IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 08, Issue 8 (August. 2018), ||V (IV) || 21-27

Assessment OfRiver Bank Erosion Potential In Brahmaputra River In Lower Assam Region Using Modified Rosgen's Bank Erosion Hazard Index Method.

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Abstract: The Brahmaputra is one of the major and mightiest rivers of India. It passes about 700 km through the middle of the state Assam and finally enters at Bay of Bengal (India). The river Brahmaputra is very much potential in producing the seasonal flood and river bank erosion in its entire course in Assam. Every year the river migrates laterally here and there by cutting its both alluvial banks and thus huge amount of sediments are produced by destroying acres of fertile land causing tremendous loss of thepoor state. It is observed that the rate of erosion is very high in certain locations, the channels are changed completely within a short interval of time with frequent change of depth of channels. After observing the entire course of river in lower Assam region, it has come to notice that the river is eroding its both banks in many locations, but the extent of erosion is not same in all locations and hence it has been attempted to apply the modified Rosgen's method to identify the nature and erosion vulnerability of the locations under consideration.

Key Words: Assam, Brahmaputra, braided, bank angle, clay content, erosion, hazard, migration, Rosgen, vulnerability

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Date of Submission: 06-08-2018Date of acceptance: 23-08-2018

I. INTRODUCTION

River bank erosion is a major, frequent, recurrent and burning problem of Assam particularly due to river Brahmaputra and at present it is the main concern to the people of Assam and the Government. Due to river bank erosion of river Brahmaputra and its tributaries every year thousands of people living along the banks and chars become homeless and loss their shelter and livelihood. The river Brahmaputra is eroding its both banks at an extremely large rate in entire course in Assam. It has been estimated by GIS survey that about 750 km bank line in both banks are having very high tendency of erosion which means more than 50 % (total length of both banks in Assam is 1400 km) locations or reaches of river Brahmaputra is vulnerable to erosion. The same survey and study also reveal that, in the down side of Guwahati the tendency of erosion of north bank is higher than the south bank and in the upside of Guwahati, the case is reversed that is the tendency of erosion of south bank is higher than the north bank. The annual rate of erosion of river Brahmaputra in the period 1990-2007-08 was 62 sq km/year and the same for the period 1997 to 2007-08 has been estimated as 73 sq km/ year. All river streams have a tendency to erode the banks and widen the channels by undercutting the bank materials due to force experienced by running water and the eroded materials is then washed away by the flow. The rate of erosion depends mainly on the bank morphological structures, surface protection 'bending of channel, composition and characteristics of the bank materials and presence of vegetative cover. The intense braiding of the channel is due to the deposition of sediments within the river bed and banks causing sand bars.

The river bank erosion is a natural process which create tremendous all dimensional ill effects in socio economic field of human life and it is not possible to prevent completely. But if the probable intensities and locations vulnerable to erosion can be identified well ahead by some mechanisms or methods then some effective anti- erosional measures can be adopted to eradicate or reduce the intensities of erosion and thus to decrease the effects or loss to great extent. In view of this attempts have been made justify the applicability of Rosgen's modified method of predicting river bank erosion by bank erosion hazard index method (BEHI)to identify the locations susceptible to erosion in lower Assam region of river Brahmaputra.

II. MODIFIED BEHI METHOD

Bank Erosion Hazard Index (BEHI) procedure for assessing the potential of river bank erosion was developed by David Rosgen (Rosgen 1996,2001,2006,2008a,2008b). The complete and original BEHI procedure consist of five matrices. They are

1. Ratio of bank height to bank full height
2. Ratio of root depth to bank height
3. Root density, in percent
4. Bank angle, in degrees
5. Surface protection.

All these matrices ore observational and to be collected from field. Due to difficulties in measuring the ratio of bank height to bank full height, this index has been removed and a modified BEHI procedure has been developed by considering other four indices and hence the four matrices of modified BEHI procedure consist of

1. Ratio of root depth to bank height
2. Root density, in percent
3. Bank angle, in degrees
4. Surface protection in percentage.

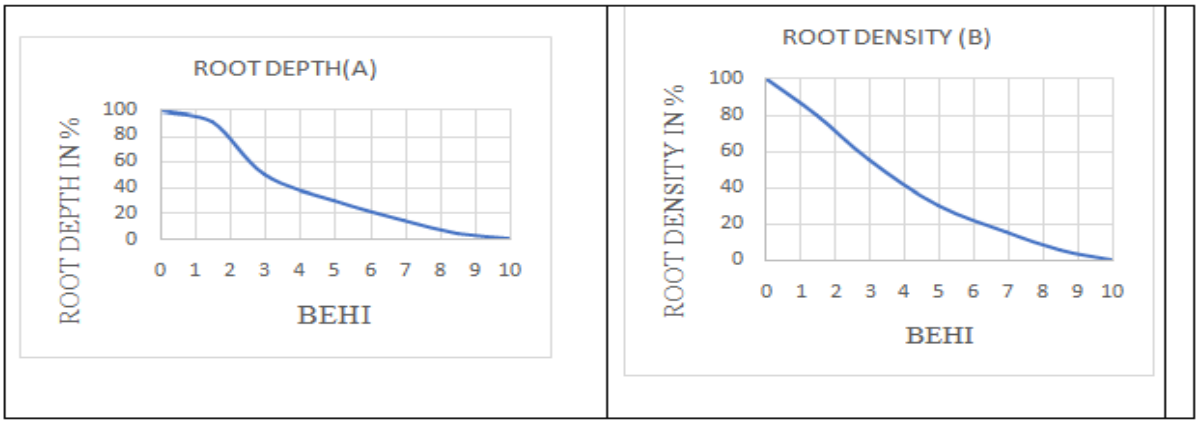
For assessing the erosion potential, all stream bank characteristics are used to develop bank erosion hazard index (BEHI) as shown in table 1.

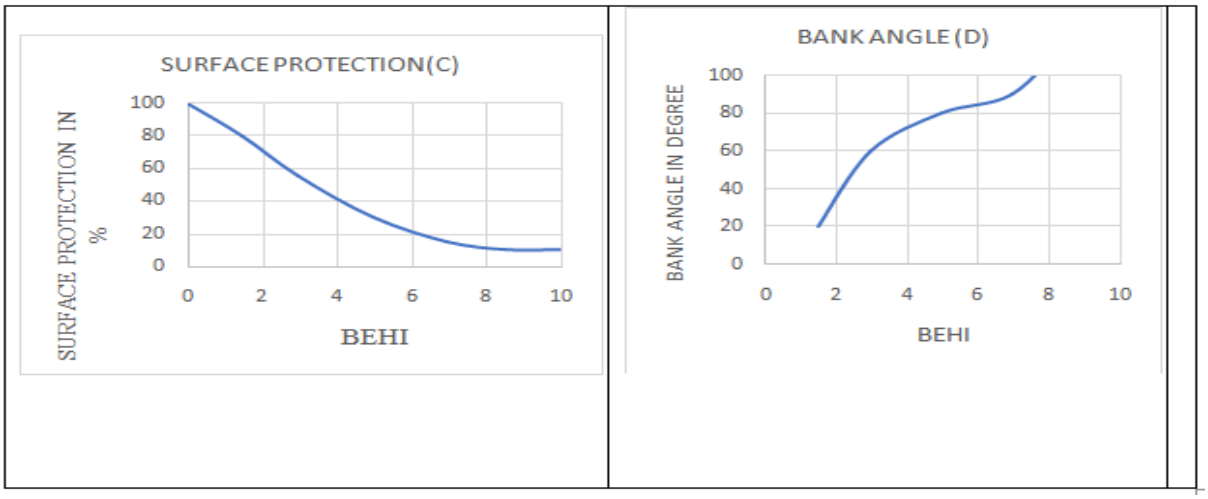
TABLE:- 1

Risk rating category		Root depth/Bank ht	Root density in %	Bank angle (degrees)	Surface protection in %	Total
Very low	Value	1.0-0.9	100-80	0-20	100-80	
	Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	4-7.6
Low	Value	0.89-0.5	79-55	21-60	79-55	
	Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	8-15.6
Moderate	Value	0.49-0.3	54-30	61-80	54-30	
	Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	16-23.6
High	Value	0.29-0.15	29-15	81-90	29-15	
	Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	24-31.6
Very high	Value	0.14-0.05	14-5.0	91-119	14-10	
	Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	32-36
Extreme	Value	<0.05	<5	>119	<10	
	Index	10	10	10	10	37-40

From table 1, it is clear that the predictors of erodibility were converted to a risk rating of 1-10 and these risk rating from 1 to 10 indicate corresponding risk rating category of risk as very low, low. Moderate, high, very high and extreme potential erodibility. Using the table number1, graphs of all key stream bank characteristics are developed to assign the value for risk rating for any observed field value of risk parameters. These graphs are shown in fig 1

FIG : 1(Stream bank erodibility of variables as per Rosgen's modified method)





III. STUDY AREA AND METHODOLOGY

To study the erosion potential of river bank in river Brahmaputra, all together sixteen suitable locations in lower Assam region are selected covering about 250 km. Out of all these sixteen locations, eight locations (location number 1 to 8) are of no erosion prone and other eight locations (locations number 9 to 16) are of very high erosion prone. The name and positions(latitude and longitude) of all selected locations are tabulated in table number 2 and all locations are also shown in map in fig2.

TABLE :2(Name and positions of all selected locations)

Sl No	Name of locations	Position of locations	Remarks
1	Joypur(South bank)	$26^0 11' 13.92''$;$91^0 44' 33.12''$	No erosion
2	Uzan bazar ghat(south bank)	$26^0 12' 4.07''$;$91^0 44' 26.95''$	No erosion
3	Ferryghat(north Guwahati)	$26^0 11' 9.55''$; $91^0 43' 16''$	No erosion
4	Majirgaon(South bank)	$26^0 8' 22.6''$; $91^0 34' 9.16''$	No erosion
5	Goalpara (south bank)	$26^0 11' 9.71''$;$90^0 36' 43.15''$	No erosion
6	Pancharatna(Both bank)	$26^0 11' 1.7''$;$90^0 32' 57.1''$	No erosion
7	Jogighopa(both bank)	$26^0 12' 1.04''$;$90^0 33' 52.1''$	No erosion
8	Dhuburi (north bank)	$26^0 0' 48.92''$;$89^0 58' 57.5''$	No erosion
9	Dakhala(south bank)	$26^0 06' 58.1''$;$91^0 25' 52.7''$	Highly eroded
10	Palasbari (both bank)	$26^0 7' 34.18''$;$91^0 32' 20.6''$	Highly eroded
11	Nayer Alga char (North bank)	$26^0 08' 44.52''$;$90^0 14' 11.12''$	Highly eroded
12	Mayer Char (North bank)	$26^0 08' 13''$;$90^0 11' 52.8''$	Highly eroded
13	Sonamukhi hills (North bank)	$26^0 08' 16.8''$;$90^0 15' 16.1''$	Highly eroded
14	Bahari(north bank)	$26^0 15' 26.41''$;$91^0 06' 30.93''$	Highly eroded
15	Garaimari(South bank)	$26^0 06' 30.69''$;$91^0 15' 58''$	Highly eroded
16	Saupata Pt-I(North bank)	$26^0 05' 52.89''$;$91^0 17' 55.87''$	Highly eroded

FIG :2 (Map showing the all locations)

(Red marked locations are of highly erosion prone and green marked locations are of very low erosion prone)

All locations are visited at least once in every two months during no rainy season for consecutive three years. During the monsoon period all eroded locations remain inundated and hence no regular visit is made. In every visit all stream bank characteristics related to bank erosion hazard index (BEHI) like bank angle, root density, root depth, surface protection, channel migration, extent of erosions are observed and noted down carefully. After completing all the visits and observation, the average of all field measuredhazard parametersare worked outand tabulated in table number 3.

TABLE : 3(Average field observation of different stream bank characteristics related to BEHI)

Location no	Root depth/bank height (A)	Root density (%) (B)	Surface protection (%) (C)	Bank angle (degree) (D)
1	0.6	45	50	60
2	0.3	30	35	45
3	0.2	25	30	50
4	0.3	60	50	30
5	0.4	35	45	40
6	0.2	40	30	45
7	0.4	20	30	50
8	0.4	50	20	60
9	0.2	10	10	90
10	0.3	10	10	110
11	0.1	15	10	100
12	0.1	5	5	110
13	0.0	10	10	100
14	0.0	5	5	100
15	0.1	5	10	95
16	0.1	5	10	90

The modified BEHI procedure are applied to determine the nature of river bank erosion in 16 locations of river Brahmaputra in lower Assam region. In every 16 locations all the BEHI parameters are measured and from graphs of every parameters appropriate values are assigned and finally total scores are calculated. On the

basis of total score, the location is categorized as very low, low, moderate, high, very high and extreme as per the table 1. Following two specimen calculations are shown to determine the degree of river bank erosion considering the modified BEHI procedure. The total final scores of all locations and category of hazard expected as per Rosgen's modified method are tabulated in table 6 and comparison of scores of all locations are shown in fig3. No any correction has been made in the final scores as all the locations under consideration are consist of alluvial soils, having no any artificial surface protection or boulder pitching or rocks.

1. Location details: - JOYPUR (NearNoonmati Refinery) Location No:- 1
2. Date: - Data collected at various dates during 2012 to 2017
3. Latitude: - $26^0 11' 13.92''$
4. Longitude: - $91^0 44' 33.12''$

TABLE :4(Specimen calculation of scores obtained)

BEHI Category	Symbol used	Observed value/ details	Score obtained	Total Score	Remarks
Root depth /bank height	A	0.6	2.5	12.3	Rate of erosion is expected to be low as per table 1
Root density (%)	B	45	3.6		
Surface protection (%)	C	50	3.3		
Bank angle (degree)	D	60	2.9		

1. Location details: - Nayer Alga Char ; Location No:- 1 1
2. Date: - Data collected at various dates during 2012 to 2017
3. Latitude: - $26^0 08' 44.52''$
4. Longitude: - $90^0 14' 11.12''$

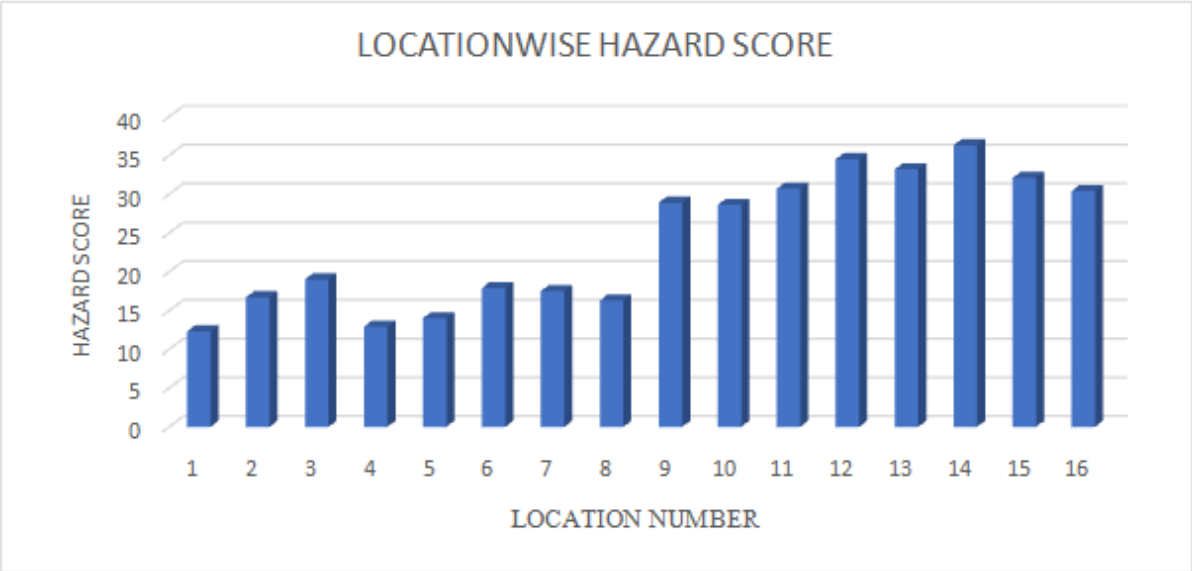
TABLE :5 (Specimen calculation of scores obtained)

BEHI Category	Symbol used	Observed value/ details	Score obtained	Total Score	Remarks
Root depth /bank height	A	0.1	7.6	30.7	Rate of erosion is expected to be high as per table 1
Root density (%)	B	15	7.2		
Surface protection (%)	C	10	8.4		
Bank angle (degree)	D	100	7.5		

TABLE: 6(Calculation of Sores of all locations)

Location	Score(A)	Score(B)	Score(C)	Score (D)	Total	Category of risk
1	2.5	3.6	3.3	2.9	12.3	Low
2	5.0	5.0	4.2	2.5	16.7	Moderate
3	6.2	5.2	5.0	2.6	19.0	Moderate
4	5.0	2.8	3.3	1.8	12.9	Low
5	3.7	4.4	3.7	2.2	14.0	Low
6	6.2	4.1	5.0	2.6	17.9	Moderate
7	3.7	6.2	5.0	2.6	17.5	Moderate
8	3.7	3.5	6.1	3.0	16.3	Moderate
9	6.2	7.5	8.2	7.0	28.9	High
10	4.9	7.5	8.2	8.0	28.6	High
11	7.6	7.2	8.4	7.5	30.7	High
12	7.7	8.8	10.0	8.0	34.5	Very High
13	10.0	7.5	8.2	7.5	33.2	Very High
14	10.0	8.8	10.0	7.5	36.3	Extreme
15	7.7	8.8	8.2	7.4	32.1	Very high
16	7.7	7.0	8.2	7.5	30.4	High

FIG :3(Comparison of hazard scores of all locations)



IV. RESULTS AND DISCUSSION

After carefully observing the average results obtained from field observation, it has come to notice that in all highly erosion prone areas, the value of bank angle is very high. Out of eight highly eroded locations, the river bank of six locations were found to be overhanging i.e. more than $90^0$with average of all eight-bank angle of 99.38^0. On the other hand, the average bank angle of all less vulnerable locations are found to be 46.25^0 with maximum value of 60^0. In case of surface protection also the average value is significantly low (8.75%) in highly vulnerable locations in respect of low erosion prone areas where same is found to be 36.25%. The trend of root density is also same as surface protection. The average value of root density in safe locations are found to be 38.13% whereas the same is only 8.13% in vulnerable locations. The average root depth in erosion free locations is quite high (35.0%) in comparison to theaverage root depth of erosion prone locations (10.0%).

V. CONCLUSION

River bank erosion, flood and earthquake are the major and frequently occurring natural hazards of Assam. The earthquake has no definite timing of occurring but the other two hazards are almost common and certain during monsoon in Brahmaputra river valley in Assam. The hazard, flood has devastating impact on human life and economy but these impacts are more or less short-term impact. Along with several bad impact, of course the flood has some positive and advantageous impact also. But the river bank erosion has all short as well as long term all round negative impact on human and environment. The tendency of bank erosion by any river is natural and this tendency cannot be stopped, but using some anti erosional measures in proper location in appropriate time, the degree of erosion can certainly be reduced. For this the whole reach of any river can be categorized as erosion free or erosion prone location on the basis of some bank characteristics. To assess the vulnerability of erosion in lower Assam region of river Brahmaputra, the utility and appropriateness of modified Rosgen's method was checked by applying it in sixteen selected locations. After carefully collecting all bank details like bank angle, root density, root depth and surface protection related to Rosgen's BEHI method, these are applied to calculate the hazard score in all locations. The results reflect a very good agreement of appropriateness of this method to assess the vulnerability of river bank erosion in lower Assam region of river Brahmaputra. As shown in table 6, the category of risk of all eight erosion free locations are either low or moderate (as assessed by modified Rosgen Method) which are quite in agreement with actual field conditions. In reality these eight locations were of low erosion prone in comparison to other extremely eroded locations. The category of risk rating of other eight locations are found to be either high, very high or extreme which are also very much true in reality. Finally it can be concluded that the modified Rosgen's method of bank erosion hazard index (BEHI) could effectively be used in lower Assam region of river Brahmaputra or in whole reach to identify the erosion vulnerable locations in the entire course of the river so that a complete hazardmap could be prepared to take anti-erosive measure on priority basis by the appropriate authority to minimize the loss due to erosion.

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