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Impact of Climate Change on Riverbank Erosion

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Abstract

Bangladesh is one of the most climate vulnerable countries in the world. This country is highly vulnerable to climate change because of a number of hydro-geological and socio-economic factors such as geographical location, topography, extreme climate variability, high population density, poverty incidence and dependency of agriculture on climate. Presently this country has been experiencing different hydro-meteorological disastrous events that have never been experienced before. Along with other natural disasters, floods are expected to be impacted by climate change in the future. Since floods are always associated with riverbank erosion, it is essential to assess the impact of climate change on bank erosion. Riverbank erosion is also a serious hazard that directly or indirectly causes the suffering of millions of people. Beyond that, most of the old cities and important infrastructures in this country are situated on riverbanks since once upon a time waterway transportation was the main mode of travel. Moreover, people like to reside near rivers because of their dependency on river water for irrigation purposes. So a major part of the total population of this country lives near riverbanks, which frequently makes them victims of riverbank erosion. The major rivers, the Jamuna, the Ganges and the Padma, annually erode thousand hectares of floodplain land and damage or destroy infrastructures. Consequently, this natural disaster has become a major social hazard.

This study aims to find out the relationship between floods and bank erosion; and hence the impact of climate changes on riverbank erosion. Since there is no record on riverbank erosion, this study attempts to measure it with the help of satellite images. It has been found in this study that climate change will play a significant role in riverbank erosion. On an average, the riverbank erosion along the major three rivers will be increased by 13% by 2050 and it will be increased by 18% by 2100. Assessment of the impact of climate change on riverbank erosion is essential for planning climate change mitigation measures for the country. Similar type of work could be applied to any other climate vulnerable countries which are prone to riverbank erosion.

Keywords: Bankline; climate change; riverbank erosion

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1. Introduction

The term “climate change” is synonymous to “Global Warming”, which refers to rising global temperatures. Warmer global temperatures in the atmosphere and oceans lead to climate change affecting rainfall patterns, storms and droughts, growing seasons, humidity, and sea level. In the geological context, climate change is not a recent phenomenon. The Earth's climate has changed throughout history. The climate has continuously changed since the glacial periods (or "ice ages") when ice had covered significant portions of the Earth to interglacial periods when ice had retreated to the poles or melted entirely. Even during the last 2,000 years, scientists have identified three major events of climate variability, known as the Medieval Climate Anomaly (also referred to as the Medieval Warm Period; 900 to 1300 AD), the Little Ice Age (1500 to 1850 AD) and the Industrial Era (the last 100 years). The linear warming trend over the last 50 years (0.13°C per decade ranging from 0.10°C to 0.16°C per decade) is nearly twice that for the last 100 years. The total temperature increase from 1850–1899 to 2001–2005 was 0.76°C ranging from 0.57°C to 0.95°C [1].

Concurrently, riverbank erosion is one of the major natural disasters of Bangladesh and an issue of major concern. It causes untold miseries to thousands of people every year living along the banks of rivers in Bangladesh. To date, erosion alone has rendered millions of people homeless and has become a major social hazard. People, who live near riverbanks, become victim of erosion which forces them to change their livelihood and community. Most of the victims of riverbank erosion become slum dwellers in large urban and metropolitan cities and towns. Since 1973 major rivers like the Jamuna, the Ganges and the Padma have eroded around 1,590 sq. km of floodplains making 1.6 million people homeless. Not only the floodplain dwellers, but the char land dwellers are also always vulnerable to river erosion. Therefore, it is a vital demand of the present day to find out the impacts of climate change on riverbank erosion.

Change of climatic parameters is not the only cause for concern, the geographical location of Bangladesh also makes the country vulnerable to different natural disasters, especially flood. The rivers of Bangladesh drain the run-off from the upstream catchment area of 1.7 million sq. km. Most of the huge quantity of water flows during monsoon. As a consequence, floods are common phenomena in Bangladesh of which 18-22 percent of area is submerged by river and rainwater during the monsoon season. Floodplains are located in the north-western, central, south central and north-eastern regions because of the existing river network of Bangladesh. Floods and riverbank erosion are concurrent events where most of the time flood and erosion occurs simultaneously or flood is followed by riverbank erosion. Since flood is directly subjected to rainfall and rainfall pattern has been changing over time, climate change is expected to have influence on riverbank erosion.

2. Approach and Methodology

The methodology part was broadly distinguished in three segments: probable change in flood discharge due to climate change, riverbank erosion along major rivers and relationship among change in flood flow and bank erosion. Finally, a prediction on riverbank erosion has been formulated to be occurred by 2050 and 2100 due to climate change.

2.1. Changes in flood discharge

There are large variations in the results predicted by using different Global Climate Change Models. Based on the model results, Mirza et *al.* mentioned in their chapter [2] that the probability of increase in flood discharge due to the rise of global temperature in the Brahmaputra is less than that of the Ganges and the Meghna rivers. Mirza developed an empirical model [3] relating the increase in precipitation in the Ganges and the Brahmaputra basin with the changes in mean annual discharge. It was shown that for different GCM model results, the probable maximum change in precipitation in the Ganges and Brahmaputra basin for 2^0C increase in temperature may be 13% and 10.2% respectively. This increase in the precipitation will result in changes in the mean annual discharge of the respective rivers by 21.1% and 6.4% respectively. Recently, the Institute of Water Modeling [4] undertook a study of the impacts of climate change on monsoon flooding in Bangladesh assuming a 13% increase in precipitation over the Ganges-Brahmaputra-Meghna (GBM) basin under the A1FI emission scenario and found a corresponding 22% increase in the peak discharge of the Ganges at Hardinge Bridge.

A recent study of Winston et al. [5] projected the effects of climate on Bangladesh for three different periods – up to 2030, 2050 and 2080, for which the projected increases in temperature are 0.750C, 1.550C and 2.40C respectively with median precipitation increase of 1.4 and 6%. Discharge during the monsoon (May to September) by 2050 would increase but the increment would vary each month as well as from river to river. The average discharge increment in August and September would be about 10%, 12% and 7% in the Brahmaputra, the Ganges and the Meghna respectively.

Since past studies show a wide range of variation in flood discharge, it has been considered in this study that flood flow will be increased by 15% by 2050 and 20% by 2100 for all the major rivers. However, this estimation can be revised for any percentage of flood flow increment. Average peak flood used in this study has been calculated using the BWDB discharge data for the period 1950-2009 for Bahadurabad (in the Jamuna), Hardinge Bridge (in the Ganges) and Baruria Transit (in the Padma) stations.

2.2. Riverbank erosion along the major rivers

Riverbank erosion along major rivers (the Jamuna, the Ganges and the Padma) has been assessed from banklines delineated from time series satellite images generated following the criterion mentioned in section 2.2.1. Satellite images for the period 1973 to 2011 available in CEGIS have been used in this study.

2.2.1 Bankline delineation

Geo-referenced images have been used to delineate the banklines of the river. Banklines are generally well defined in meandering rivers, but the task is not straightforward with regard to very dynamic braided rivers. In delineating banklines for large rivers using satellite images, CEGIS followed the criteria developed by EGIS (1997) [6] while carrying out a study on the morpho-dynamics of the Brahmaputra-Jamuna River. In brief, the criteria for bank line delineation are: the bank line should separate the floodplain from the riverbed; all sand bodies except crevasse splays (coarse sediments that are spread over floodplains during floods by overtopping the banks) should be considered as part of the riverbed; vegetated char land, bounded by flanking channels and the width of which is more than 100 m, should be considered as part of the riverbed as well.

2.2.2 Riverbank erosion

Riverbank erosion has been calculated by superimposing two consecutive banklines. Although images are available since 1973, there are time gaps except from 1994. Hence, decadal erosion rate has been calculated by dividing total erosion of each decade by the number of years using data for the period 1973-2010. On the other hand, erosion data for the period 1994 to 2010 have been used for finding the relationship with flood discharge since data on consecutive erosion and peak discharge are available only for that period. Since the annual rate of riverbank erosion along the Jamuna, Ganges and Padma rivers varies largely with time, the natural trend is needed to be eliminated to establish relationship between flood discharge and bank erosion.

A simple statistical method has been used to eliminate the natural trend. For example, y_t is time series erosion data and y_{avg} is the average value of raw data series (Fig. 1a). A trend value 'y_{trend}' has been deducted from y_t and the average of value y_{avg} has been added to each deduced value to eliminate the trend from the data series (Fig. 1b). Finally, a new data series (after elimination of trend) has been used to find out the relationship between discharge and erosion.

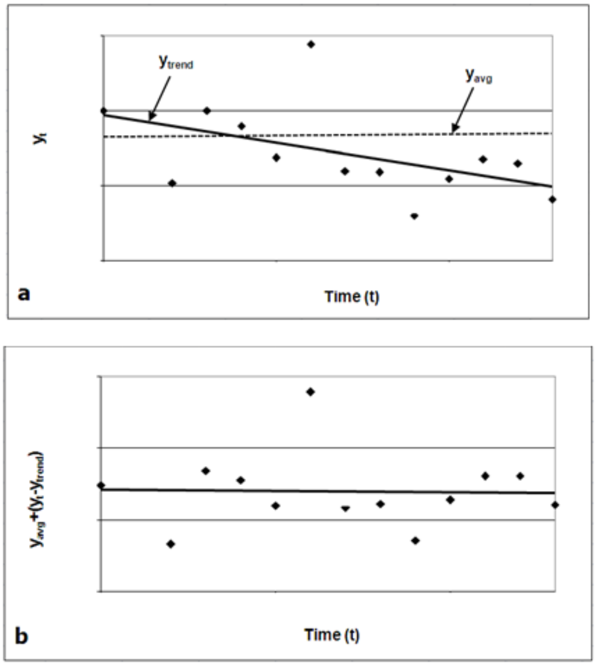

Fig. 1. method for trend elimination for riverbank erosion

2.3. Relationship between flood discharge and bank erosion

Erosion data generated by trend elimination was used to find out the relationship between peak discharge and riverbank erosion. Simple mathematical relationship has been established by plotting annual peak discharge (in X-axis) and erosion (in Y-axis) in a graph. Future prediction of erosion has been carried out through calculation using relationship formulas for each of the rivers.

3. Results and Discussion

It has been found that rate of riverbank erosion varies in decade-scale along the major three rivers (Figs. 2, 3 and 4). Sometimes variation may be naturally induced and/or sometimes it is induced by anthropogenic activities (such as installation of bank protection structures).

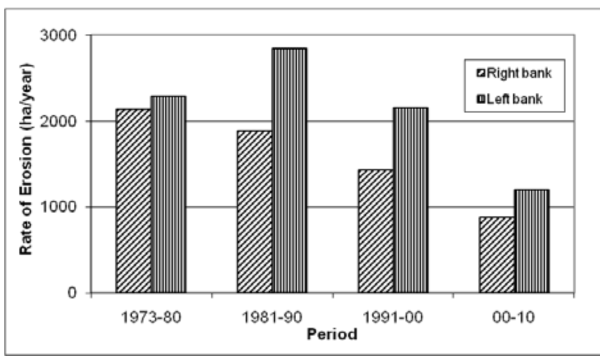

Fig. 2. decadal erosion pattern along the banks of the Jamuna River

Fig. 3. decadal erosion pattern along the Ganges River

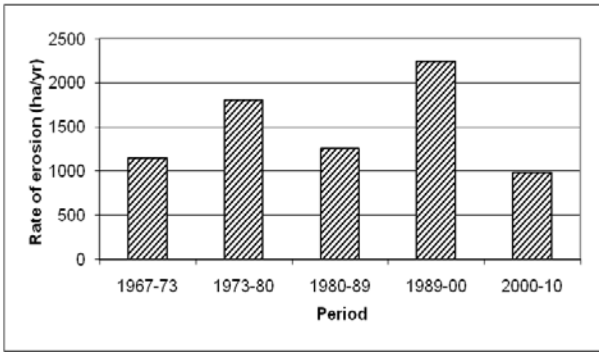

Fig. 4. decadal erosion pattern along the Padma River

Changing in morphological process has been observed in the Jamuna, the Ganges and the Padma over the period which makes fluctuation in bank erosion. The phases of meandering bend development and subsequent chute cut-off also determines the annual rate of riverbank erosion, which has been observed in the Ganges and partly in the Padma. Therefore, we can conclude that naturally riverbank erosion has a trend of fluctuation. So, to find out actual erosion change trend, we must eliminate natural trend first. Then we should attempt to find out relationship between flood discharge and bank erosion. Exactly this process has been followed here. However, after elimination of trend it has been found that the magnitude of riverbank erosion is dependent on annual flood discharge (Figs. 5, 6, 7 and 8). Equations for predicting riverbank erosion due to increase in flood discharge read as:

For the Jamuna River:

Right bank

$$E = 0.009Qmax + 423 \quad (1)$$

Left bank

$$E = 0.043Qmax - 1344 \quad (2)$$

For the Ganges River:

$$E = 0.008Qmax + 1465 \quad (3)$$

For the Padma River:

$$E = 0.015Qmax + 122 \quad (4)$$

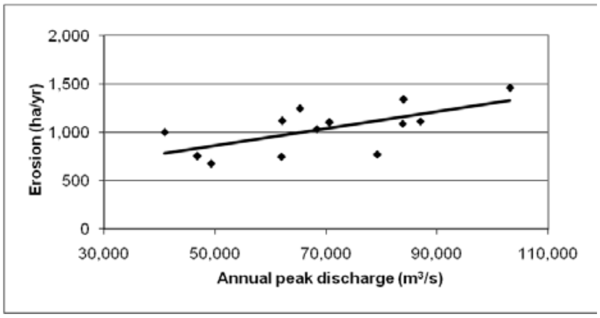

Fig. 5. Relationship between annual peak discharge and bank erosion along the right bank of the Jamuna River

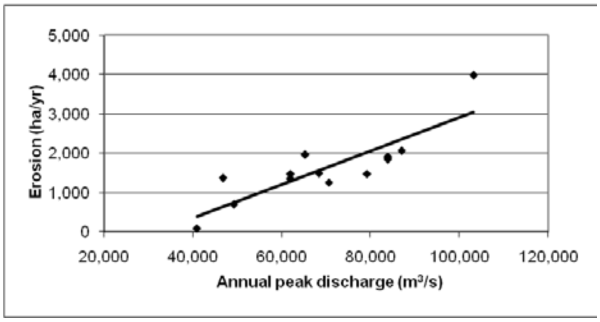

Fig. 6. Relationship between annual peak discharge and bank erosion along the left bank of the Jamuna River

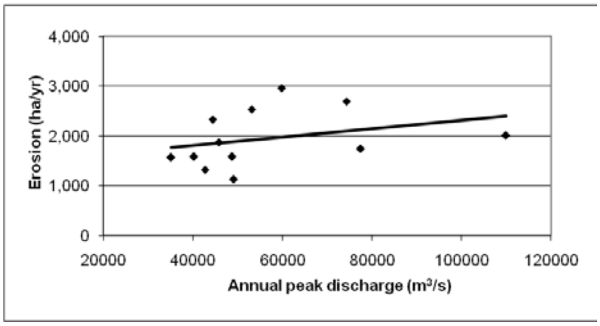

Fig. 7. Relationship between annual peak discharge and bank erosion along the Ganges River

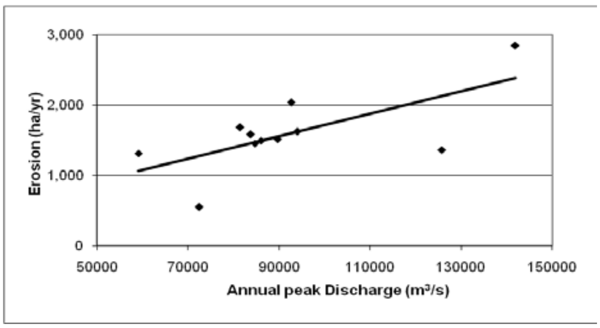

Fig. 8. Relationship between annual peak discharge and bank erosion along the Padma River

Annual average peak discharges have been calculated as 70,000 m^3/s, 50,000 m^3/s and 90,000 m^3/s for the Jamuna, the Ganges and the Padma rivers respectively for the period of 1950-2010. It has been found that an increase in flood discharge by 20% within the year 2100 will increase the annual rate of riverbank erosion substantially. The predicted riverbank erosion for 2050 and 2100 are presented in Table 1 which shows that increase in the average annual erosion rate is higher for the Jamuna and the Padma by 2050 than that by 2100. On the other hand, the Ganges is in a balance position for 2010-2050 and 2050-2100 durations.

Table 1: Predicted riverbank erosion along the Jamuna, Ganges and Padma Rivers

River name	Erosion in 2010	Erosion by 2050 (%increase from base)	Erosion by 2100 (%increase from base)
Jamuna	2,700	3,250 (20.7%)	3,450 (27.8%)
Ganges	1,850	1,900 (2.7%)	1,950 (5.4%)
Padma	1,500	1,700 (13.3%)	1,750 (16.7%)
Total	6,050	6,850 (13.2%)	7,150 (18.2%)

4. Conclusion

The relationship between climatic parameters and river planform is complicated. This study establishes prediction formulas for bank erosion which is dependent on peak discharge. Even if the projection for peak flow is revised in future research, the same study can generate future projections of erosion.

This study shows that riverbank erosion is expected to be increased by 13% and 18% by 2050 and 2100 respectively due to the assumed 15% and 20% increment in flood discharge for the mentioned years.

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References

[1] IPCC. "Technical Summary" in *Climate Change 2007: The Physical Science Basis. Disclaimer Contribution of Working Group - I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, 1st ed., S. Solomon, D. Qin and M. Manning, Eds. 2007, pp. 37.

[2] M.M.Q. Mirza, N.J. Ericksen, R.A. Warrick, and G.J. Kenny. "Are floods getting worse in the Ganges, Brahmaputra and Meghna basins?" in *Climate Change and Water Resources in South Asia*, M.M.Q. Mirza and Q.K. Ahmad, Eds. Taylor & Francis, 2005, pp. 55-56.

[3] M.M.Q. Mirza. "The implications of climate change on river discharge in Bangladesh" in *Climate Change and Water Resources in South Asia*, M.M.Q. Mirza and Q.K. Ahmad, Eds. Taylor & Francis, 2005, pp. 103-136.

[4] IWM. *Impact Assessment of Climate Change and Sea Level Rise on Monsoon Flooding*. Dhaka, BD: IWM, 2008.

[5] H.Yu. Winston, M. Alam, H. Hassan, A.S. Khan, A.C. Ruane, C. Rosenweig, D.C. Major and J. Thurlow. *Climate Change Risks and Food Security in Bangladesh*. London, UK: Earthscan, 2010.

[6] EGIS. *Morphological dynamics of the Brahmaputra-Jamuna River*. Dhaka, BD: WARPO, 1997, pp. 15-17.