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Research Article

ASSESSMENT OF BANK EROSION PROBABILITY: A STUDY ON KUNUR RIVER, EASTERN INDIA

***Sunil Saha and Sutapa Mukhopadhyay**
Department of Geography, Visva-Bharati, Santiniketan, West Bengal
**Author for Correspondence*

ABSTRACT

High stream bank erosion and failure rates on streams bank may be attributed to land use change and degradation of riparian environment. Excessive rate of river bank erosions and failures result in loss of land, increased stream sediment loads and increased stream instability. For assessing potential risk of river bank erosion, Bank Erosion Hazard Index (BEHI) has applied. Out of 12 selected sites six sites (Dhobani, Malandighi, Ausgram etc.) are highly hazardous and erosion prone. It has found that the probability of erosion increases downward. The main causes that are responsible for such condition in the lower catchment area are loose bank material, less woody vegetation cover, high volume of water discharge. From source to mouth it is also found that the rate of erosion is more on right bank of the river. Such unequal rate of erosion between left and right banks is indicating that the right side migration tendency of channel and erosional vulnerability of the right bank.

Keywords: *Bank Erosion Hazard Index, Bank Full Height, Root Density, Surface Protection, Bank Angle, Surface Protection, Bank Erosion Vulnerability*

INTRODUCTION

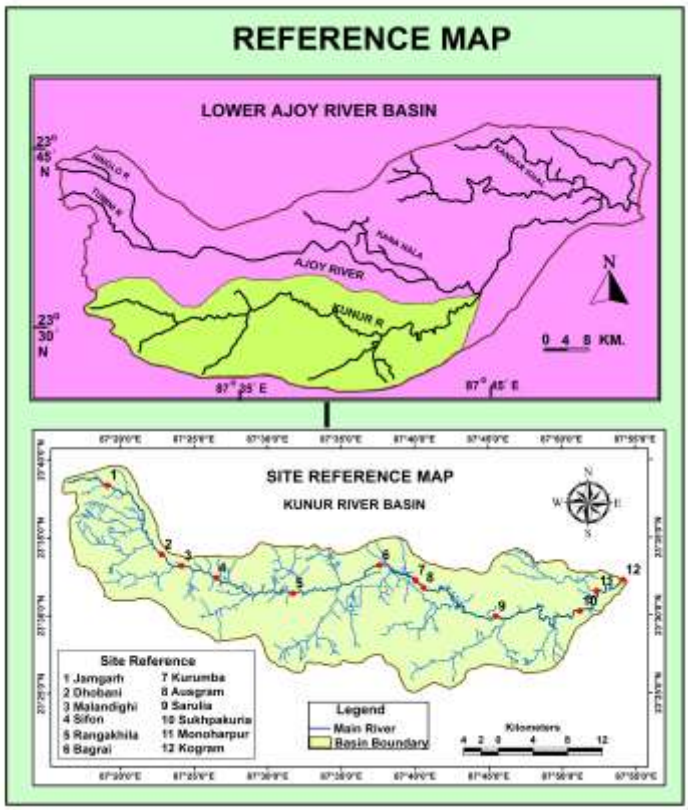

Figure 1: Location of Kunur River Basin-Study Area

Stream bank erosion is a natural process that occurs in every watershed but excessive erosion has serious adverse consequences for the physical and biological function of rivers. Eroding stream banks can be a major source of sediment to a stream (Simon and Thorne, 1996), and human activities such as urbanization or use of bank as agriculture land can accelerate bank erosion rates by more than an order of magnitude. Extensive research has been underway on bank failure types, bank erosion mechanism, stream bank stability and prediction of failure by Thorne (1982), Simon and Thorne (1996), Darby and Thorne (1997), Thorne, (1999) and Simon *et al.*, (1999). It assigns point values to several aspects of bank condition and provides an overall score that can be used to inventory stream bank condition over large areas, prioritize eroding banks for remedial actions, etc.

Objectives

The present study is an attempt to examine the spatial bank erosion condition of Kunur River. The main objectives of this study are-

1. To assess the nature and extent of stream bank erosion of Kunur river from source to mouth.
2. To show the potential probability of bank erosion hazard.

Location of the Study Area

The Kunur River, a 5th order tributary of Ajay River is a well-known name in the riverine landscape of Rarh Bengal (Figure 1). It originates from a spring near Jhanjra village of Burdwan district. It has been flowing through Durgapur-Foridpur, Kanksa, Ausgram-I &II police stations and finally terminates into the Ajay River near Kogram village of the Mongalkote block. The basin area can be delimited by 23°25'50.4"N. latitude to 23°39'21"N. latitude and 87°16'26.4"E. longitude to 87°54'12.6"E. covering an area of about 753.90 sq. km. with 112 km. total length of the main channel and shape of the basin is elongated in nature. This basin lies to the south of the Ajay River and to the north of the Khari River. The upper portion of the study area has few numbers of protected and reserved forests. The soil includes laterite, clay with sand, kankar and alluvium. Physiographically, the upper part of this basin is the extension part or fringe area of the Chhotonagpur plateau region, where maximum elevation of the surface is about 124m.from mean sea level. The upper part is moderately dissected and erosion prone area. The lower part of this basin starts just from the eastern flank of the lateritic hard crust (below 40 m. contour), which is almost flat surface with meandering course of the river.

MATERIALS AND METHODS

Database and Methodology

The present paper has been completed by collecting secondary as well as primary data. Site specific information has been collected through field survey. For location identification GPS survey has done on each site. Toposheets of SOI (Map No 73 M/6, 73 M/7, 73 M/10, 73 M/11, 73 M/14 and 73 M/15), SRTM are also consulted.

For the fulfilment of my objectives two versions of the Bank Erosion Hazard Index (BEHI), technique of Dave Rosgen (2001) has been used in the present study. This method has been applied for 12 selected sites from different parts of the river.

(1) ***Bank Erosion Hazard Index (BEHI)***

It consists of five metrics to evaluate the lateral stability of the channel-

- ***Ratio of Bank Height to Bankfull Height:*** Bankfull indicators in unstable streams (i.e., incising or aggrading streams) can be more difficult to identify, but are usually less than top of bank.
- ***Ratio of Root Depth to Bank Height:*** This is the ratio of the average plant root depth to the bank height, expressed as a percent.
- ***Root Density:*** Root density, expressed as a percent, is the proportion of the stream bank surface covered (and protected) by plant roots (e.g., a bank whose slope is half covered with roots = 50%).
- ***Surface Protection:*** Surface protection is the percentage of the stream bank covered (and therefore protected) by plant roots, logs and branches, rocks, etc. In many streams surface protection and root density are synonymous.

• ***Bank Angle:*** Bank angle is the angle of the "lower bank" – the bank from the waterline at base flow to the top of the bank, as opposed to benches that are higher on the floodplain. Bank angles greater than 90º occur on undercut banks.

Table 1: Guidelines for Measuring BEHI (Dave Rosgen's method)

BEHI Rating	Bank Height/Bankful Height		Root Depth (%)		Root Density (%)		Surface Protection		Bank Angle (%)		Total Score, by Category
	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	
Very Low	1.0–1.1	1.45	90-100	1.45	80-100	1.45	80-100	1.45	0-20	1.45	≤ 7.25
Low	1.11–1.19	2.95	50-89	2.95	55-79	2.95	55-79	2.95	21-60	2.95	7.26 – 14.75
Moderate	1.2–1.5	4.95	30-49	4.95	30-54	4.95	30-54	4.95	61-80	4.95	14.76 – 24.75
High	1.6–2.0	6.95	15-29	6.95	15-29	6.95	15-29	6.95	81-90	6.95	24.76 – 34.75
Very High	2.1–2.8	8.5	5-14	8.5	5-14	8.5	10-14	8.5	91-119	8.5	34.76 – 42.50
Extreme	>2.8	10	< 5	10	< 5	10	< 10	10	> 119	10	42.51 - 50

Overall scores for the Complete BEHI are calculated by summing the scores for each individual metric using the values in Table 1. The overall BEHI score corresponds to an erosion hazard category.

RESULTS AND DISCUSSION

Result of Complete BEHI

The entire stretch of the river has been viewed in detail from topographical sheets, Google map and satellite imageries in GIS environment.

After careful investigation12 sample stream reaches (like, straight reach, meandering reach, channel bifurcation point, channel confluence point, migrating reach etc.) are selected for field study.

To have a good idea of the downstream pattern of BEHI almost regular intervals have tried to maintain. During the inventory process, 12 individual sites of main stream banks have been evaluated.

Based on the field evaluated BEHI variables, the erosion risk of the stream banks along the main stream of the Kunur river basin was estimated.

Table 3 indicates the number of stream banks within each erosion risk rating category, which are calculated on the basis of table 1 that were catalogued.

Table 2: Characteristics of different Reaches

Sl. No.	Sites	Distance from Source (Km.)	Type of Reaches	Bank Materials	Bank Angle in Degree	
					Right	Left
1	Jamgarh	9.59	Channel confluence	Silt	38.66	18.92
2	Dhobani	16.3	Straight reach	Gravel	16.70	8.31
3	Malandighi	24.8	Channel confluence	Gravel & Sand	59.04	12.68
4	Sifon	30.7	Migrating reach	Sand & silt	10.15	67.75
5	Rangakhila	43.1	Straight reach	Sand & silt	41.38	65.56
6	Bagrai	55.9	Channel bifurcation point	Silt & Clay	69.44	16.60
7	Kurumba	61.6	Straight reach	Silt & Clay	60.42	13.74
8	Ausgram	64.9	Meandering reach	Silt & Clay	34.70	50.19
9	Sarulia	82.7	Straight reach	Silt & Clay	35.10	9.88
10	Sukhpukuria	98.1	Meandering reach	Silt & Clay	55.44	18.26
11	Monoharpur	105.7	Channel confluence	Silt & Clay	15.36	32.35
12	Kogram	111.6	Straight reach	Silt & Clay	23.81	23.96

Source: Field Survey

Table 3: BEHI Score at Different Sites

Site ID	Site Name	BEHI Score			
		Left Bank	BEHI Rating	Right Bank	BEHI Rating
1	Jamgarh	14.75	Low	15.25	Moderate
2	Dhobani	24.3	Moderate	30.3	High
3	Malandighi	34.75	High	38.85	Very High
4	Sifon	26.75	High	22.75	Moderate
5	Rangakhila	20.75	Moderate	22.75	Moderate
6	Bagrai	30.3	High	30.3	High
7	Kurumba	26.3	High	30.3	High
8	Ausgram	36.9	Very High	38.9	Very High
9	Sarulia	30.3	High	26.8	High
10	Sukhpukuria	35.8	Very High	35.8	Very High
11	Monoharpur	26.75	High	28.3	High
12	Kogram	33.85	High	33.85	High

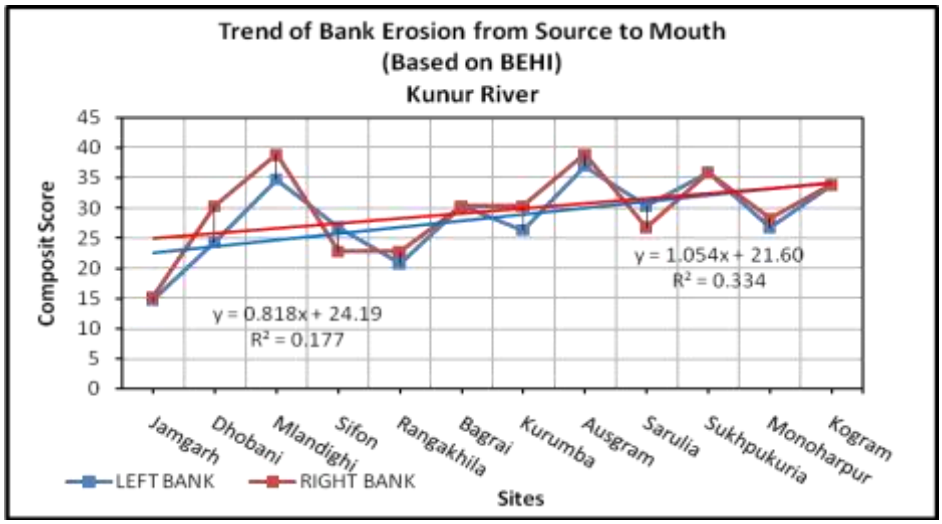

Figure 2: Trend of BEHI from source to mouth

It has been found that the out of 12 sites, six sites namely Malandighi, Bagrai, Ausgram, Sukhpukuria, Monoharpur and Kogram are highly hazardous and erosion prone. Bare bank, steep slope, loose bank material and rightward migration of thawleg line are some major responsible factors for high erosional probability of these sites.

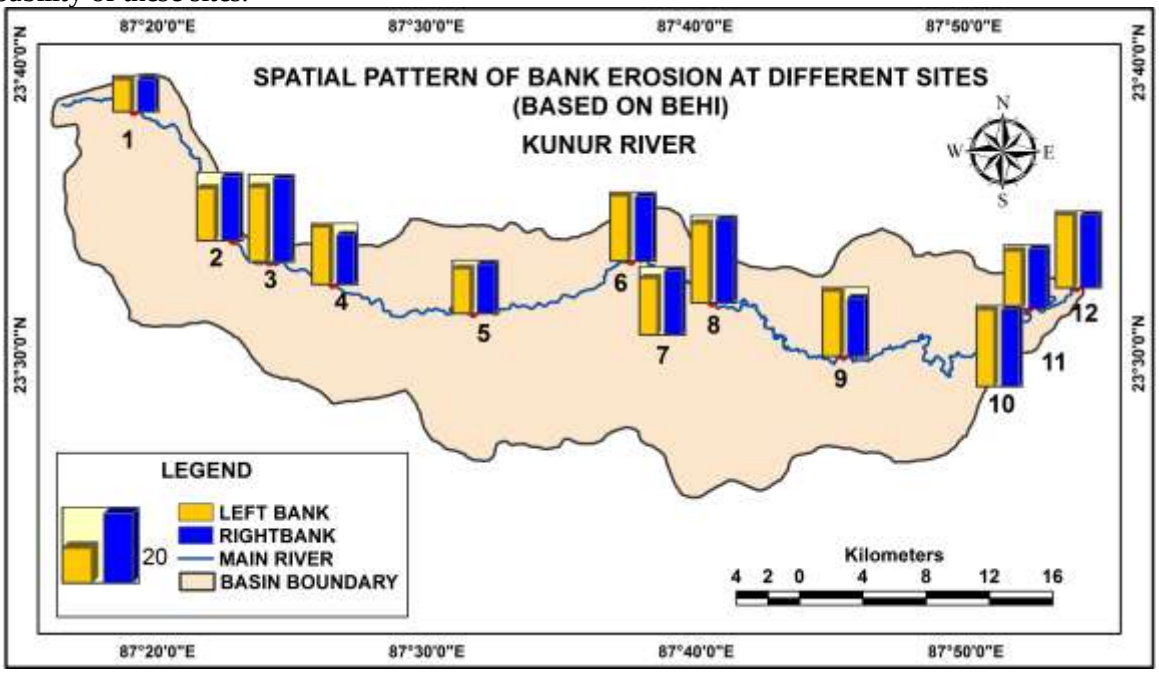

Figure 3: Spatial pattern of BEHI

The trend line of complete BEHI (Figure 2) is showing that value of BEHI scores increase downstream that means the erosion rate as well as probability of channel modification is more in the lower catchment area. In lower reach of the channel, probability of bank erosion rate as well as probability of channel modification is relatively high. This kind of erosional tendency and channel modification in the lower part of the main river, which may happen on this portion, because of there are less vegetation coverage on both sides of the river banks, bank soil is loose and more susceptible to erosion, unscientific use of river

bank and high volume of water discharge. But at Kogram in the lower catchment just few meter before of confluence the rate of erosion is less than other places because people of that area has covered both banks of the river with medium size stone and stopped the erosional activity of the river.

Bank wise Variation of BEHI Score

From source to mouth it has been noticed that the rate of erosion is not same on both the banks of the trunk stream. Result of BEHI is depicting that the average BEHI score is 29.51 on right bank of the Kunur River where it is 27.45 on left bank. So, such unequal score indicates the more potentiality of bank erosion on right bank (Figure 3). Such unequal rate of erosion between left and right banks is also indicating that the rightward migration tendency of channel and erosional vulnerability of the right bank. In some specific sites like Dhobani, Malandighi, Ausgram etc. erosion rate is exceptionally higher on right bank than left bank because of barren bank, steeped slope of bank, finer bank materials and right ward migration of thawleg line.

Bank Erosion Rate at Different Sites

For temporal bank erosion rate estimation of pegging operation has done on these 12 reaches. Interviewing the bank dwellers the rates have been confirmed. Previous toposheets, present high resolution satellite imageries, Google maps have also studied for temporal channel shift detection and associated rate of bank erosion.

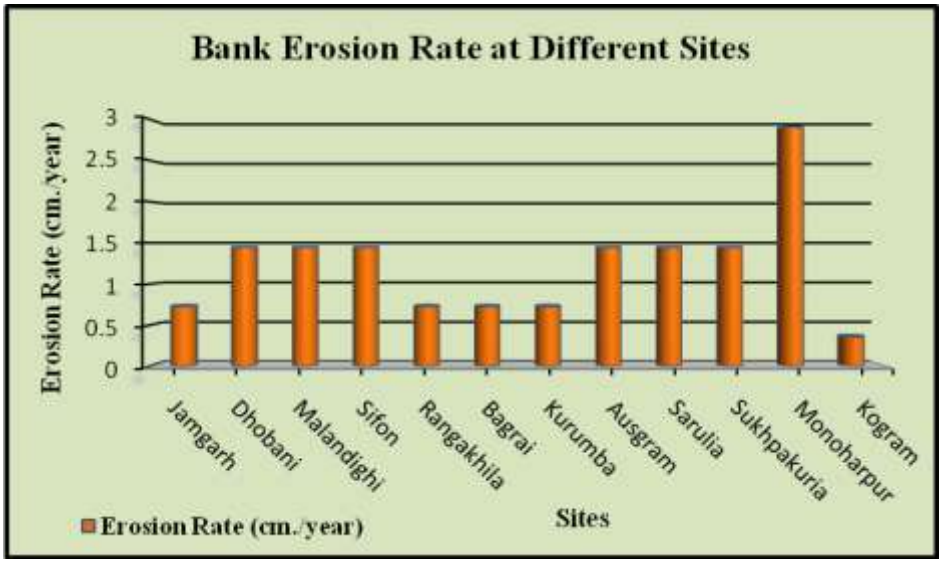

Figure 4: Bank erosion rate at different sites

The rate of bank erosion is not same at all sites throughtout the Kunur river. The average rate of bank erosion is 1.29 cm/year in lower reach of the channel, which is relatively higher than upper reaches of the cahnnel (1.10cm/year). This kind of erosion, which is happening on this portion, because of there is less vegetation coverage on both sides of the river banks; soil is loose and more susceptible to erosion, use of bank as agricultural land and natural process of widening. Among the all selected sites the channel widening rate is exceptionally high at Monoharpur which is 2,91 cm,/year, just few kilometers before the confluence due to high water discharge, loose soil material, barren river bank, establishment of settlement on bank etc. But at Kogram in the lower catchment just few meter before of confluence the rate of erosion is less than other places because people of that area have covered both banks of the river with medium size stone and stopped the erosional activity of the river (Figure 4).

Relation of BEHI with Observed Erosion Rate

BEHI ratings have been plotted separately against erosion rate to identify any correlated trends in the data. Over all bank stability is poor for Kunur river channel and erosional rate is also high in the lower and middle catchment area of the basin. In upper reaches of the channel, the BEHI Score and bank

erosion rate is low as well as stream is more stable and channel configuration is regular because of dense vegetation cover and less human interference with the channel. But in lower reach of the river, the BEHI Score is high and river bank erosion rate is also high as well as stream is more unstable. Higher BEHI ratings often indicate a higher erosion rate along the bank (Rosgen, 2001), which has been observed in table 3 and figure 5. So, there is good positive relation between BEHI and bank erosion.

Table 4: Rate of Erosion and BEHI Score at Different Sites

Sites	BEHI Rating	Rate of erosion (cm./Year)
Jamgarh	Moderate	0.73
Dhobani	High	1.45
Malandighi	Very High	1.45
Sifon	Moderate	1.45
Rangakhila	Moderate	0.73
Bagrai	High	0.73
Kurumba	High	0.73
Ausgram	Very High	1.45
Sarulia	High	1.45
Sukhpakuria	Very High	1.45
Monoharpur	High	2.91
Kogram	High	0.36

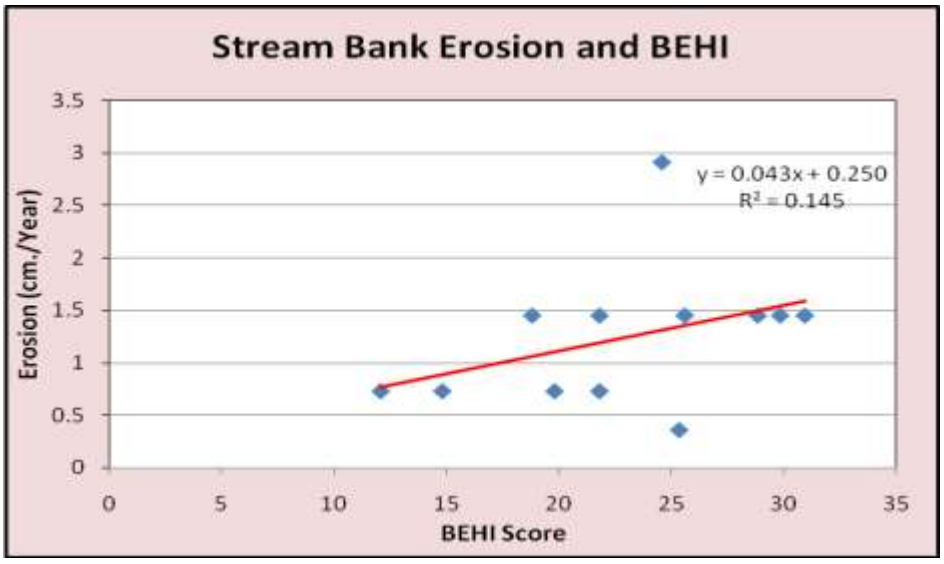

Figure 5: Relation between Stream Bank erosion and BEHI

Major Findings

An inventory of eroding stream banks in the Kunur river basin has been developed by travelling the entire length of the main stream here are the major findings-

❖ Both the bank of Ausgram, Sukhpakur, Kogram and the right bank of Dbobani, Kurumba, Monoharpur, are highly hazardous as these sites are bare to erosion.
❖ The value of BEHI increases downstream that means the erosion rate as well as probability of channel modification is more in the lower catchment area.
❖ However, at the lower segment bank erosion rate is relatively high because of barren bank, steeped slope of bank, finer bank materials and right ward migration of thalweg line. Seasonal huge water level fluctuation is also a major ingredient.
❖ From source to mouth it has been noticed that the rate of erosion is not same on both the banks of the trunk stream. Such unequal rate of erosion between left and right banks indicates the erosional vulnerability of the right bank.

Conclusion

The BEHI scores have several potential uses, including ranking multiple stations for further study or remedial actions on the present river basin. The adverse consequence of increased stream bank erosion results not only in accelerated sediment yields, degrade the physical and biological function of rivers, but also changes in stream channel instability and associated stream type changes. So, our ways would be to select some remedies like afforestation along river banks mainly shrub type vegetation, check dam formation, control of grazing along river bank, restriction over terrace cultivation etc. that can reduce the high rate of bank erosion.

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