PRIMARY ARTICLE

Analysis of the Factors Responsible for River Bank Erosion : A Study in Shantipur Block, Nadia District, West Bengal.

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ABSTRACT

River Bank erosion has emerged to be one of the most annoying environmental hazards these days. It is a complex process which incorporates actions of several complex processes and cannot be attributed to any single process. At present, the average quantum of land engulfed by the rivers is about 800 hectares in West Bengal. River Bhagirathi –Hooghly, the most prominent river of the state has resorted to large scale bank slumping and flood in Shantipur, Nadia, the birth place of Vaishnavism. Though there has been immense study on the erosional activity of this river in the state, Shantipur has not got enough importance on this matter. Eminent national and international scholars have detected the causes of such erosional activities to be the typical flow properties of the river, the structural and compositional properties of the bank and climatic characteristics of the concerned area. This paper tries to throw some light upon the factors which have probably acted jointly to produce such large scale wearing away of land in this part of the planet.

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1.INTRODUCTION

The word erosion has been derived from a Latin word "erodere" which means to gnaw. In fact erosion is the process in which various erosive agents, obtain and remove rock debris from the earth's crust and transport them for long distance. (Savindra Singh, 1973) River Bank erosion is a hazard. Almost all Indian rivers are prone to bank erosion making half of the country's land affected and the plight of millions deplorable. In West Bengal, the river Bhagirathi-Hooghly makes large scale devastations in the Districts of Malda, Murshidabad, Nadia and Hooghly. Though there have been a lot of studies on different aspects of bank erosion and works of eminent scholars highlight the problem of Malda and Murshidabad, Nadia gets a lesser importance. Shantipur Community Development Block of Nadia is a typical prey to such large devastating attitude of the river. Here, massive rate of corrosion and disintegration of the left bank of the river Bhagirathi-Hooghly has left thousands homeless with all their properties lost. There has been a trial on our part to delve deep into the problems and to find out the causes behind such activity of the river.

2) OBJECTIVES:

The major objectives of this paper are to detect the problem of bank erosion in Shantipur, and to find out reasons behind such erosion.

3) METHODS

Analysis of river bank erosion has been primarily carried out by Google Earth and SRTM images using Map Info, and Arc GIS software. Distance between the river bank and a placemark taken at a definite coordinate was calculated for nine years from 2003 to 2009 .Soil samples were collected and duly tested in the Laboratory of the department of Geography, the University of Burdwan. Climatic data were

collected from the Meteorological Department.

4) STUDY AREA

The course of the river Hooghly, in Belghoria 1, Haripur, Gayeshpur, and Bagachra Gram Panchayats in Shantipur Community Development Block, in the Ranaghat Subdivision, in Nadia District, in West Bengal, India has been studied. The study area is characterized by an average elevation of 15 meters above the mean sea level. It possesses an average slope of nearly 7 degrees. The river Hooghly (also known as the river Bhagirathi) flows in a south eastern direction along the western boundary of Shantipur and separates it from Burdwan in the north and southward from the Hooghly District. The river in Shantipur has registered numerous riverine features, the ox bows, the cut offs, a number of paleo channels, and an extensive flood plain. Here the river is at its late maturity and lateral erosion of the river is continuously widening the valley sides.

5) RESULTS AND FINDINGS

5.1) Bank Erosion in Shantipur

While assessing the rate of bank erosion in the study area, we found that in the Kalna Ghat area, land loss is about 10 meters each year on an average. In the Gobarchar area, in the northern part, there has been an erosion of about 23.50 meters of land on an average, which if allowed to continue, shall eat up the whole Ghorolla region within just a few years. In the middle and the southern part, the rate of the land loss was 44.83 meters and 21.525 meters respectively. Three villages have been submerged, the most prominent being the Methidanga village, which can be found even in the Survey of India, topographical map of 1970. However, people have shifted themselves and named their new land.

5.2) Factors Influencing Bank Erosion

Hydraulic action- this is the ability of moving water to dislodge and transport rock particles. It is an erosive process that occurs when the motion of water against a rock (or earth) surface produces mechanical weathering. This process is the result of friction between the moving water and the static stream bed and banks. This friction increases with the speed of the water and the roughness of the bed. Once loosened the smaller particles are actually held in suspension by the force of the flowing water, these suspended particles can scour the sides and bottom of the stream.(Wikipedia).The flow forces were 6 times more effective than any other process (Knighton 1973; Hook 1979; Simons 1979).

Slumping-Slumping or collapse of large blocks is more closely related to soil moisture than flow conditions although stages of river oscillation can control the rate of slumping. Wet bank slumping mainly takes place when the main flow has receded and the bank is thoroughly wet. And can be a major contribution to bank retreat. The process is influenced by bank stratigraphy for example where cohesive materials overlie non cohesive ones, a relatively common condition in rivers flowing thorough alluvial deposits.

Table I: Factors Influencing Bank Erosion. Source: Fluvial Forms and Processes: David Knighton 1984.

Flow Properties	Magnitude, Frequency and variability of streams Discharge magnitude and Distribution Velocity Degree of turbulence
Bank Material Composition	Size, Gradation, Cohesivity, Stratification of bank sediments.
Climate	Amount, Intensity and duration of rain
Subsurface Conditions	Seepage Force, Piping, Soil Moisture Level.
Channel Geometry	Width and Depth of channel, Height of bank.
Biology	Type of Vegetation, Root Density
Anthropogenic	Urbanization, Land Drainage reservoir, Development, Boating

5.3) ANALYSIS OF THE FACTORS OF BANK EROSION IN SHANTIPUR

5.3.1) Flow properties

The most important flow property is discharge. Discharge is the volume of water passing through a given cross section in a unit time. The catchment of a river above a certain location is determined by the surface area of all land which drains towards the river from above that point.

Below, are the diagrams which show the discharge of the river Hooghly in Malda.

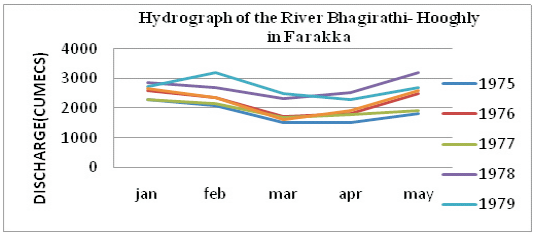

Figure I: Source Erosion in Bhagirathi.2000, A case Study in Malda

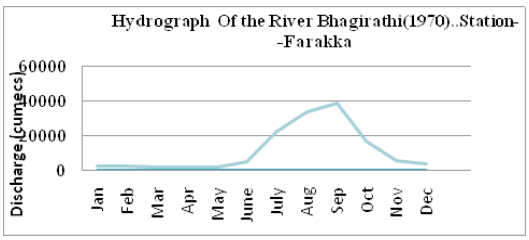

Figure II: Source: Centre for Sustainability and Global Environment Wisconsin Madison.

This is the hydrograph of the year 1970, that is before the Farakka barrage came into operation.

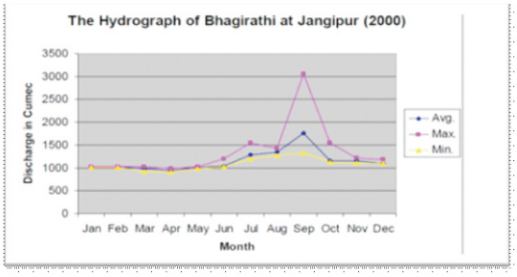

Figure III: Source: KPT, 2000

This diagram is the hydrograph of the river in Jangipur in 2000.

From the two diagrams it is clear that the construction of the barrage has regulated the discharge of water of the river. In 1970, when the minimum discharge of the river was 1999cumecs, it turned to below 1000 cumecs in 2000.The most notable change is observed from July. In 1970, the July discharge was 22358, cumecs whereas in 2000, July, the maximum discharge was 1500cumecs and the average discharge was, between 1000 and 1500 cumecs. The September discharge was the highest. In 1970 the September discharge was, 38992 cumecs and the regulated discharge in 2000 was only nearly 3000 cumecs. Therefore the control of water in the Farakka is notably important in the process of river shifting. A continuous discharge is not that effective in bank erosion as compared to a sudden high discharge. The problem of river shifting in Nadia lies here. It happens that Farakka barrage at times emits very large volumes of water mainly during and after rainy season. This sudden emission of a large volume of water, causes slumping of the river bank. According to people of the affected areas of Shantipur, It is after the construction of the Farakka barrage, that, large scale bank failures have taken place. Again they say that bank failures are most in the months of September October and November. Firstly after the heavy monsoonal rainfall in Shantipur and the emission of large volume of water from the Farakka reservoir, huge amounts of land get inundated. That is flood condition occurs after the heavy rain of July to September. This flood condition weakens the subsurface soil layer which predominantly consists of sand. Sand is a soil particle which has the least Cohesivity and has the highest erosibility. The weakening of the sandy lower layer, causes bank slumping and therefore the river bank is gradually washed down into the river bed.

5.3.2) Bank Material Composition

In order to analyze the soil structure of the region, we had collected 2 samples from the Kalna Ghat area and 2 samples from the Gobachar region. Then the samples were tested for their texture in the laboratory and the following results were obtained.

Table III: Soil Structure of the Study Area. Source: Self Collected Soil Samples

Location.	Depth from the Surface(m)	% Sand	% Silt	% Clay	Texture
23d13'6.97"N &88d22'18.6"E	0	78	9	13	Loamy Sand
	1	89	3	8	Sand
	1.6	58	10	32	Sandy Loam
23d13.7'12"N& 88d22.146"E	1	77	9.2	14	Loam
	1.3	44	26	30	Loamy Sand
	1.8	63	12	25	Sandy Loam
23d13'45.6"N &88d27'36.82"E	0	79	10	11	Loamy Sand
	1.6	69	9	23	Sandy Loam
23d13'46"N & 27d31'22"E	0	74	13	13	Loamy Sand
	.6	30	48	23	Loam
	1.4	28	58	14	Sandy Loam

Therefore from the above findings it is clear that the bank is composed of mainly sand and loam or a composition of both. This is the reason that the bank is so fragile and erosion is so prominent here.

5.3.3) Climate

The March 19 issue of Science reports that climate has a previously unappreciated influence on river meandering, researchers have found. Colin Stark and colleagues correlated a 20 to 30 year-old record of typhoon rainfall in Japan with digital elevation models and found that climate directly influenced river meandering, presumably

by weakening the bedrock channel walls. Expanding their analysis to a larger region of the western North Pacific, the researchers found that rivers' sinuosity was greatest in the subtropics, where extreme rainfall and flood events are common, and decreased both toward the equatorial tropics and mid-latitude Japan, where such extremes are rare. The results also indicate that underlying bedrock strength, as opposed to tectonic uplift as some have proposed, acts as a secondary control. (Chinese eurekalert)

The study area has a hot, wet and dry tropical climate. Rainfall occurs in the months of May to September from the south –west monsoonal wind. Summer months start from the middle of March. The temperature remains nearby 35 degrees or more in these months with an average of 27 degrees.

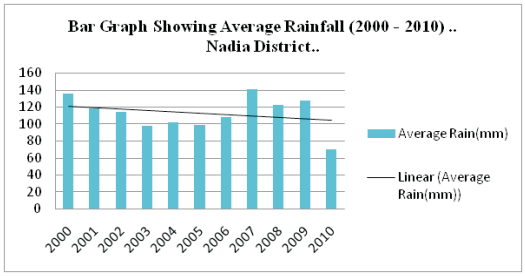

Figure IV: Source: Data from Meteorological Department, India

From the ten years average rainfall diagram of Nadia district, we find that rainfall in the District varies from about 100 to 175 mm. The rainfall is obtained mainly by the south west monsoonal winds and therefore the maximum rainfall occurs in the summer months. 92% of the rainfall is obtained in the period between April and November. According to the villagers surveyed, maximum rainfall occurs in the period between July and September and this is the most vulnerable time of the year when both acute flooding and river bank failure occurs.

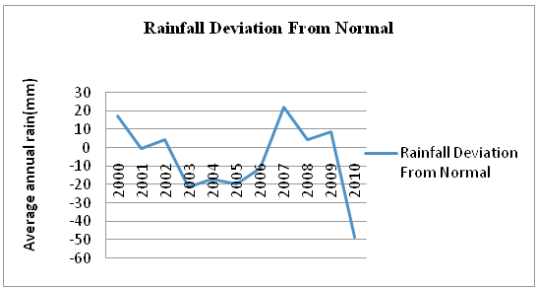

Figure V: Source: District Statistical handbook 2000, Nadia.

Here it is found that, only in2001, rainfall was near normal. Otherwise, either rainfall is very high or very low and fluctuation has become more or less a normal phenomenon here. Both rainfall and runoff factors must be considered in assessing a water erosion problem. The impact of raindrops on the soil surface can break down of soil aggregates disperse the aggregate material. Lighter aggregate materials such as very fine sand, silt, clay and organic matter can be easily removed by the raindrop splash and runoff water; greater raindrop energy or runoff amounts might be required to move the larger sand and gravel particles. Soil movement by rainfall (raindrop splash) is usually greatest and most noticeable during short-duration, high-intensity thunderstorms. Although the erosion caused by long-lasting and less-intense storms is not as spectacular or noticeable as that produced during thunderstorms, the amount of soil loss can be significant, especially when compounded over time. Runoff can occur whenever there is excess water on a slope that cannot be absorbed into the soil or trapped on the surface. The amount of runoff can be increased if infiltration is reduced due to soil compaction, crusting or freezing. Runoff from the agricultural land may be greatest during spring months when the soils are usually saturated.

5.3.4 Channel Geometry

Channel geometry representing the size and shape of cross sectional and longitudinal channel form, includes width, channel depth, wetted perimeter, channel slope, channel bends, shape of channel thalwegs, and their interrelationships. (S.Singh geomorphology edit. 2007)

Width of the Channel: Kalna - Shantipur-Channel width, is the mean of measurements taken at crossovers wherein crossover means straight line joining two points across a channel.

The reach under study, has the average width of 0.46 kms. The reach is so less in width that it just takes one minute or less to cross the river from Kalna Ghat (in Kalna) to Shantipur. This proves that despite the fact that rapid erosion is taking place in Shantipur area, deposition is also not a rare phenomenon

in the Kalna region in Burdwan district. The width of the river channel is a factor of the volume of water in the stream, and the slope of the river channel.

Depth of the Channel in Shantipur-As erosion of one bank proceeds, the depth of the river channel decreases as the eroded materials are deposited in the channel bed.

Shantipur Reach (2006-2007) The overall depths at the upper part of the reach have shoaled considerably. The deepest water in the deep water pocket between longitude 88027'25''E to 88028'10''E has a maximum depth of 8.2 meters as compared to 7.7 meters. in the previous year. The tail of the Island has extended east ward by about 120 mtrs. Bank erosion was observed on the left bank from longitude 88027'12''E to longitude 88028''17''E.). The sand at the centre of the reach has encroached into the channel by about 60 mtrs. as compared to the last year. The crossing between the two sand patches showed a least depth of 0.4 mtrs. as compared to 0.7 mtrs. in the previous year. The maximum depth obtained at the lower part of the channel is 16.0 mtrs. as compared to 19.0 mtrs. in the previous year.(Source- Port Trust of India)

Shantipur Reach(2008-2009) The overall depths at the Upper Part of the reach showed further improvement. The crossing at the Upper Part of the reach carried a least depth of 0.3 mtrs. as compared to 0.2 mtrs. in the previous year. The deepest water in the deep water pocket between longitude 880 27' 25'' E and 880 28' 10'' E carried a maximum depth of 8.2 mtrs. as compared to 8.9 mtrs. in the previous year. The sand at the centre of the reach has shifted west wards by about 20 mtrs. as compared to previous year. The crossing between the two sand patches carries a least depth of 0.6 mtrs. as compared to 0.7 mtrs. in the previous year. The Island between Lat 23° 12' 40″ N & 23° 12' 30″ N has increased southward by about 400 mtrs. and westward by about 100 mtrs.The sand patch near Pumulia has encroached into the channel by about 125metres. (Source: Port Trust of India.)

Slope factor: Slope of the area ranges between, 0 degree and 3.5 degrees. It was observed from SRTM data processed by Global Mapper. If we analyze the slope that the slope of and the degree of meandering, we notice that right from,23d16'18.8047"N , both the bank show a south wards slope from 23d15'11.74"N where the cut off has occurred , the area shows both a North and a eastward slope. At the axis of the ox-bow, there is the dominance of South east and east ward slope. As we move southwards, the general slope direction is towards south and south west. Near Kalna (Right bank) at latitude,23d13'44.263" we see a drastic slope change from about 184.2degrees that is eastern slope (23d13'49.703"N & 88d21'32.73"E) to 45 degrees north eastern slope (23d13'46.0769"N & 88d21'32.7267"E).This has resulted, in a sudden force and led the river to strike against the right bank in Shantipur (Nrishingapur) and this has resulted in such a huge amount of erosion. But in the left bank in Shantipur the general slope is towards south. And this has resulted in the southern flow of the river. So on one hand, the river is getting a push towards east, in Kalna. Downslope, (23d13'19.78"N&88d22'52.5047"E) we see the dominance of eastward slope in Shantipur. Whereas, right on the opposite bank, the slope is N.E. So, the river runs eastwards. The river in Methidanga (the place where a village has been completely wiped out) follows the regional slope. In the axis of the meander, the slope at 23d13'7.0944"N & 88d27'58.18"E,the slope direction is 182.9degrees—that is southern slope which has given a southward turn to the meander. However, despite these facts, there are many anomalies, which prove that slope direction alone does not control oscillation of the river. In places, we see the slope to be towards the south where the channel has registered a northern flow. In 23d12'40.0212"N &88d20'2394"E the slope direction is towards the south east (161. 1d) but here the river has a tendency to run northwards.

5.3.5) Vegetation of the Region-

Soil erosion potential is increased if the soil has no or very little vegetative cover of plants and/or crop residues. Plant and residue cover protects the soil from raindrop impact and splash, tends to slow down the movement of surface runoff and allows excess surface water to infiltrate. The erosion-reducing effectiveness of plant and/or residue covers depends on the type, extent and quantity of cover. Vegetation and residue combinations that completely cover the soil, and which intercept all falling raindrops at and close to the surface and

the most efficient in controlling soil (e.g. forests, permanent grass. Partially incorporated residues and residual roots are also important as these provide channels that allow surface water to move into the soil.

As we travelled by the side of the Ganges, we could see a number of deciduous trees. These trees shed their leaves in winter. Plants of low height also dominate the area. Shrubs and grasses with hard knify leaves are found scattered. Though the soil is sandy, it has a good percentage of silt and loam in it. The ground has grass but is not covered by it. The height of the shrub layer is seen to increase towards the river but as erosion proceeds, it engulfs the land areas. We heard a date palm tree falling in the river just the day before our 4th day of survey.

Al these processes have a joint action on the bank materials and thus cause a substantial part of land to get detached and flow away with the running water.

6) CONCLUSION

Erosion is a complex process brought about by the compound actions of several processes. In order to check erosion in Shantipur, though many schemes have been adopted by the government, only sand bags along the bank are in vogue. To fight erosion, a number of measures can be effectively followed.

i)Concretization of river banks, ii) Plantation of erosion resistant crops, iii) Regular desilting of the river bed, iv) Use of nut fibers as well as synthetic erosion control options have been proved useful by the erosion control team of the Granite Environmental, v) Use of erosion control mats of coir straw, wood fibers and coconut fibers and synthetic erosion resistant mats. (Impact of river bank erosion on human life: a case study of Shantipur block, Nadia District, WB. S Chatterjee, B Mistri)

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