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Study of the Morphological Change of the River Old Brahmaputra and Its Impacts

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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 for the years 1997 and 2004, it is found that significant changes have occurred in north eastern 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) is situated. Transport of sediment is the major contributing factor of such morphological changes, which causes significant socio-economic impact along the region.

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

Introduction

Bangladesh stands on a thick alluvial deposit. It is the result of the deltaic activity of the Ganges and the Brahmaputra. These main rivers, their tributaries and distributaries control its hydrological and morphological behaviour. The Padma, the Meghna, and 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 differ from one another in their physical characteristics and general behaviours. Among these small rivers, the Old Brahmaputra is an active river and plays an important role in changing morphological behaviour of some other rivers in the downstream (Hossain, 1998). Constant changes of the river course constitute a significant factor in the hydrology of the Brahmaputra. At the same time, a large number of people living beside the river use to be affected because of such change in course of the river. The study is strictly focussed on the Old Brahmaputra River and its morphological changes using remote sensing and GIS.

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Channel Morphology: Characteristics

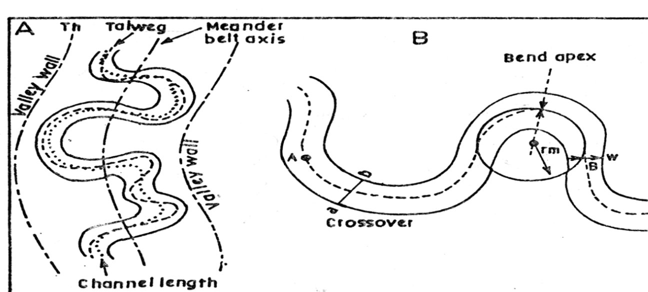

Figure 1: Channel form: valley walls, channel length, channel thalweg, meander belt axis, crossover, curvature of radius (rm) and channel width.

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.) (Jansen, 1979; Simons & Albertson, 1960; Shahid, 2002). Figure 1 shows different variables of channel morphology. Figure 2 shows the different types of channel pattern. The rivers studied are meandering rivers in pattern. Different types of meander changes are shown in Figure 3.

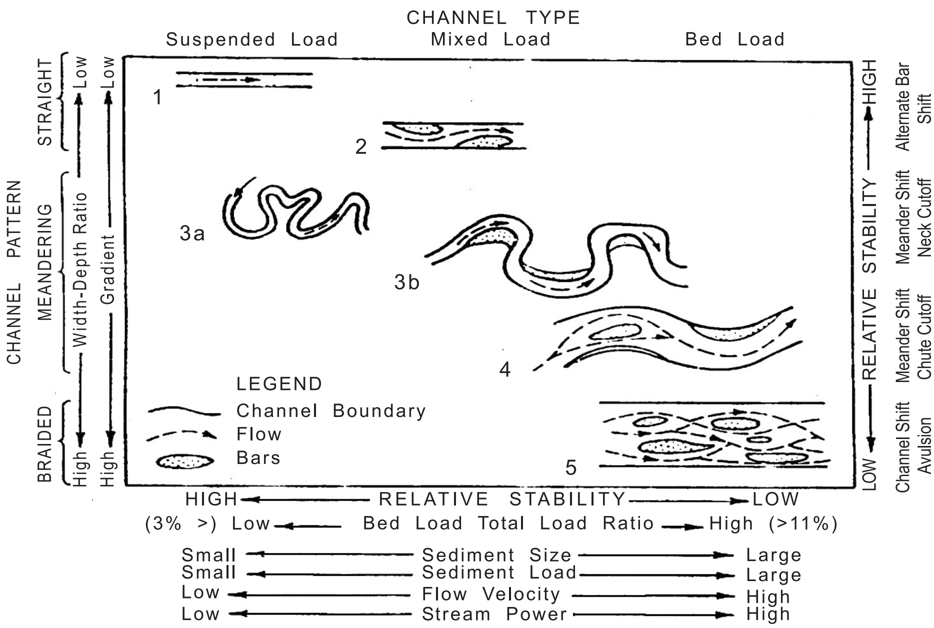

Figure 2: Channel classification based on pattern and type of sediment load, showing types of channels, their relative stability and some associated variables (Simons, 1977).

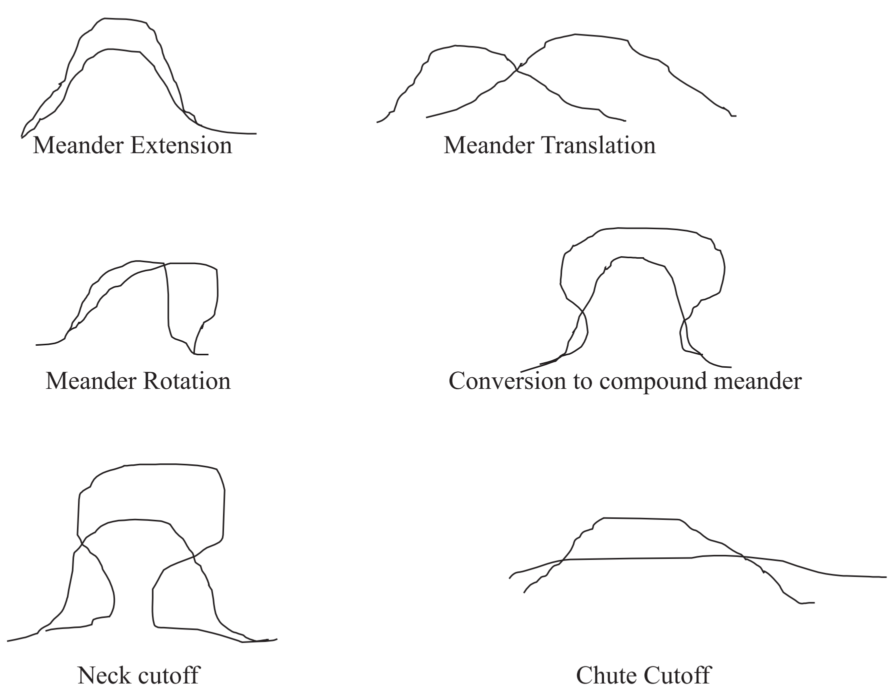

Figure 3: Different types of meander changes (Simons, 1977).

Many researchers use remote sensing technology in studying channel pattern, which is a part of morphological change study (Shahid, 2002; Alam and Hossain, 1998). Alam and Hossain (1998) studied on identifying the morphological changes in one of the distributaries of the Ganges within Bangladesh in response to the declining flow using remote sensing data. It observed that in response to the changes in 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. On the other hand, hydrologic data are used to show the relation between the changes in morphological parameters with the change in hydraulic regime. For planning and sustainable development, identification of morphological change is essential. So, in this study, an attempt has been made to present the pattern of morphological change in one of the main rivers of Bangladesh (Old Brahmaputra) and its social impact for future planning to protect agricultural land and ecology of the surrounding area.

Study Area

The main part of the study area is in the district of Mymensingh and partially in the districts of Tangail, Jamalpur, Sherpur and Netrokona. Figure 4 shows the study area along with the major river networks. Geographically the study area is situated within 90° 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 the study area.

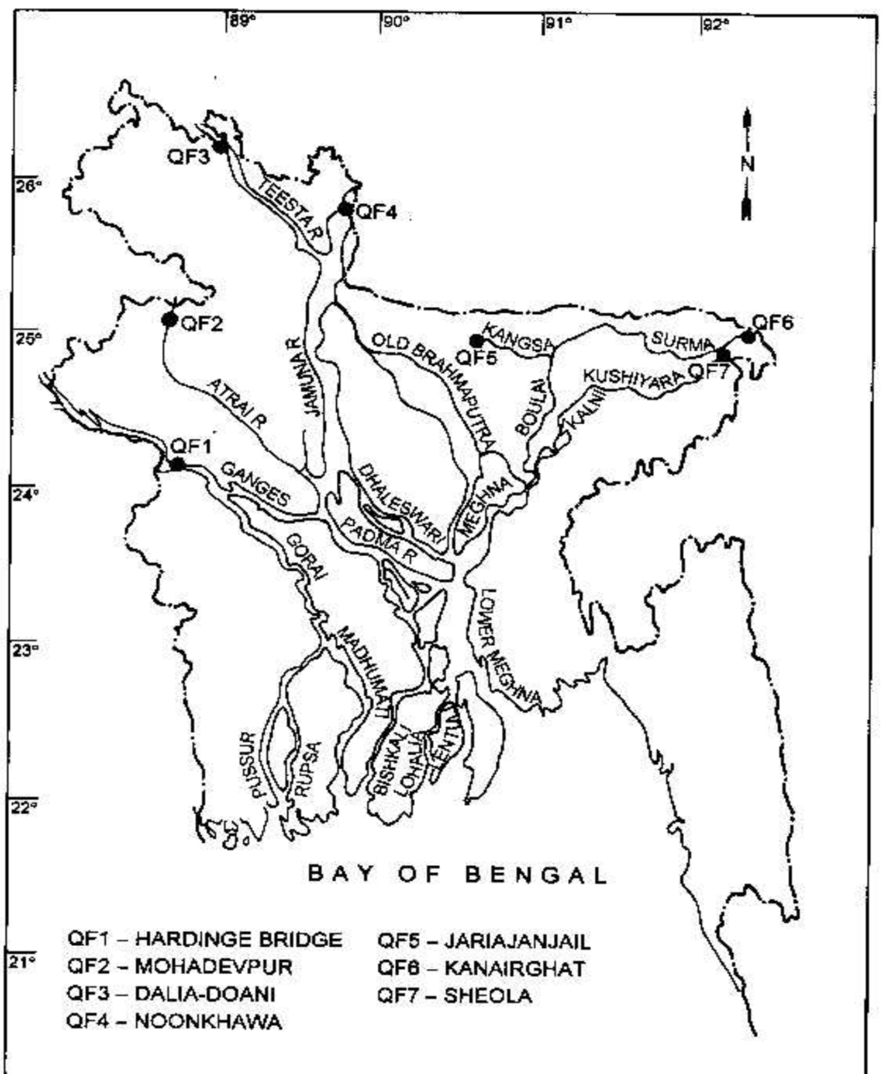

Figure 4: Location map of the study area.

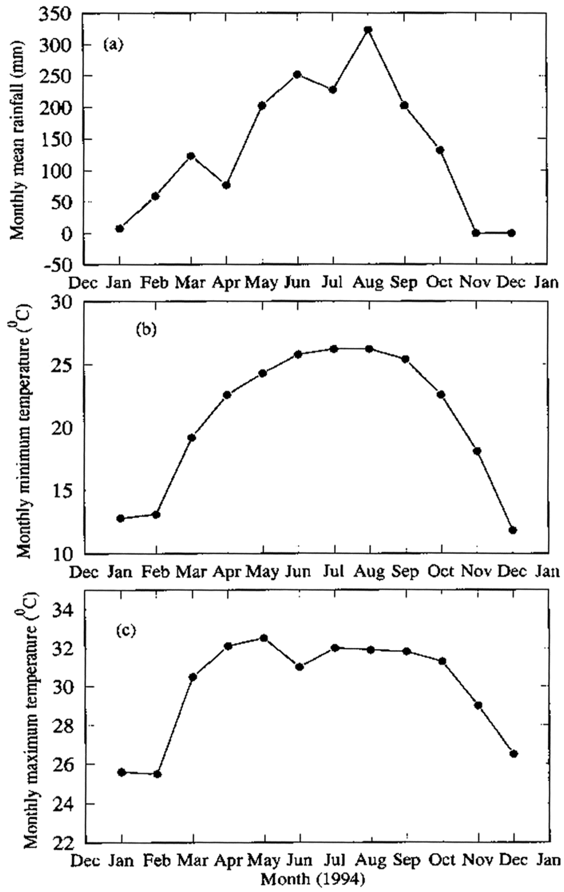

Figure 5: Typical monthly variation characteristics of rain and monthly minimum and maximum temperatures in Mymensingh district.

The general soil types of the area are non-calcareous gray flood plain soils. The landuse/land cover of the area is categorized into 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 lack the knowledge of soil conservation.

Methodology

Input Data Used

Landsat TM data has been used for the present study. To detect the changes in two images, data were as:

(i) January 10, 1997 and
(ii) January 25, 2004.

In both cases Bands 2, 3 and 4 have 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 (ESRI, 1994).

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 reached between two iterations. Performing an unsupervised classification is simpler than a supervised classification because the signatures are automatically generated by the Isodata algorithm.

ESRI (1994) suggests users 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 values 37 (1997) and 33 (2004) for better land water separation were found. After land water classification two classified images have 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.

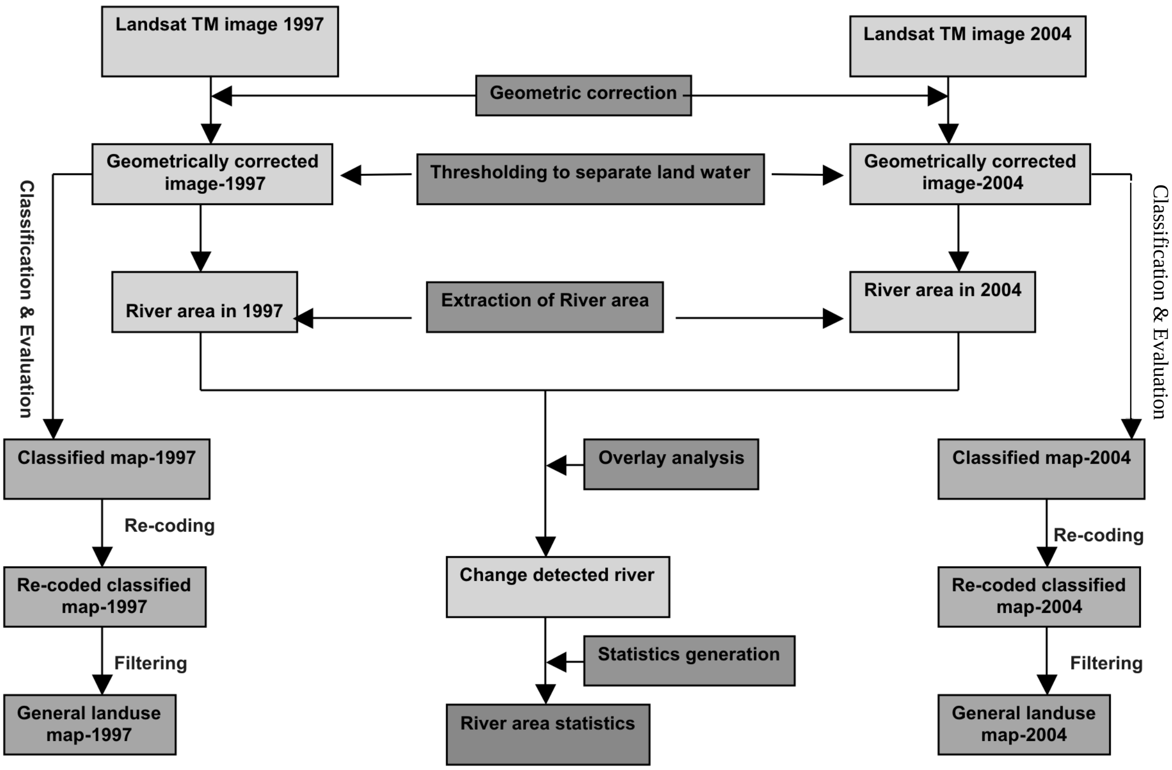

Figure 6: Flow diagram of the whole study.

Result and Analysis

Hydrological Characteristics of the Study Area

Old Brahmaputra is a river that originates from the left bank of the Brahmaputra (http://banglapedia.search.com.bd/HT/B_0615.HTM) 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 (http://banglapedia.search.com.bd/HT/E_0002.HTM) 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. (http://banglapedia.search.com.bd/HT/S_0450.HTM) Soils of this geomorphic unit are more oxidized and darker than soils developed in the last 200 years on the young Old Brahmaputra floodplain. Groundwater in the unit has a characteristic chemical composition.

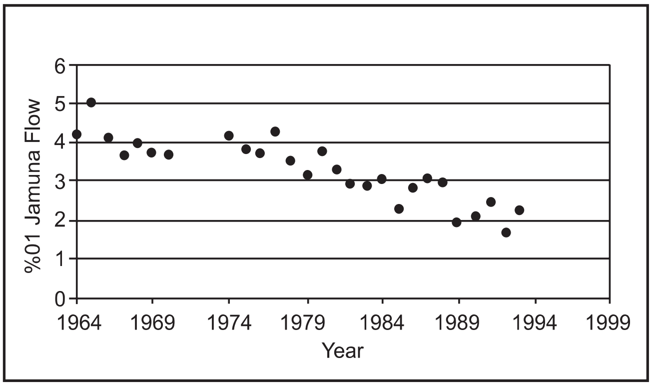

Figure 7: Variation of flow with year expressed in % of the Jamuna Discharge.

Table 1: Land water area in 1997

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

Table 2: Land water area in 2004

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

Table 3: Composite statistics of changing the land-water area

Class name	*Class ID in 1997*	*Class ID in 2004*	*Area (in ha)*
Land in both years	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 years	2	2	729.5

Tables 1 and 2 show the changes in physical characteristics of the river at two periods. From the above tables 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. 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. The impacts of river course also have changes on agriculture, settlement, forest, fisheries, infrastructure, hydraulic structure, etc.

Significant changes have 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 junction in Mymensingh town where less changes have occurred (Figures 8 and 9).

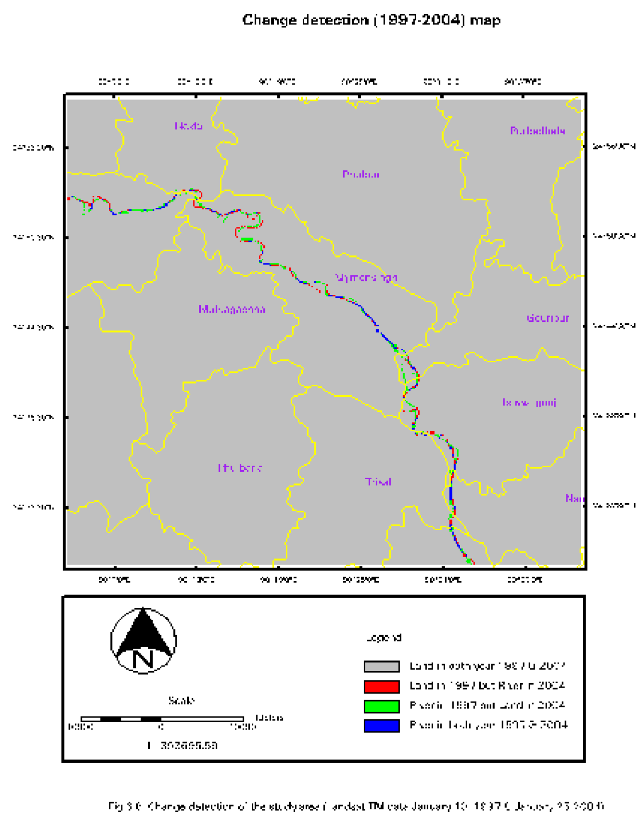

Figure 8: Change detection map of the study area (Landsat TM data: January 10, 1997-January 25, 2004).

It is clear from Figure 8 that changes occurred at east part of Mymensingh sadar upazila. The reason of change may be due to meandering nature of river **(**IWM, 2002**)**. 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

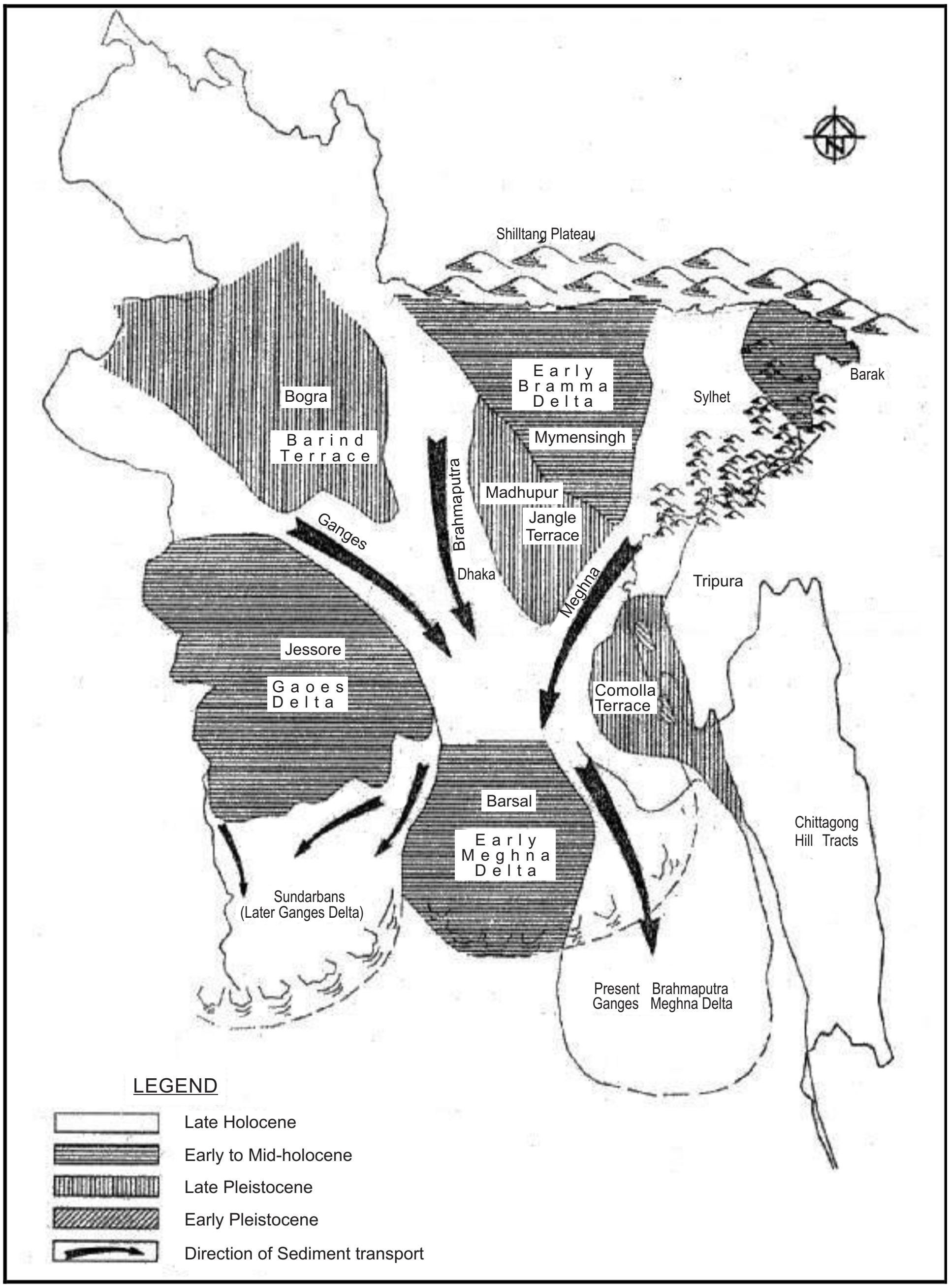

Figure 9: Quaternary sedimentation in Bangladesh.

Mymensingh mainly translation occurs. At Raysrr, neck cutoff type of change occurs. Close to the Mymensingh town both chute cutoff and translation occurs at the middle section; at the upper and lower portions 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 (1998) 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 average width and braiding intensity with year for the river at north-east part of Mymensingh is significant.

Socio-economic Impact

In order to get idea about socio-economic impact of morphological change during the study period, a questionnaire survey was conducted among the people, local representative and experts (200 persons) through Focus Group Discussion (FGD). The randomness of the sample, which was 234 household 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. 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-economic parameters in areas mostly affected due to erosion and siltation.

Table 4: Environmental Impact Evaluation of erosion and siltation in Old Brahmaputra River

		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						√
	Siltation	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

Conclusions

Remote sensing and GIS technology show that the morphological change of the river is significant which needs to be studied properly. This type of study is helpful for further planning of river training and management in an effective manner considering the long time (historical) trend in changes in the river morphology. Analyzing the image of part of the Old Brahmaputra River during the years 1997 and 2004, it is found that significant change has 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 plani-meter. Transportation of sediment is the major contributing factor to morphological changes. From the study agricultural land, associated people, irrigation, fisheries and 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 (2005) and Syed (1996) can be applied in the study area.

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