ASSESSMENT OF BANKLINE SHIFTING PATTERN AND IMPACT OF MAJOR FLOOD EVENTS ON TETULIA RIVER BANK USING MULTI TEMPORAL SATELLITE IMAGE ANALYSIS

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ABSTRACT

Bangladesh is one of the most geomorphologically active countries situated within the world's largest basin of the Ganges-Brahmaputra-Meghna (GBM). Most of the rivers in this country exhibit a considerable amount of erosion-accretion every year, causing the shifting of banklines. The Tetulia River is one of the coastal rivers of Bangladesh, located at the Meghna estuary. Being a coastal river, it frequently experiences erosion-accretion due to wave action, cyclonic storm surges, and floods. Therefore, an analysis was conducted on the rate of erosion-accretion, as well as the pattern of bankline shift of the Tetulia River during the period 1991-2021. Short-term analyses were conducted every 5 years, while long-term analysis was carried out over a 30-year period. The erosion-accretion rates were also analyzed for three major flood events occurring in 1988, 1998, and 2004. Multi-temporal satellite Landsat images were utilized for the analysis, and the erosion-accretion rates were calculated using ArcGIS software. The analysis was performed separately for each riverbank, and variations in morphological changes were observed. The highest erosion, measuring 30.864 sq. km, was recorded between the years 1996 and 2001, whereas the highest accretion, totaling 28.734 sq. km, occurred between 2011 and 2016. When the analysis was conducted separately for each bank, the right bank was found be more prone to erosion. The left bank, on the other hand, had zones of heavy sedimentations, with a few selected regions of erosion. Overall, the left bank was found to be more susceptible to morphological changes in the selected 30 year period. In the analysis of the major flood events, the flood of 1988 showed the highest amount of accretion, whereas the flood of 1998 eroded the banklines more significantly. The 2004 flood had the least impact on the morphological changes of River Tetulia. The analysis of the river's bankline shifting provides an overview of the vulnerability of the river to erosion-accretion and can help in building mitigation plans to address this issue.

Keywords: *Tetulia River, Bankline shifting, Erosion-Accretion, Flood, Arc-GIS*

1. INTRODUCTION

Bangladesh is one of the world's largest deltaic plains, where more than seven percent of its lands are occupied by river systems (Billah, 2018). Bangladesh is considered the most disaster-prone country in the world, and in recent times riverbank erosion is becoming more frequent and intense as a result of climate change (Alam, 2016). Around 20 out of 64 districts in Bangladesh are prone to riverbank erosion, which consumes around 8700 ha of land each year (Alam, 2017). Riverbank erosion is one of the most unpredictable and critical disasters that takes into account the quantity of rainfall, soil structure, river morphology, topography of river and adjacent areas and effect of floods (Pal et al., 2017). A fluvial system's two primary geomorphic processes are river bank erosion and accretion, driven by natural events such as flooding, sedimentation, high energy current and anthropogenic influences such as land use patterns (Surian, 1999). Land deposition due to accretion process plays a significant role in changing the shape of river over time. Land deterioration due to erosion and accretion is usually recorded at the beginning of the rainy season (Iva et al., 2017).

Bangladesh is one of the most vulnerable countries exposed to the impacts of global warming and climate change due to its unique geographic location, low topography, relatively higher population density and an overwhelming dependence on natural resources. It causes undesirable adverse outcomes like storm surges, cyclones and floods (Biswas et al., 2017). Flooding and riverbank erosion often occur as cascading hazards i.e., one hazard leads to another one. Being a coastal river, Tetulia river faces both monsoon flooding and tidal flooding. The riverbanks have observed shifting and new bars are being formed over the years. However, no long-term analysis has been done on the rate of erosion and accretion of this river. This study focuses on the shifting of the banklines of the Tetulia River between the years 1991-2021. The whole assessment is based on multi-temporal satellite image analysis in GIS, while observing the shifting pattern and calculating the amount of erosion and accretion at 5-year intervals. The impacts of three major floods (1988, 1998 and 2004) on the erosion-accretion of the river is also analysed.

2. MATERIALS AND METHODOLOGY

2.1 Study Area

Tetulia River is one of the largest coastal rivers of the southern part of Bangladesh. The river originates from Meghna River in the South-East part of Bhola district and then flows down over three important coastal districts like Barisal, Bhola and Patuakhali. There are nearly 120 chars in the Tetulia River due to sedimentation which get inundated in high tide and dry up in low tide due to tidal action (Hossain, 2021).

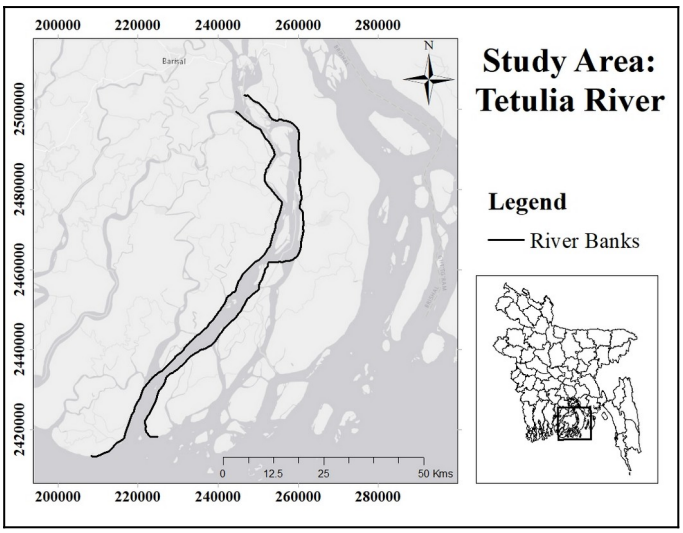

Figure 01: Tetulia River with Specified Bank Lines

A number of places under Bauphal, Dasmina and Galachipa upazila, Lalua, South Dighalda, Debir char are facing severe bank erosion caused by the river Tetulia whereas other places such as Dularhat, Sibar char, Charkajol, Rangabali, Chota Baisdia are more prone to accretion than erosion. A map of Tetulia River highlighting its both banks are shown in Figure 01.

2.2 Data Collection and Methodology

Bankline shifting is generally assessed by observing and calculating the amount of erosion and deposition occurring along river banks. Bankline shifts never follow any systematic pattern as a large number of variables are involved in the process. Geospatial technologies like GIS and Remote sensing (RS) can be used in identifying river changes and bankline movements (Khan et al., 2014).

To assess the bank line shifting pattern and erosion-accretion of Tetulia River, multi-temporal satellite images ranging between the years 1988 and 2021 were collected. Landsat 4-5 TM, Landsat 7ETM+ and Landsat 8OLI were selected for this purpose. The selected study area was covered by two satellite scenes (Path: 137, Row: 44 and Path: 137, Row: 45). For having cloud free atmosphere and consistency of water level and vegetation, all the images were taken during the dry season (January to February). Moreover, vegetation cover and other ground conditions, particularly the water level, are found relatively consistent in dry months which is essential for assessing the inter-year change of erosion and accretion of the river.

To quantify erosion-accretion rate and to determine bank line changes, a GIS-based approach was followed using ArcGIS (Version 10.5 and 10.7). Short term (5-year intervals) and long term (30-year interval) erosion-accretion analysis was conducted along with the assessment of the impacts of three major floods (1988, 1998 and 2004) on the river bank line migration. The collected images were referenced in the World Geodetic System (WGS_1984) datum and projected using the Universal Transverse Mercator System (UTM zone 46N). The image tiles were mosaicked first and then bank lines were digitized. The erosion-accretion analysis was done by simply superimposing bank lines of two different years and calculating the intervening areas between them. The simplified illustration of the methodology is showed in Figure 02, marking the erosion and accretion which was calculated.

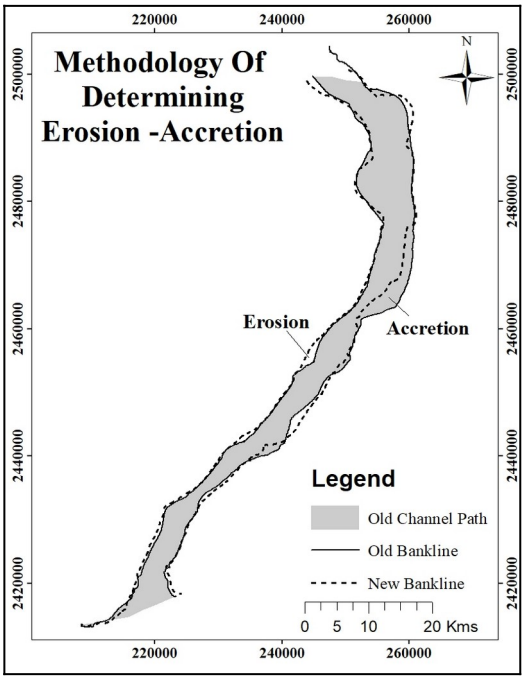

Figure 02: Methodology of Erosion-Accretion Determination

3. RESULTS AND DISCUSSION

The erosion-accretion of Tetulia River was analyzed and the changes in the bank line pattern was observed for three different scenarios. The short-term analysis was done at 5-year intervals between years 1991-2021, to see the shifting in the river bank lines over the years. A long-term analysis of 30 years was done to see the overall migration of the channel and to assess the total amount of erosion and accretion between these years. As flood events usually augment to the rate of erosion of channels, three major flood events occurring in 1988, 1998 and 2004 were selected to analyze their impacts on the erosion-accretion pattern of Tetulia River.

3.1 Short-term Analysis

The short-term analysis of erosion and accretion was done at 5-year intervals between the years 1991-2021. The calculated values are represented in Table 01. The erosion-accretion did not follow any particular pattern, rather fluctuated between this selected time frame. Amount of erosion and accretion were observed to be almost the same between the years 1991-1996. Maximum erosion of 30.864 sq.km was observed between the years 1996-2001, where the accretion was found to be the lowest (2.798 sq.km). However, the following 5 years (2001-2006) showed the least amount of erosion, which was 7.688 sq.km. Accretion was highest between the years 2011-2016, 28.734 sq.km.

Table 01: Amount of Erosion and Accretion at 5-year Intervals

	1991-1996	1996-2001	2001-2006	2006-2011	2011-2016	2016-2021
Erosion (sq.km)	14.915	30.864	7.688	17.295	12.992	23.570
Accretion (sq.km)	15.937	2.798	13.479	6.773	28.734	18.212

The erosion and accretion patterns were compared for both of the banks and clear differences were observed. The amount of erosion-accretion and their trend were plotted in separate bar charts for both the banks (shown in Figure 03).

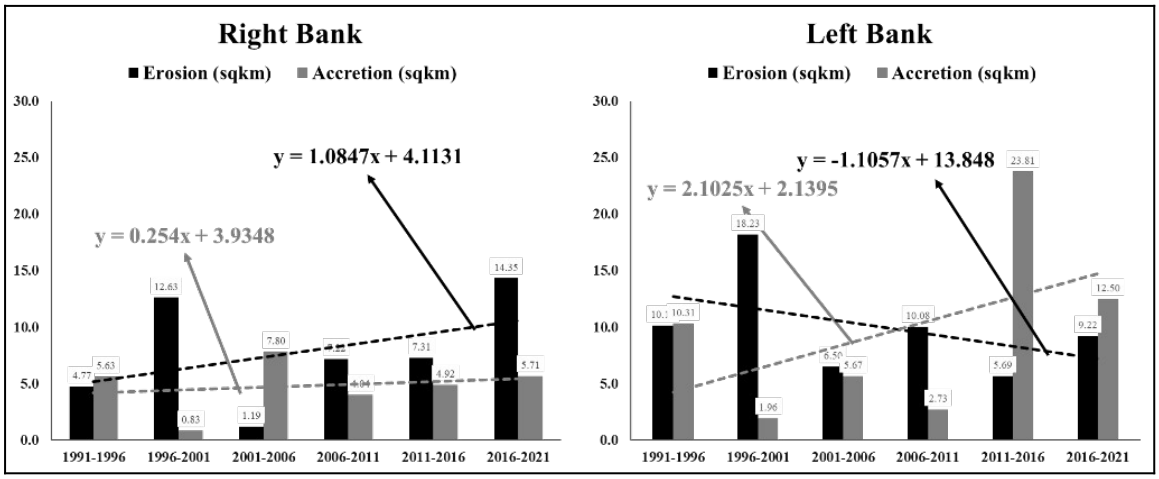

Figure 03: Trends of Erosion-Accretion for both Right and Left banks

For the right bank, major erosion was observed between the years 1996-2001 and 2016-2021, where the values were found to be 12.63 and 14.35 sq.km respectively. An uprising trend for erosion can be observed in the right bank. Amount of accretion was moderate and almost consistent between these 30 years. However, for the left bank almost an opposite scenario was noticed. Even though the amount of erosion was very high between the years 1996-2001 (18.23 sq.km), the overall trend of erosion in the last 30 years is downwards. On the other hand, an upward trend of accretion can be observed in this bank, with major accretion 23.81 sq.km between the years 2011-2016. This analysis supports the natural tendency of bank line adjustment of rivers, where one bank gradually washes away while the

other gets sedimented. The right bank of Tetulia River is more prone to erosion in the recent years, while the left bank is getting highly sedimented.

3.2 Long-term Analysis

As the erosion-accretion pattern was not consistent and showed several fluctuations in the short-term analysis, it was difficult to understand the net shifting of the banks. The long-term analysis of 30 years (1991-2021) was done to get an idea about the net erosion-accretion occurring at the banks of River Tetulia. The map in Figure 04 shows that the right bank shifted towards the land in the selected 30 years period, which indicates it has an overall pattern of erosion. In case of the left bank, the middle region gets heavily accreted, which shows an indication of bar formation in that region. Along the left bank, there are also some zones of erosion, but they are not as prominent as the accretion zone.

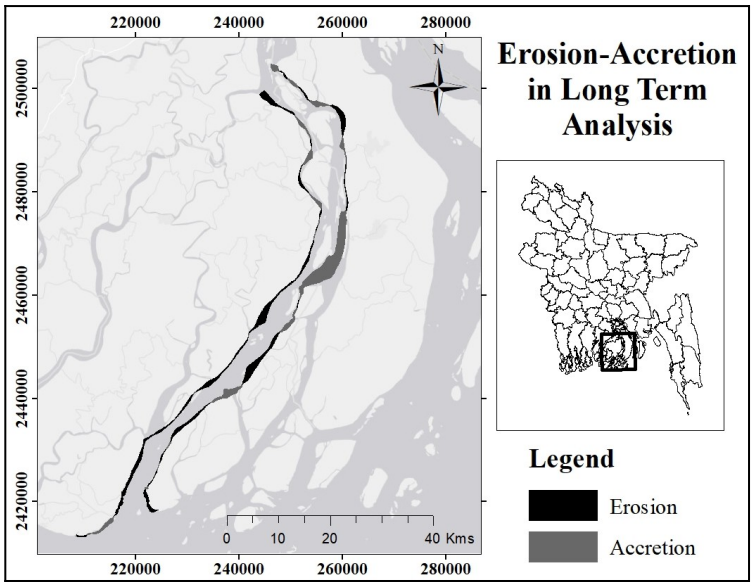

Figure 04: Net Erosion-Accretion of Tetulia River in 30 years (1991-2021)

The net amount of erosion and accretion for both the banks is plotted in a bar chart (Figure 05). The values give a clear indication that the right bank was more prone to erosion, whereas there was a higher rate of accretion in the left bank. The total amount of erosion in the right bank is 27.812 sq.km, which is 21.117 sq.km for the left bank. Even though the amount of erosion is almost similar for both the banks, accretion governs in the left bank with an amount of 35.023 sq.km accreted area in last 30 years. Overall, the left bank is more susceptible to morphological changes as it exhibits both erosion and accretion at a higher amount.

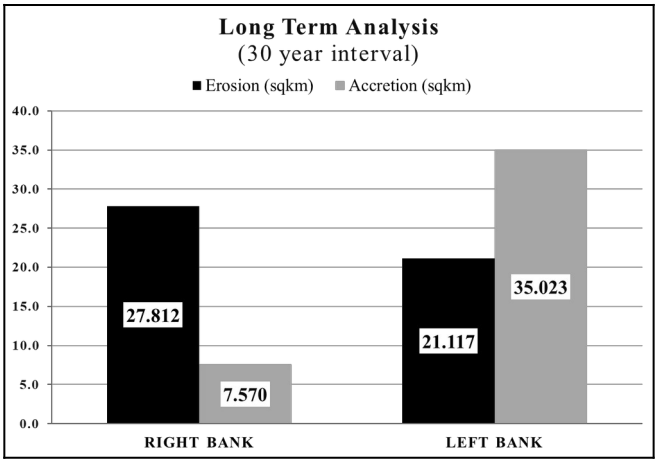

Figure 05: Amount of Erosion-Accretion in 30 years (1991-2021)

3.3 Impact of Major Flood Events

Bangladesh has a long history of destructive flooding, causing major damages to communities and livelihoods. Floods of 1988, 1998 and 2004 are such three out of many. The flood of 1988, occurred throughout August and September, and about 60% of the country was inundated. The floods of 1998 and 2004 lasted for three months, from July to September, and almost two-thirds of the country was flooded. A lot of times, floods cause changes in the river channel by eroding banks. To capture the impact of major floods on the bank line change of Tetulia River, analysis was conducted by observing the bank lines before and after the occurrence of each flood.

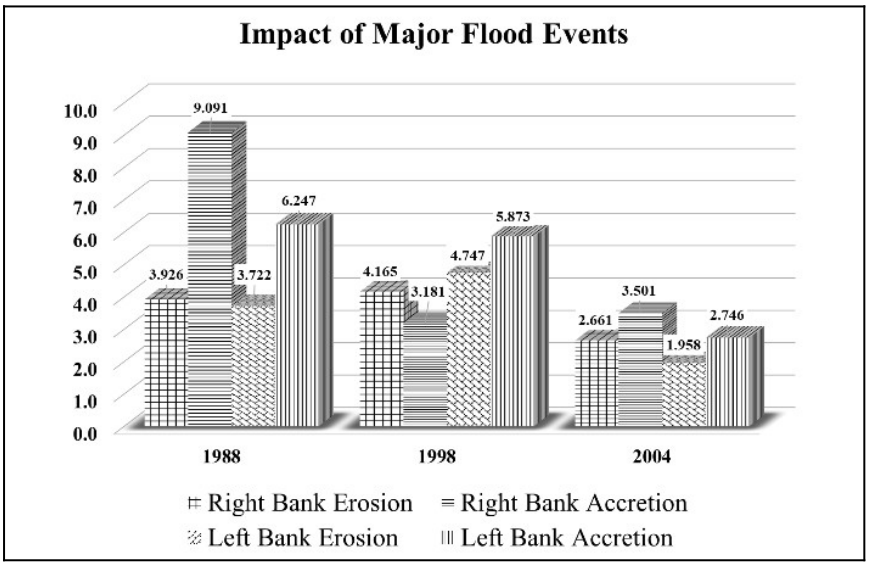

Figure 06: Calculated Erosion and Accretion for Each Flood Event

The amount of erosion and accretion was calculated separately for each of the banks for all the three flood events, and the values were plotted in a bar chart, showed in Figure 06. The flood of 1988 had the most impact on the morphological changes of the river, compared to the other two flood events. Both the banks got heavily sedimented after the occurrence of this flood. The amount of erosion was relatively less. However, for the flood of 1998, erosion for both banks were significant, 4.165 sq.km on the right bank and 4.747 sq.km on the left bank. Among these three flood events, the flood of 2004 had the least impact on the bank line changes of River Tetulia. All the three flood events resulted in a net accretion for both the banks.

4. CONCLUSIONS

The bank line analysis of Tetulia River reveals that the river undergoes morphological changes every year. Both erosion and accretion exhibit an increasing rate in the last 30 years, which is alarming. From the long-term analysis, net erosion and accretion were found to be 48.929 sq.km and 42.593 sq.km respectively, considering both banks together. Some points of the left bank of the river show heavy deposition in the recent years, which points toward a possibility of bars forming around the area. The study also shows that, floods too heavily affect the bank line migration, which is a matter of concern, as Bangladesh faces floods more or less every year. All the results show an urgent need to take necessary steps to protect the river banks by afforestation or other strategies and flood management plans should be formulated. For a better overview of the bank line migration situation, a yearly analysis can be conducted and a larger time span can be taken for the study. As the river shows a tendency of bar formation, analysis of bar dynamics and possible bar formation scenarios can be taken into account for further studies.

REFERENCES

Alam, G.M.M. (2016). An Assessment of the Livelihood Vulnerability of the Riverbank Erosion Hazard and Its Impact on Food Security for Rural Households in Bangladesh. Ph.D. Thesis, School of Commerce, University of Southern Queensland, Toowoomba, Australia, 2016.

Alam, G. M. M. (2017). Livelihood Cycle and Vulnerability of Rural Households to Climate Change and Hazards in Bangladesh. *Environmental Management, 59, 777–791.*

Billah, M.M. (2018). Mapping and Monitoring Erosion-Accretion in an Alluvial River Using Satellite Imagery - The River Bank Changes of the Padma River in Bangladesh. *Quaestiones Geographicae, 37 (3), Pp. 87–95.*

Biswas, Abir & Islam, Rahatul. (2017). Coastal Erosion and Accretion on the Island of Bhola, Bangladesh. Proceedings of Civil and Water Resources Engineering Conference, Civil and Water Resources Engineering Conference At: BIAM Foundation, Dhaka, Bangladesh.

Hossain, MM & Hossen, Md & Rahman. (2018). Operational System and Catch Composition of Charberjal (Fixed Net) in Tetulia River and its Impact on Fisheries Biodiversity in the Coastal Region of Bangladesh. *Nature and Science 2018;16(1)*.

Iva, T. T., Hazra, P., Faisal, M., Saha, S. and Hossain, S. (2017). River bank erosion and its impact on population displacement in Bauphal upazila under Patuakhali district, Bangladesh. *Journal of Science, Technology and Environment Informatics, Volume 05, Issue 02, pp. 371-381*.

Khan, Imran & Ahammad, Muneer & Sarker, Shiblu. (2014). A study on River Bank Erosion of Jamuna River using GIS and Remote Sensing Technology. *International Journal of Engineering Development and Research, Volume 2, Issue 4*, *3365-3371.*

Surian, N. (1999). Channel Changes Due to River Regulation: The Case of the Piave River, Italy. *Earth Surface Processes and Landforms*, *Volume 24, Issue 12, 1135-1151*.