
Impact of River Bank Erosion on Human Life: A Study of Sub-Himalayan North Bengal Region in India From Geographical Perspective

Madhusudan Karmakar

Assistant Professor, Maynaguri College

ABSTRACT

River bank erosion is a natural geomorphic process which occurs in all channels as adjustments of channel size and shape are made to convey the discharge and sediment supplied from the stream catchment. This erosion has been emerged as one of the most important environmental hazards in India. Unlike other parts of India this erosion is also active in the Sub-Himalayan North Bengal region of West Bengal. The study was conducted with an objective on analyzing the impact of erosion on the socio economic lives of the affected people of the study area, their displacement, loss scenario and their perception about the causes of erosion. Based on primary and secondary data the findings of the study show that the Teesta, the Jaldhaka, the Torsha, the Kaljani, the Sankosh, the Lish, the Gish, the Balason etc. rivers cause severe bank erosion in their courses in the study area during the monsoon season. Bank erosion causes severe damage to the embankments and thousands of inhabitants are either displaced or suffered huge loss in the form of land, cattle and houses and thrown as destitute.

Keywords: *Processes; erosion prone areas; impact; measures*

INTRODUCTION

Bank erosion is the wearing away of the banks of a stream. It is a dynamic process affecting the concave side of the bank while depositing sediments on the opposite side. Hydraulic processes at or below the surface of the water may entrain sediment and directly cause erosion. River banks are particularly vulnerable to this type of failure and it causes bank undercutting, bed degradation, and basal clean-out. Channel down cutting rate is determined by weathering, breakdown and transportation of boulders (Seidl et al,1997). Gravitational failure includes shallow and rotational slides, slab and cantilever failures, and earth flows and dry granular flows. It is the process of detaching sediment primarily from a bank and transporting it fluvially. Unlike other rivers of India the rivers of the Sub-Himalayan North Bengal region experience massive bank erosion. These rivers cause bank erosion every year during the monsoon season. People suffer a lot due to the bank erosion of these rivers. However the present study first describes the nature of bank erosion of these rivers and then it proceeds to describe the impact of bank erosion on the human life with case studies. The study ends with an account of some preventive measures to reduce the severity of bank erosion.

OBJECTIVES

The present study embraces the following objectives-

- To identify the nature of bank erosion
- To present the impact of bank erosion on human life
- To suggest preventive measures

LITERATURE REVIEW

River bank erosion and channel shifting are a geo-morphological phenomena that have been studied by various researchers in last few years (Pati et al. 2008; Phillip et al. 1989; Das et al. 2007). Winterbottom and Gilvear (2000) used a GIS-based approach for mapping probabilities of river bank erosion in regulated River Tummel, Scotland. Mani et al. (2003) carried out the erosion study of a part of Majuli River Island using remote sensing data. Kotoky et al. (2005) has studied the nature of bank erosion along the Brahmaputra river channel, Assam, India. Kummur et al. (2008) used remote sensing to detect the riverbank changes along the Mekong River in the Vientiane–Nong Khai area.

The change in Ganga river course and resulting river bank failure is a long-term natural disaster in West Bengal. This has become a chronic problem from early sixties, and it has manifested itself to a formidable magnitude during last four decades as evident from many studies (Rudra 1996a, b, 2004; Banerjee 1999; Mukhopadhyay 2003). The effect of flood and associated land erosion of socio-economic aspects of this area was studied in details by Showkat (2010). The rate of river bank erosion is very high and frequent, which causes a huge amount of river bank cutting and population migration from the villages near the river every year (Iqbal 2010). Saha(2011) in his study mentions the changes of course of the River Ganga in Malda district and its impact on Economy and society. Sarkar, et. al.,(2011) in his study in the Sub-Himalayan North Bengal rivers puts forward the nature of bank erosion of the Teesta,Mahananda,Balason,Kaljani Lish,Ghish Diana Dima Jainti Pagli rivers.

DATA BASE AND METHODOLOGY

The present study is based on both primary and secondary data generated through author's field survey. In this study, the relevant secondary data were collected from the research based books and the Disaster Management Section (Relief) of Maynaguri Block Development Office. The obtained data help the author immensely providing necessary information.

To show the nature of bank erosion several processes of stream bank erosion have been mentioned. To reflect the bank erosion prone areas of the present study area, North Bengal has been categorized as Very high vulnerable zone, Highly Vulnerable zone, Moderately Vulnerable zone and Low vulnerable zone. Again for showing the impact of bank erosion on human life three criteria like the affected areas, their loss scenario and the affected number of people have been highlighted.

Primary data were generated by interviewing people through intensive schedule field survey. The survey was carried out from 2nd September to 7th September,2015. For examining the severe effect of river bank erosion on the lives of the people of Domohani-I gram panchayet

250 affected people were interviewed. The sample population were mainly chosen from Barmanpara and Chatrarpar villages of Domohani -I gram panchayet area of Maynaguri block, Jalpaiguri district as these places are now actively witnessing erosion. The data were collected for obtaining the information on profession wise distribution of the displaced people, kinds of properties lost and people's perception about the erosion. Finally several protective measures like structural and non-structural measures have been mentioned. A literature review has also been done based on available books on river bank erosion.

However all these collected primary and secondary information were later on systematically processed, arranged, tabulated and analyzed to have a clear view of the bank erosion scenario of North Bengal and the Maynaguri block. The information collected from primary and secondary sources have been verified with the field experience.

The Present Study Area

North Bengal covers seven districts like Darjiling, Jalpaiguri, Alipurduar (Formed on 25th June, 2014) Koch Bihar, Uttar Dinajpur, Dakshin Dinajpur and Malda. The Sub-Himalayan North Bengal region lies in the lap of northern part of West Bengal, comprising four districts- Darjiling, Jalpaiguri, Alipurduar and Koch Bihar. These four districts embrace a population of 8.53 million (Census 2011) out of 91.35 million of state population and the region covers 9.35% of the total state population.

The Sub Himalayan Zone is built up of debris washed down from the Himalayan slopes especially through the rivers. The study area is drained by several rivers such as – the Teesta the Torsha, the Jaldhaka , the Raidak, the Sankosh , the Mahananda, the Kaljani etc. The climate of the study area is characterized by hot and humid summer season. The area receives copious rainfall during the monsoon season i.e., from June to September.

Processes of stream bank erosion in the study area

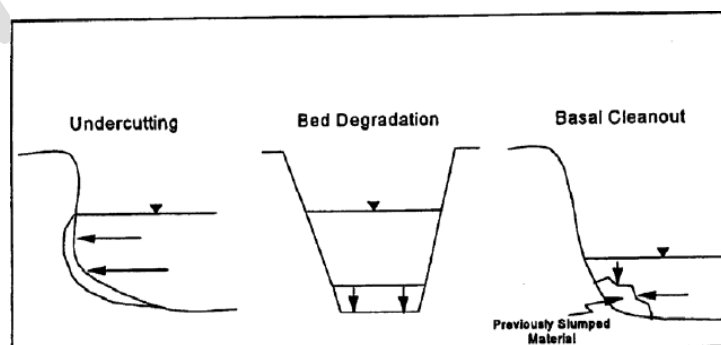
A river bank can be divided into three zones: Toe zone, bank zone, and overbank area. The toe zone is the area which is most susceptible to erosion. Because it is located in between the ordinary water level and the low water level, it is strongly affected by currents and erosional events. The bank zone is above the ordinary high water level, but can still be affected periodically by currents, and gets the most human and animal traffic. The overbank area is inland of both the toe and bank zones, and can be classified as either a floodplain or a bluff, depending on its slope. A river bank will respond to erosional activity based on the characteristics of the bank material. However bank erosion includes two main groups of processes- hydraulic processes (bank undercutting, bed degradation, and basal clean-out) and Gravitational failures (shallow and rotational slides, slab and cantilever failures). Table-1 shows the characteristics of these processes. However bank erosion processes are accelerated by factors like

- inundation of bank soils followed by rapid drops in flow after flooding saturation of banks from off-stream sources
- redirection and acceleration of flow around infrastructure, obstructions, debris or vegetation within the stream channel
- removal or disturbance of protective vegetation from stream banks as a result of trees falling from banks or through poorly managed stock grazing, clearing or fire

- bank soil characteristics such as poor drainage or seams of readily erodible material within the bank profile
- wave action generated by wind or boat wash;
- excessive or inappropriate sand and gravel extraction
- intense rainfall events such as cyclones or flash floods.

Table-1: River Bank Erosion Processes of North Bengal

Processes	Characteristics
<i>Hydraulic processes</i>	Bank undercutting, bed degradation, and basal clean-out
<i>Gravitational failures</i>	
Rotational failures	It is a result of scour at the base of the bank and/or high pore water pressure within the bank material where the slopes less than 60°.
<i>Slab failure</i>	It results from the combination of scour at the bank toe, high pore water pressure in the bank material and the development of tension cracks at the top of the bank.
<i>Cantilever failures</i>	It is the collapse of an overhanging block into the channel, often occurring after the bank has been undercut.
<i>Pop out failure</i>	It is a term used to describe failures where small to medium sized blocks are forced out at or near the base of the river bank due to excessive pore water pressure and overburden.
<i>Piping failure</i>	This is the collapse of part of the bank due to high groundwater seepage pressures and rates of flow causing selective removal of sections of the bank



Hydraulic Processes



Rotational failure



Cantilever failure



Slab failure

Bank erosion prone areas of North Bengal

Bank erosion is a common phenomenon in any uncontrolled channel of the deltaic tract. But in North Bengal this phenomenon is active in selected rivers. Bank erosion is prominent in Malda district caused by the river Ganges. Now it is well accepted that the intensity of the Ganges-bank erosion in West Bengal has increased after the construction of Farakka Barrage (Rudra, 2010). The Ganges in Malda district in the upstream of Farakka Barrage has been undergoing extensive erosion along the left bank even though it has been strongly protected. In Darjeeling, Jalpaiguri, Alipurduar, and Kochbihar districts also bank erosion is active. Table-2 shows the erosion prone areas of different rivers of North Bengal.

Table-2: Major Bank erosion prone areas of North Bengal

Type of vulnerable zones	Majors areas
Very high vulnerable zone	<ol style="list-style-type: none"> 1. Manikchak, Kaliachak-II&III blocks of Malda 2. Birpara- Lankapara-Chamurchi-Makrapara area 3. Barobhisa-Kumargram area 4. Jaigaon-Hasimara area 5. South Tufanganj area 6. Dima-Pana-Kaljani area
Highly Vulnerable zone	<ol style="list-style-type: none"> 1. Teesta-Jalpaiguri-Maynaguri area 2. Jaldhaka-Gilandi area 3. Kaljani-Dima area 4. Totopara area 5. Mekhliganj-Kuchlibari area
Moderately Vulnerable zone	<ol style="list-style-type: none"> 1. Mechi 2. Balason-Burhi-Balason 3. Changmari area 4. Bagrakot-Odlabari 5. Rangdhamali-Jalaiguri-Haldibari area 6. Torsa-Kaljani interfluvium
Low vulnerable zone	<ol style="list-style-type: none"> 1. Mahananda-Giulma area 2. Fuleswar-Mahananda area

Impact of bank erosion on human life

Landscape degradation, environmental and socio-economic impacts are observed in different countries at different scales due to river bank erosion. But quantitative information on socio-economic consequences of river bank erosion (viz., total human displacement, loss of occupation, loss of property, impact on health and education, etc.) for all the cases, however small it may be, is not available unlike other natural disasters. Recently, few attempts have been made to collect and analyse data at household and community level. Such attempts are highly needed to quantify the human vulnerability due to river bank erosion, and in turn to formulate appropriate public policy. Table-3 shows the affected people and other losses due to bank erosion combined with flood from 2003 to 2010 in North Bengal.

Table-3: Major Bank erosion prone areas of North Bengal

Year	Affected areas	Affected people	Loss scenario
2003	Jalpaiguri & Kochbihar district	31882	170 m embankment of Irrigation & Water dept. destroyed in Koch bihar 215 m long embankment washed away in Hasimara-Malbazar-Banarhat area 500 acre of tea garden land destroyed
2004	Lish-Gish catchment areas of Jalpaiguri district	1000	200m left embankment of Lish river destroyed
2007	Jalpaiguri district	25000	6500 homestead destroyed and 4500 hectare of arable land destroyed
2009	Darjeeling and Jalpaiguri district	25000	Severe bank erosion along Balason river. Railway bridge over Balason near Matigara was destroyed
2010	Jalpaiguri & Kochbihar district	414	Embankments in many places of Kochbihar and Falakata district were damaged
2015	Jalpaiguri district	4000	3 km Pradhan Mantri Gramin Sarok nYojana(Road) near Domohani of Maynaguri block was severely affected Damage of 3 km embankment in Basusuba, Raipara & Senpara areas of Chadanga Gram panchayet of Mal block. Bank erosion was also active in Amguri, Churabhandar and Ramsai gram panchayet areas

Source: Sarkar et. al,(2011)& the Disaster Management Section (Relief) of Maynaguri block development office (2015)

The recent flood of Teesta river during the period of 30th June to 2nd July, 2015 caused assive bank erosion along the eastern banks of Teesta river in Domohani -I gram panchayet area of Maynaguri block, Jalpaiguri district. To have a glimpse of impact of bank erosion on human life field surveys were carried out at Barmanpara and Chatrarpar villages in Domohani -I gram panchayet area of Maynaguri block which were affected severely by Teesta bank erosion. The followings are the outcomes of the field survey-

Profession wise distribution of the Displaced people

Most of the affected people of the present study area were engaged in farming activity(62%). They would grow crops on the sandbars formed on the Teesta bed during the lean season. Some of them would cultivate along the rich eastern floodplain areas. The percentage of displaced people engaged in fishing was 28%. Among the displaced people 6% was wage labourers and 4% was for others (Table-4).

Table-4: Profession of the Displaced people

Type of Profession	Percentage of people
Farming	62
Fishing	28
Wage labourers	6
Others	4

Source: Field survey by the author(2015)

Kinds of Properties lost

Most of the people of the study area lost their land cattle and houses (85%).The percentage of people who lost the cattle was 12%. People who live quite raised ground did not suffer much due to bank erosion. So their percentage was only 3%.(Table-5).

Table-5: Kinds of properties lost of the people

Kinds of Properties Lost	Percentage of people who suffered the Loss
Land+Cattle+House	85
Cattle	12
No loss till now	3

Source: Field survey by the author (2015)

People's Perception about the Erosion

In order to study what people feel about the causes of Teesta bank erosion, a schedule survey was also conducted. The results obtained are in table-6.

Table-6: Perception of people about the factors responsible for bank erosion

Factors behind the bank erosion	Percentage of people
Natural	42
Anthropogenic	20
God's Will	38

Source: Field survey by the author(2015)

The survey reveals that 42% people believe in natural factor for the Teesta bank erosion and 20% people find anthropogenic factor. Again, a number of people (38%), attribute it to the will of God. The people, who stressed the factor to the will of the Almighty, were either old or middle aged, God fearing and of course illiterate or have some minimum literacy. They carried this age-old idea in their minds due to lack of proper education.

Protective measures

There are several common measures to reduce the bank measures. These include the structural and non-structural measures.

Structural measures

1. Riprap made of rocks and other materials, arranged in a way as to inhibit erosional processes on a river bank. This method is expensive and can experience failure, but has the ability to be used for large areas.
2. Windrows are the piling of erosion-resistant material on a river's bank, where if buried, they become known as trenches. When erosion persists an already determined location, these windrows and trenches are made to slide down with the bank in order to protect it from further occurrences of erosion.
3. Gabions are stacked, rectangular wire boxes filled with stones. They are useful on steep slopes when the water is too fast for the use of a riprap technique. They are expensive and labor-intensive, as well as require periodical inspection for damage and subsequent maintenance, though they have been seen to demonstrate positive performance.
4. The exact placement of soil cement may be different depending on the slope of the bank. In rivers with high wave action, a stair step pattern may be needed to dissipate the energy coming from the waves
5. Three main types of vegetation exist to prevent bank failure: Trees, shrubs, and grasses. Trees will provide for deep and dense root systems, increasing the stresses a river bank will accommodate. Shrubs are staked into the river bank in order to provide a protective covering against erosion, creating good plant coverage and soil stability.
6. In the erosion prone areas spur dams are very effective where meandering bends cause bank erosion.



Riprap structures



Spur dam structure



Windrows or Slash Terraces



Gabious structure



Soil cement Structure

Non- Structural measures

Non-structural measures include the awareness of people about their living site. People should not build their homes on the raised sand bars and nearby bank areas because these sites are the most vulnerable to erosion. In the present surveyed area most of the people built their houses on the above site and so they have been victimized much. Hence people should be motivated not to build their houses on the sand bars and nearby bank areas. The role of Village level Disaster Management Committee should be active and effective for the distress people.

Findings

The Sub-Himalayan North Bengal region is vulnerable to river bank erosion. The Teesta, the Jaldhaka, the Torsha, the Kaljani, the Sankosh, the Lish, the Gish, the Balason etc. rivers cause severe bank erosion during the monsoon season. Based on the severity of bank erosion the study area has been classified into four zones like very high vulnerable zone, highly vulnerable zone, moderately vulnerable zone and low vulnerable zone. Bank erosion causes severe damage to the embankments, grasps fertile lands and tea garden areas and displaces a number of people. Displaced people become unemployed and homeless as they have lost their habitation and agricultural lands.

It is neither possible to stop bank erosion nor to completely eliminate its damages. Bank erosion occurred in the past and will continue to occur in future as well in this part of India. However, it is possible to minimize the severity of the impact and the damage potential. In this case mitigation measures like structural and non- structural measures have to be adopted in the present study area. Active and effective role of Village level Disaster Management Committee is essential for the distress people.

CONCLUSION

River bank erosion is a natural process of a stream. We cannot prevent it. Therefore proper propaganda should be carried out by the respective gram panchayet offices to keep away human settlement from the erosion prone areas. Local Gram panchayet office can play an important role with the help of respective Block Development Office to build structural measures in the erosion prone areas.

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