International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 06, June-2019

FACTORS AFFECTING THE STREAM BANK EROSION VULNERABILITY OF RIVER BRAHMAPUTRA

Nripen Mazumdar[1], Dr. Bipul Talukdar[2]

[1]*(HOD and Principal in-charge of Barpeta Polytechnic, Barpeta, Assam, India)*
[2] *(Associate Professor in Civil Engineering of Assam Engineering College, Jalukbari, Guwahati, Assam, India)*

***ABSTRACT**: River bank erosion is a very complex and an acute natural hazard all over the world. Every year tremendous multi-dimensional loss has been faced by human beings due to river bank erosion. The river Brahmaputra which is believed to be the identity of Assam is one of the major rivers of the world. This mighty river Brahmaputra along with its numerous tributaries have extreme potential in producing seasonal flood and erosion all over the state. Every year, the river erodes its both banks here and there, causing great negative impact on the human living along the bank sides. It has been observed that the degree of erosional tendency of river Brahmaputra is not same in all locations along its 700 km journey throughout the state. This is obvious as the extent of erosion depends on many factors like river morphology and geometry, physical properties of soil, hydrodynamic characteristics etc. This particular study is carried out to find out the factors responsible for accelerating or retarding the degree of river bank erosion in terms of river morphology and river bank soil characteristics.*

***KEYWORDS**: Assam, Brahmaputra, Erosion, Flood, River Bank, Physical property,*

I. INTRODUCTION

The seasonal flood and river bank erosion is the burning problem of Assam. The mighty river Brahmaputra and Barak along with their tributaries are creating great problem to the people of Assam by producing flood and erosion. The Brahmaputra river system is flowing through different sovereign countries like China, India and Bangladesh. This river system is about 3848 km and one of the longest rivers of the world. This river is known by different name in different locations. In Tibet, it is known as Yarlung Tsangpo, in India it is famous as Brahmaputra, Lohit, Siang and Dihang and in Bangladesh, it popularly known as Jamuna. The nature of river bank erosion in river Brahmaputra is quite unpredictable and tremendous. Of course, the erosional tendency of bank erosion is not same in all places in its course (fig 1). From the map of the river in its course in Assam, it is found that the extent of erosion is very high in some locations and very low in some other locations. In this particular study, it is attempted to ascertain the causes and factors of erosion in river bank particularly in lower Assam region of river Brahmaputra by comparative study of some very high erosion prone locations and low erosion prone locations so that by knowing these factors the erosional tendency of any location can be estimated.

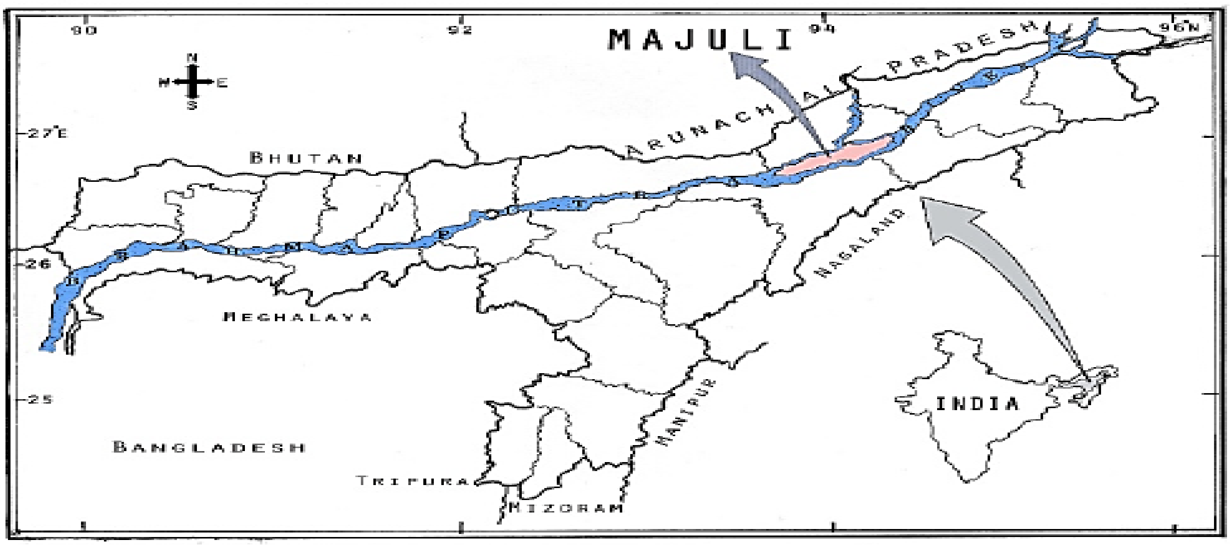

Fig 1 : The course of river Brahmaputra through Assam.

II. METHODOLOGY

For the study purpose of erosional nature of stream bank in river Brahmaputra, the whole lower Assam reach (from Guwahati to Dhuburi) of the river has been visited and surveyed and finally sixteen suitable locations have been selected for detailed study. Out of all these sixteen locations, eight locations are of very low erosion prone and next eight locations are of very high erosion prone. The selected locations are shown in table number 1 with their positions in latitude and longitudes along with their present status of vulnerability in terms of river bank erosion.

Table: I Selected locations for study purpose

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

During the study time, all locations are visited several times to collect the data relating to the river bank geometry, morphology and steam bank characteristics like river bank angle, ratio of root depth to bank height, root density and surface protection. Also, representative soil samples from each and every location was collected for laboratory analysis for comparative study.

III. OVERVIEW ON PRESENT SCENARIO OF EROSION IN RIVER BRAHMAPUTRA.

The river bank erosion by river Brahmaputra is very severe and recurrent. Almost every year the bank line of river Brahmaputra changes due bank erosion and subsequent deposition of eroded materials causing huge multidimensional loss to the state. The table 2, table 3, table 4 and table 5 depict the various losses and effect of river bank erosion in Assam.

Table 2 : Erosional Damage of Assam during 2001-2006 (Source : Revenue Department of Assam and updated in 2019 by Water Resource Department of Assam).

Year	Area eroded in (Ha)	Villages affected (Number)	Family affected (Number)	Value of property (including land loss) (Rs in Lakh)
2001	5348	227	7395	377.72
2002	6803	625	17985	2748.34
2003	12589.6	424	18202	9885.83
2004	20724	1245	62258	8337.97
2005	1984.27	274	10531	1534
2006	821.83	44	2832	106.93

Table 3 : Flood and Erosion Damage Trends in the Brahmaputra Valley (Source water Resource Dept of Govt of Assam and NRSC as per update in 2019)

Period	Average annual area flooded (in Mha)		Flooded crop area as % of total inundated area	Average annual population affected	Average annual damage (Rs in lakh)	Value of crop lost as % of total damage
	Total	Cropped				
1953 – 59	1.13	0.10	8.85	860,000	586	66%
1960 – 69	0.75	0.16	21.33	15,20,000	757	92%
1970 – 79	0.87	0.18	20.69	20,00,000	1,518	89%
1980 – 88	1.43	0.40	28.05	45,50,000	14,552	96%
1999 – 05	1.07	0.38	5.65	45,86,000	71,717	34%

Table 4 : Loss of land due to erosion by river Brahmaputra (Source : water Resource Department, Assam)

Sl no	Survey Period	Area covered by Brahmaputra in km2	Area covered by Brahmaputra in hectares	Loss of area in hectares
1	First Survey (1912-28)	3870	387000	
2	Second Survey (1963-75)	4850	485000	98000
3	Third Survey (2006)	6080	608000	123000

Table 5 : District wise erosional loss and soil deposition by river Brahmaputra and Barak (Source :RS and GIS Application area, National Remote Sensing Agency, Hyderabad, 2004)

District name	Area eroded (ha)	Area deposited (ha)
Barpeta	2098	146
Bongaigaon	316	142
Cachar	270	146
Darrang	1165	563
Dhemaji	2929	235
Dhuburi	2876	377
Dibrugarh	1296	34
Golaghat	2277	219
Goalpara	1429	103
Hailakandi	9	4
Jorhat	1673	320
Kamrup	784	332
Karimganj	14	9
Lakhimpur	633	342
Marigaon	3328	77
Nalbari	206	124
Nagaon	711	357
Sibsagar	354	46

IV. FIELD AND LABORATORY RESULTS

All sixteen locations (table 1) under consideration for detail study has been visited several times for observation and measurement of some stream bank characteristics related to river bank erosion like ratio of root depth to bank height, root density, surface protection and bank angle. All such parameters are measured and noted down in every visit and finally the average of each parameter is shown in table 6 and comparison of these characteristics are depicted in fig 2.

Table 6: Average value of observed field parameters

Location number	Root depth (root depth/ bank height) (A)	Root density (percentage) (B)	Surface protection (percentage) (C)	River 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

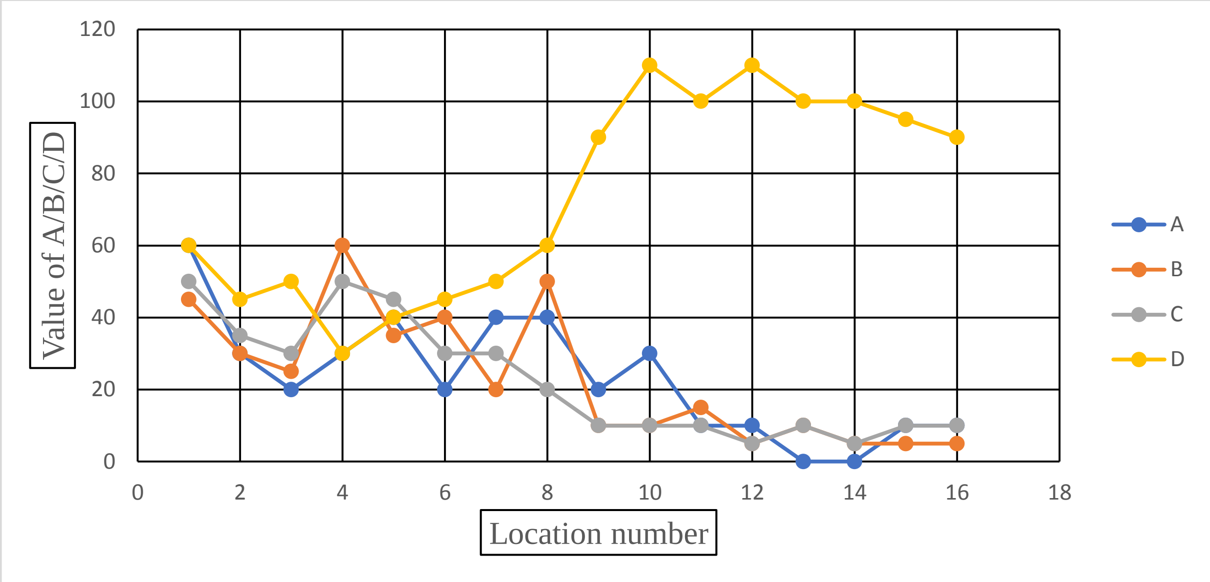

Fig 2 : Observed values of all parameters (A= Ratio of root depth to bank height in percentage; B= Root density in percentage; C= Surface protection in percentage; D= Bank angle in degree)

Along with measurement of field parameters, the soil samples are also collected from all sixteen selected locations. All collected samples are then carried to the laboratory for determination of some intended physical properties related to the stream bank erosion. Tests are done as per Indian standard. The result of sieve and hydrometer analysis along with classification of soil as per United soil classification system is tabulated in table number 7. The average laboratory results of some other geotechnical properties are shown in table number 8.

Table 7 : Classification of soil of lower Assam region of river Brahmaputra as per Unified soil classification system

Location number	Clay (percentage)	Silt (percentage)	Sand (percentage)	Classification as per Unified Soil Classification system
1	14.6	5.0	80.4	SC
2	15.5	1.9	82.6	SC
3	8.6	2.2	89.2	SC
4	13.6	5.6	80.8	SC
5	18.2	3.2	78.6	SC
6	16.5	2.1	81.4	SC
7	9.4	1.4	89.2	SC
8	8.6	4.4	87.0	SC
9	2.7	2.7	94.6	SM
10	2.4	2.4	95.2	SM
11	4.45	4.45	91.9	SM
12	3.2	8.0	88.8	SM
13	1.25	1.25	97.5	SM
14	2.55	2.55	94.9	SM
15	2.2	8.2	89.6	SM
16	2.8	2.8	94.4	SM

Table: 8 Results of other physical properties

Location	Particle density (kg/m^3)	Liquid limit (%)	Permeability (cm/sec)	Bulk density(kg/cum)	Relative density (%)
1	2710	38.60	$2.6x10^{-5}$	2130	69.56
2	2690	36.40	$8.3x10^{-5}$	1956	73.24
3	2770	40.52	$5.6x10^{-5}$	2036	59.10
4	2670	39.60	$2.1x10^{-5}$	1987	62.35
5	2690	37.82	$9.2x10^{-5}$	1991	66.32
6	2700	38.62	$2.6x10^{-5}$	2054	61.56
7	2700	38.00	$8.3x10^{-5}$	2006	58.30
8	2660	40.20	$1.26x10^{-5}$	1897	58.64
9	2610	31.85	$8.2x10^{-4}$	1789	41.65

10	**2610**	**30.61**	$3.1x10^{-4}$	1765	**31.25**
11	2560	34.45	$4.6x10^{-4}$	1896	36.54
12	2620	34.78	$7.9x10^{-4}$	1881	26.41
13	2610	30.12	$8.0x10^{-4}$	1821	28.96
15	2620	29.88	$8.2x10^{-4}$	1794	36.41
15	2600	30.26	$3.5x10^{-4}$	2136	41.57
16	252 0	31.89	$4.1x10^{-4}$	1842	30.89

V. RESULT ANALYSIS AND CONCLUSION

The results of stream bank characteristics reveal that the value of ratio of root depth to bank height, root density and surface protection is significantly high in case of low erosion prone area (table 1 and fig 1) in comparison to high erosion prone area. On the other hand, the average value of bank angle is quite high in low erosion prone locations as compared to high erosion prone locations. The average value of ratio of root depth to bank height, root density, surface protection and bank angle for low risk locations (location number 1 to 8 of table 1) is found to be 0.35, 38%, 36.25% and 47.5^0 respectively. The average value of ratio of root depth to bank height, root density, surface protection and bank angle for high risk locations (location number 9 to 16 of table 1) is found to be 0.11, 8.125%, 8.75% and 99^0 respectively. The results of all such parameters indicate that these stream bank characteristics have great influence in producing or retarding the river bank erosion process and hence all these parameters , ratio of root depth to bank height , root density, surface protection and bank angle can be used as factors or assessor of river bank erosion in lower Assam region of river Brahmaputra.

The sieve and hydrometer analysis of all samples reveal that the river bank materials of river Brahmaputra are rarely homogenous in their composition. The sand dominates the silt and clay. The quantity of clay in low risk locations are found to be relatively high as compared to high risk location which suggest that clay content is an important factor to assess the river bank erosion vulnerability of a location. From the classification of soil of all locations (table 7), it is understood that the soil of all erosion free locations fall under SC (Clayey sand) category and soil of all erosion prone locations fall under SM (Silty sand) category which reveal that the sand with high amount of clay is strong to resist the river bank erosion than sand with silt.

There are also distinct variations of values of other physical parameters of soil in between low risk location and high risk locations. In case of particle density measured from different sixteen locations, it is observed that the value of particle density of erosion free locations are relatively high than the erosion prone locations. The value of liquid limit and relative density also found higher in all erosion free locations as compared to erosion prone locations. The permeability of less erosion prone locations are found much lesser than the highly erosion prone locations.

From the comparative study of different parameters between less erosion risk location (location number 1 to 8 of table 1) and high erosion risk locations (location number 9 to 16 of table 1), it can be concluded that many factors are related in stream bank erosion in lower Assam region of river Brahmaputra. The parameters like ratio of root depth to bank height, root density, surface protection, stream bank angle, particle density, liquid limit, permeability, relative density may be considered some important factors to assess the erosional susceptibility of river in lower Assam region of river Brahmaputra.

REFERENCES

[1] David L. Rosgen P.H. 2008, A practical method of computing stream bank erosion rate. *Wildland hydrology.*
[2] N Mazumdar and B Talukdar, Assessment of river bank erosion potential in Brahmaputra river in lower Assam region using modified Rosgen,s bank erosion hazard index, IOSR Journal of engineering, vol 8. Issue 8, 21-27
[3] N Mazumdar and B Talikdar, Role of physical properties of soil in river bank erosion assessment: A case study in lower Assam region of river Brahmaputra, American Journal of Engineering Research, vol 7, issue 9, 197-205
[4] Rosgen, D.L. 1996. Applied River Morphology. *Wildland Hydrology Books, Pagosa Springs, CO*
[5] Roslan Zainal Abidin, Md Sofiyan Sulaiman, Naimah Yusoff. 2017. Erosion risk assessment: A case study of Langat River bank in Malaysia. *International Soil and Water Research. 5(1): 26-35.*
[6] Purusottam Nayak, Bhagirath Panda 2016. Brahmaputra and socio economic life of people of Assam, *A technical report*.
[7] Naser Hafezi Moghaddas, Reza Jalilvand, Hamid Reza Soloki, 2012. The role of soil engineering in producing bank erosion and morphological changes of Sistan river.*Archives of Applied Science Research,2012 4(4):1650-1658.*
[8] Z.A. Roslan, Y. Naimah and Z.A. Roseli,2013. River bank erosion potential with regards to soil erodibility. *WIT Transaction on Ecology and The Environment, Vol 172.*
[9] Md. Bellal Hussain, Toshinori Sakai, Md Zakaria Hossain2011. River embankment and bank failure: A study on geotechnical characteristics and stability analysis. *American journal of environmental science 7(2):102,2011,2010 science publication*.
[10] Chandan Nath, Pankaj Goswami2016. Effect of soil properties on river bank erosion in lower Assam region. *International journal of research in engineering and management Vol 1 no 1 2016 P 7-15.*
[11] LA Clerk, TM Wynn 2007. Methods for determining stream bank critical shear stress and soil erodibility; Implication for erosion rate prediction. *American society of agricultural and biological engineers ISSN 0001-2351 Vol 50(1) 95-106.*

[12] VA hid Gholami, Md Reza Khaleghi. The impact of vegetation on the bank erosion A case study : The Haraz River. *Soil and water Res 8203(4):158-168.*

[13] IS1498-1970. Code for classification and identification of soils for general engineering purposes. *Indian Standard Institution*.

[14] IS 2720 (Part 1), 1983, Methods for preparation of dry soil samples for various test. *Indian Standard Institution*

[15] IS 2720 (Part 3, section 1),1980. Determination of specific gravity of fine grained soils. *Indian Standard Institution*

[16] IS 2720 (Part 3, section 2),1980. Determination of specific gravity of fine, medium and coarse grained soils. *Indian Standard Institution*

[17] IS 2720 (Part 4),1985. Methods of test for soils. Part 4, Grain size analysis. Indian Standard Institution

[18] IS 2720 (Part 5),1985. Methods of test for soils. Part 5, Determination of liquid limit and plastic limit. *Indian Standard Institution*

[19] IS 2720 (Part 14),1985. Methods of test for soils. Part 14, Determination of density index (relative density) of cohesionless soils.
Indian Standard Institution

[20] IS 2720 (Part 17),1992. Methods of test for soils. Part 17, Laboratory determination of permeability. *Indian Standard Institution*