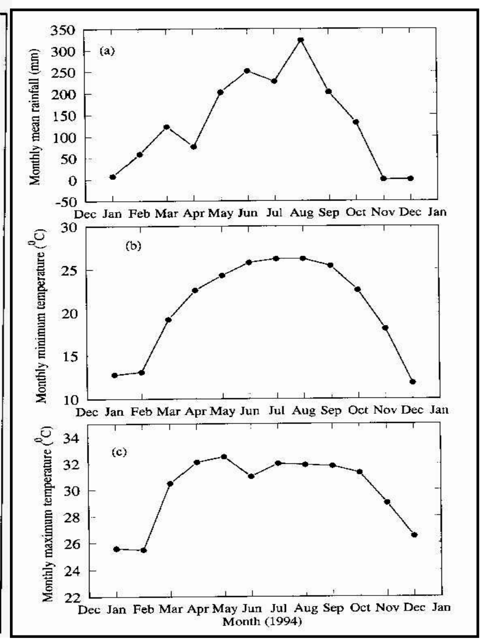


Fig. 5. ***Typical monthly variation characteristics of rain and typical monthly minimum andmaximum temperatures in Mymensingh district.***

Raster Attribute Editor to compare the original image data with the individual classes of the thematic raster layer that was created from the unsupervised classification. This process helps identify the classes in the thematic raster layer. Also use this process to evaluate the classes of a thematic layer that was generated from a supervised classification.

Thresholding divides an image into two classes. For example, in the near IR band, water has low reflectance values while land areas, either vegetated or bare ground, have higher reflectance values. By examining a frequency distribution of the brightness values, we may be able to determine that water bodies have brightness values less than 40 (on a scale of 0 - 255). This threshold is used to separate water from land. In the present study, the threshold value 37 (1997) and 33 (2004) for better land water separation were found out. After land water classification two classified image has been overlaid through "indexing" operation in ERDAS Imagine environment. Thus the thematic layer of two images of different year has been indexed (added) to create a composite layer. The output layer contains the sums of the input layer values. Finally the changed statistics has been calculated for results and discussion. Figure 6 shows the methodology of the study.

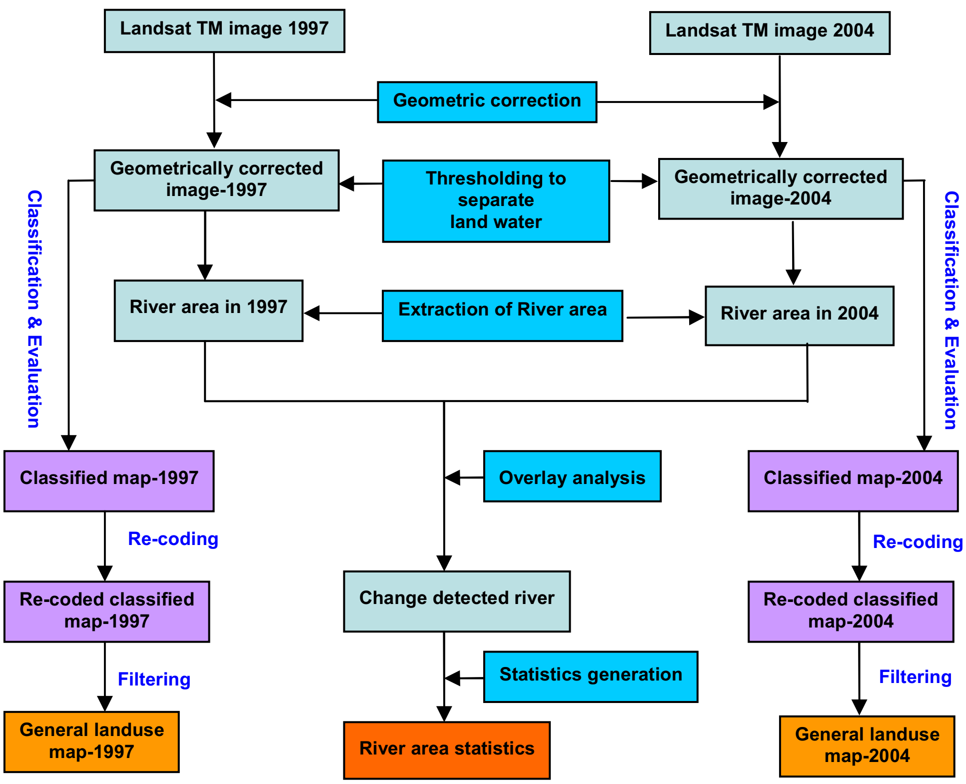
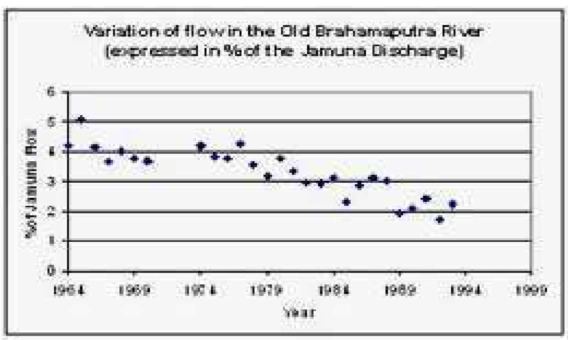


Fig 6. ***Flow diagram of the whole study***

4. RESULT AND ANALYSIS

Hydrological characteristics of the study area

Old Brahmaputra River a river that originates from the left bank of the Brahmaputra to the north of Bahadurabad. Flowing more or less to the southeast it passes by Jamalpur and Mymensingh towns and falls into the MEGHNA at Bhairab Bazar. River shifting has been a characteristic feature of the BENGAL BASIN, affecting small sections or even the entire river. The most dramatic was the shifting of the courses of the TISTA, Brahmaputra and lower GANGES river channels as evident from maps prepared hundreds of years ago. James RENNELL produced the most accurate map back in 1760. According to this map, the Brahmaputra at that time was flowing a course east of the MADHUPUR TRACT, presently known as the Old Brahmaputra. The lower part of the Brahmaputra channel between Dhaka and Mymensingh subsequently was silted up diverting the Old Brahmaputra flow to SHITALAKSHYA river and then to the DHALESHWARI and Meghna rivers southeast of Dhaka. The Old Brahmaputra acquired its present course between the Madhupur Tract and the BARIND TRACT in the year 1787. In that year the river shifted its course and was named the JAMUNA. This shifting followed a major FLOOD in the same year. The severe EARTHQUAKE reported from Mymensingh region in 1782 may also have contributed to this shift. The shifting of the Old Brahmaputra, along with other major shifting rivers, is now considered the effect of neotectonic activities in recent times. The shifting process seems to have taken place over a period of 30 years. The Old Brahmaputra floodplain stretching from the southwestern corner of the Garo Hills along the eastern rim of the Madhupur Tract down to the Meghna river exhibits a gentle morphology composed of broad ridges and depressions. Soils of this geomorphic unit are more oxidized.



In both of the year to total area is not two much changed even land area are also similar but river area has decreased in 2004. The possible reason behind that is the 2004 image has been acquired 15 days latter than 1997 (Table 1 and Table 2).

Fig. 7. ***Variation of flow with year***

Land water area in 1997

Table 1

Class name	Class ID	Area (in ha)
Land	1	360430
River	2	1780.74
Total area		362210.7

Land water area in 2004

Table 2

Class name	Class ID	Area (in ha)
Land	1	361031
River	2	1564.81
Total area		362595.8

Composite statistics of changing the land – water area

Table 3

Class name	Class ID in 1997	Class ID in 2004	Area (in ha)
Land in both year	1	1	359379
Land in 1997 but river in 2004	1	2	834.69
River in 1997 but Land in 2004	2	1	1049.63
River in both year	2	2	729.5

From the above table it has been found that the river area is changing towards land area from 1997 to 2004. The probable reason is siltation. River normally gets silted during their course of flow. Every river carries certain amount of sediment load. The sediment particles try to settle down to the river bottom due to the gravitational force, but may be kept in suspension due to the upward currents in the turbulent flow which may overcome the gravity force. Due to these reasons, the river carries the fine sediment in suspension as suspended load. Whenever the flow velocity in the channel reduces, the silt carried by the water in suspension gets deposited on the bed and sides of the canal. The deposition of sediment in the river is known as 'River Silting' or 'River Sedimentation'. The silt so deposited reduces the effective canal cross-section and the carrying capacity of the channel. Also impacts of river course changes on agriculture, settlement, forest, fisheries, infrastructure, hydraulic structure etc.

Significant changed has been occurred in north east part of Mymensingh sadar upazila and less change is found in the lower part which is close to the Mymensingh town. China Bangladesh Friendship Bridge (Shambhuganj Bridge) has been constructed in the place Patugudam more; Mymensingh town where the less changed has been occurred (figures 8, 9). The reason of change may be due to meandering nature of river [9].

Engelund and Hansen equation:

$$g_s = 0.05\gamma_s v^2 \sqrt{\frac{D_{50}}{g(\frac{\gamma_s}{\gamma}-1)}}\left[\frac{\tau_0}{(\gamma_s-\gamma)D_{50}}\right]^{3/2}$$

Where: g_s = Sediment transport/unit time/per unit width

τ_o = bed shear stress = γRS= 0.23

v = average flow velocity = 1.17 m/s

D_{50} = 0.00034

γ_s = Specific weight of sediment particles = 2650 kg/m^2

γ = Specific weight of water = 1000 kg/m^3

S= slope = 0.00007 and B= width = 74.6 m

g_s = 26.21 kg/sec

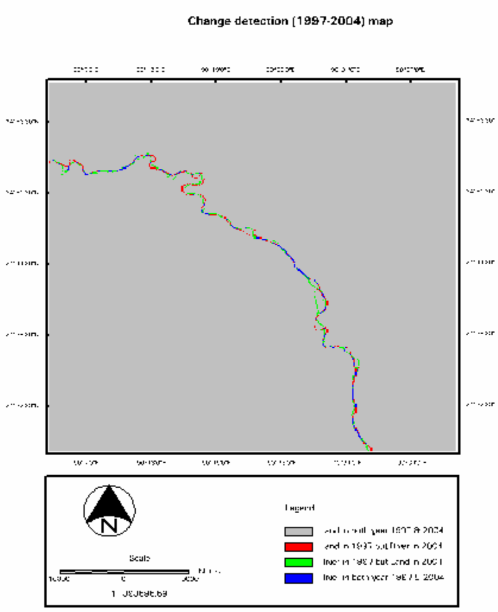


Fig. 8. ***Change detection map of the study area (Landsat TM data: January 10, 1997- January 25, 2004)***

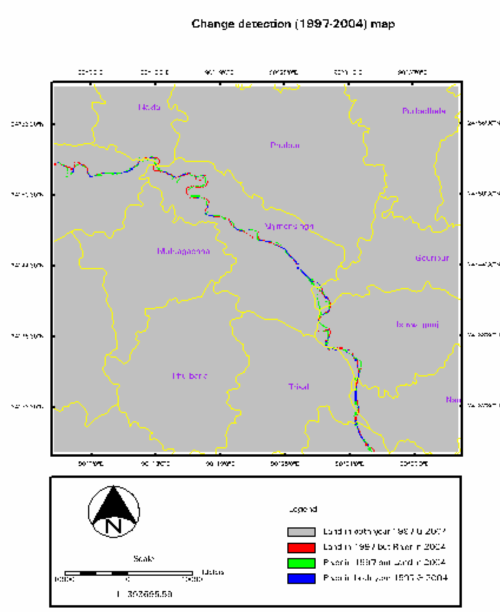


Fig. 9. ***Change detection map of the study area (Landsat TM data: January 10, 1997- January 25, 2004)***

It is clear from the Figure 8 that changes occurred at east part of Mymensingh sadar upazila. The reason of change may be due to meandering nature of river [9]. Use of satellite images provides more information regarding bank erosion. Erosion occurs along a 1.12 km long (maximum) at China Bangladesh Friendship Bridge (Shambhuganj Bridge) over time. The river course-changing pattern due to sedimentation is measured 168.34 ha by using plani-meter.

With the help of figure 3; the change showing in figures 8 and 9 at Shambhuganj Bridge is chute cutoff type change. At north east part of Mymensingh mainly translation occurs. At Raysrr neck cutoff type of change occurs. At close to the Mymensingh town chute cutoff and translation combinedly occurs at the middle section and at the upper and lower portion rotation occurs and at Telibil chute cutoff type change occurs. The cause of morphological changes of the rivers is sediment transport. The rate of sediment transport in rivers depends on many variables, such as water discharge, average flow depth, flow velocity, energy slope, shear stress, stream power, particle size and gradation as well as temperature. Based on concept of dimensional analysis and similitude argument, Hossain [1] proposed that sediment concentration in a stream of steady water and sediment flow is a power function of the product of Froude number and slope of energy gradient, the settling velocity ratio and the discharge ratio. Change of averaged width and braiding intensity with year for the river at north east part of Mymensingh is significant.

In order to getting idea about socio-economical impact of morphological change during the study period, a questionnaire survey was conducted among the people, local representative, experts (200 persons) through Focus Group Discussion (FGD). The randomness of the sample, which was 234 house hold in size, was kept. In each unit, proportionate representation of social class was maintained in selection of the households. However, in order to present the actual picture of the existing condition of effected area, in terms of social categories samples were distributed as follows: poor 147, middle 75 and rich 12. Number of poor and middle class respondents was proportionately much higher like the universe and henceforth it can easily be assumed that the sample represents the population exactly.

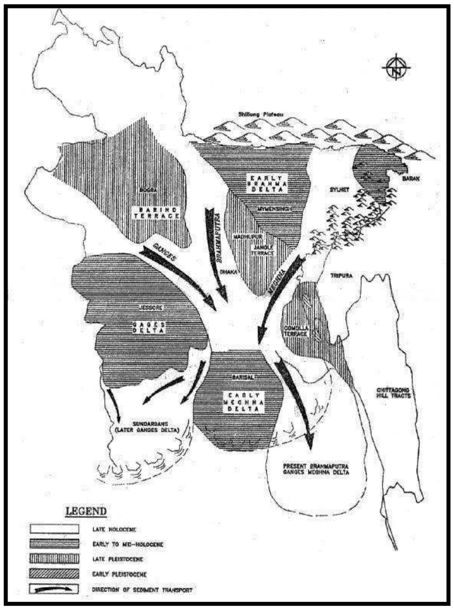


Fig. 8. ***Quaternary Sedimentation in Bangladesh***

Using a face-to-face technique, empirical data were collected for the study by sample survey method where the universe contains whole area. Based on the information and the data, collected from the first visit, several meetings of the team members were held and an interim test information-checklist was prepared. The information-checklist was pre-tested in the non-sampled area through a pilot survey before finalization. The final information-checklist contained both pre-coded and open-ended questions. Table 4 shows the present socio-economical parameters which area mostly affected due to erosion and siltation. Major causes of erosion are currents, strong river discharge, high waves, and increases of population. The historical maps are used to analyze the complex pattern of sediment movements. Analysis of historical maps of 1990 and 1997 reveals very large changes near Mymenshing town and its erosion/accretion pattern is a function of the increased currents, high upstream flow, high water level, most of the plain of the study area is composed of silty sand and clay deposits, which is highly susceptible to erosion. According to Khan (1999) the gargling effect of water in rivers of Bangladesh will increase with the rise of water level in sea. The major environmental imbalances in the river basin are described below:

From time immemorial, people of Bangladesh Prefer to settle along the bank of the river. Fertility of soil and stableness of the river regime guide the density of the habitation. Habitation along the flood plain bank of the river decreases flood passage of the river. In the river, there are habitations along the both bank of the rivers. People live in very close proximity to the active river channels and are exposed to high risks from erosion and channel changes. In a flood plain, land use practices depend mainly on the depth of flooding due to population pressure, crop variety and intensity has increased. And low-lying area, fallow and pastureland are being cultivated to cope with the increasing demand of the food gain. The flood peak of Old Bramaputra is in fluctuating in nature. The entire main crops of the area are susceptible to flood damage.

Environmental Impact Evaluation of erosion and siltation in Old Bramaputra River

Table 4

		Probability (p)	Severity (s)	Impact Value (IV) = p * s	No Impact	Positive Impact	Insignificant	Low	Medium	High
1.	**PHYSICAL ENVIRONMENT**									
	Topography									
	Plane land	1	6	6				√		
	Soil									
	Erosion	6	6	36						√
	Siltration	6	6	36						√
	Pollution	2	1	2			√			
2.	**ECOLOGICAL ENVIRONMENT**									
	Terrestrial Flora									
	Destruction of plantation	3	6	18						√
	Terrestrial Fauna									
	Disturbance to wildlife	4	3	12				√		
3.	**SOCIO-ECONOMIC ENVIRONMENT**									
	Loss of Land									
	Agriculture	4	4	16					√	
	Residential/Community	3	4	12					√	
	Industrial/Commercial	2	3	6				√		
	Impact On									
	Crops/Plantation	2	6	12					√	

*Negative Impacts Severity (s)
1= No damage
2= Minor damage (hazard to single receptor)
3= Minor damage (hazard to multiple receptor)
4= Significant damage (hazard to single receptor)
5= Significant damage (hazard to multiple receptor)
6= Destruction of single/multiple receptor

Probability (p)
1= Negligible
2= Slight
3= Possible
4=Likely
5=Very likely
6= Inevitable

5. CONCLUSIONS

Remote sensing and GIS technology shows the great potentiality to study the morphological change study of the river. This type of study is helpful for further planning of river training and management in an effective manner as it could be incorporated the long time (historical) changes of the river morphology. Analyzing the image of part of the old Brahmaputra River among the year 1997 and 2004, it is found that significant changed has been occurred in north east part of Mymensingh sadar upazila and less change is found in the lower part which is close to the Mymensingh town where China Bangladesh Friendship Bridge (Shambhuganj Bridge) has been constructed. Use of satellite images provides more information regarding bank erosion. Erosion occurs along a 1.12 km long (maximum) at China Bangladesh Friendship Bridge (Shambhuganj Bridge) over time. The river course-changing pattern due to sedimentation is measured 168.34 ha by using planimeter. Transportation of sediment is the major contributing factor of morphological changes. From the study, agricultural land, associated people, irrigation, fisheries, hydraulic structures are identified as most affected parameters due to the morphological change of part of the old Brahmaputra River. River protection works suggested by Nahar [10] and Syed [11] can be applied in the study area.

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