PROBLEM OF RIVER BANK FAILURE AND THE CONDITION OF THE EROSION VICTIMS: A CASE STUDY IN DHULIAN, WEST BENGAL, INDIA

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Abstract
The present paper deals with the problem of bank failure and the present condition of erosion victims in Dhulian. Continuous shifting of river course and erosion introduce vulnerable conditions on physical as well as social environment. Simple methodologies have been adopted to conduct this study. Primary data have been collected from the erosion victims regarding their condition. Satellite images have been used here for mapping purposes. Several statistical methods have also been used for discussions as well. Thousands of people - especially living along the river bank - are in a high risk condition. Population displacement from the river bank areas is the main impact of erosion. Gradual areal extension of riverine islands (chars) is one of the cause which leads to continuous sifting of Ganga towards right bank exhibits not a good sign for the densely populated Dhulian. Overall the condition of the erosion victims is very poor and challenging.

Keywords: River bank erosion, vulnerability, erosion victims, protective strategies
JEL classification:

1. Introduction

River bank erosion is a natural and inevitable phenomenon of river and can be defined as a dynamic natural process which involves the removal of materials from the banks of a river. The bank erosion will be occurred when the magnitude of flowing water exceeds the strength or shearing resistance of materials or sediments on the basal part of a river bank. The sediments at basal part of the bank are washed out by the running water (rising stage of discharge or effluent flow of ground water into the river) leads to form vacuum at the base and form a steep wall or cliff above which ultimately collapses by hydraulic pressure, geotechnical events or combined effect of both. Das et al., (2014) commend on river bank erosion that once sediment load in river exceeds the carrying capacity of river, the river will transfer from single channel meandering river to a braided channel. Bank erosion mainly occurs in meandering river. In meandering river, river shifting takes place through bank erosion and deposition on the point bar. Most of the rivers in the world are subjected to meandering along with bank erosion. Bank erosion in devastating nature can be found in Mississippi-Missouri river system of North America, Ganga-Brahamaputra-Mekong of Asia, Amazon of South Africa and river Nile of Africa. The Mississippi river is eroding at high rate on the lower part of Brule Reservation Central South Dakota in United States and the rate of losing shoreline in some locations is approximately 8 feet per year. Chakrabarti and Nag (2008) commend on the mechanism of bank failure in upstream and downstream of Farakka Barrage that retreat of water after the initial high discharge, removal of fine materials (sand/silt) by the water force accelerates the process of bank failure. According to Rudra (2006) erosion in Ganges happens during the month of monsoon (June- September) and this erosion has two separate phases: Pre-flood and Post-flood erosion. The sudden fast moving current during the rising stage of discharge helps to remove unconsolidated materials from the base of bank which ultimately collapses. In the post-flood period, erosion which is happened

by effluent flow of ground water into the river which leads to liquefaction and flowage of basal materials into the river. Though river bank erosion is natural phenomena but it is accelerated by anthropogenic activities. Rudra (1998) commend on the bank failure issue of Malda district that un-working of almost 54 sluice gates of Farakka barrage by the side of Malda has been obstructing the flow of Ganges during rainy season and leads to emerge a long strip of land in upstream of the barrage which is also responsible for severe erosion in Malda district. Dhulian and its surrounding areas in the downstream section of Farakka Barrage have been facing the problem of bank erosion by river Ganga and total municipality area lies in highly risky zone caused by severe bank erosion problem of river Ganga. Rudra (1992) stated on the problem of erosion in Dhulian and apprehended that Dhulian may be disappeared in future. Most vulnerable wards are 1, 2, 4, 5, 19, 18, 17, 16. UNDP (2004), stated about vulnerability as "a human condition or process, resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of given hazard". According to National Institute of Disaster Management (2004), "vulnerability is defined as the extent to which a community, structure, service or geographical area is likely to be damaged or disrupted by the impact of particular hazard on account of either nature, construction and proximity to hazardous terrain or disaster prone area". According to Flood Preparedness and Management Plan (2014), Government of West Bengal, Dhulian town has been shifted four times due to devastating bank erosion problem. People of Dhulian, especially who living along the river bank have been suffering from displacement, unemployment, crisis of habitation, unhygienic surroundings and different socio-economic problems introduced by sifting of river path and severe erosion. Uddin and Basak (2012) stated about the bank failure problem of Bangladesh that severe erosion causes different problems in terms of displacement, loss of agricultural land, loss of production etc and ultimately these ensure more vulnerability. Chatterjee and Mistri (2013) stated about the impact of river bank erosion at Santipur of Nadia that erosion brings mass displacement of population, loss of property which ensure poverty. Again Rudra (2003) stated on the erosion issue of West Bengal that it brings different socio-economic problems mostly the agrarian economy has been seriously affected by loss of fertile land. Actually, Dhulian and its adjoining area are situated in a curse of nature. Severe erosion of 1930, 1950 and 1970 pushed the entire development process of Dhulian and its adjoining area into further deteriorating condition and their effect can also be felt till now. In this context, the present paper deals with the problem of bank failure in Dhulian and the condition of erosion victims on the one hand and on the other hand tries to give necessary measures for the development of life style of erosion victims and fight against erosion.

The present paper has the following objectives-

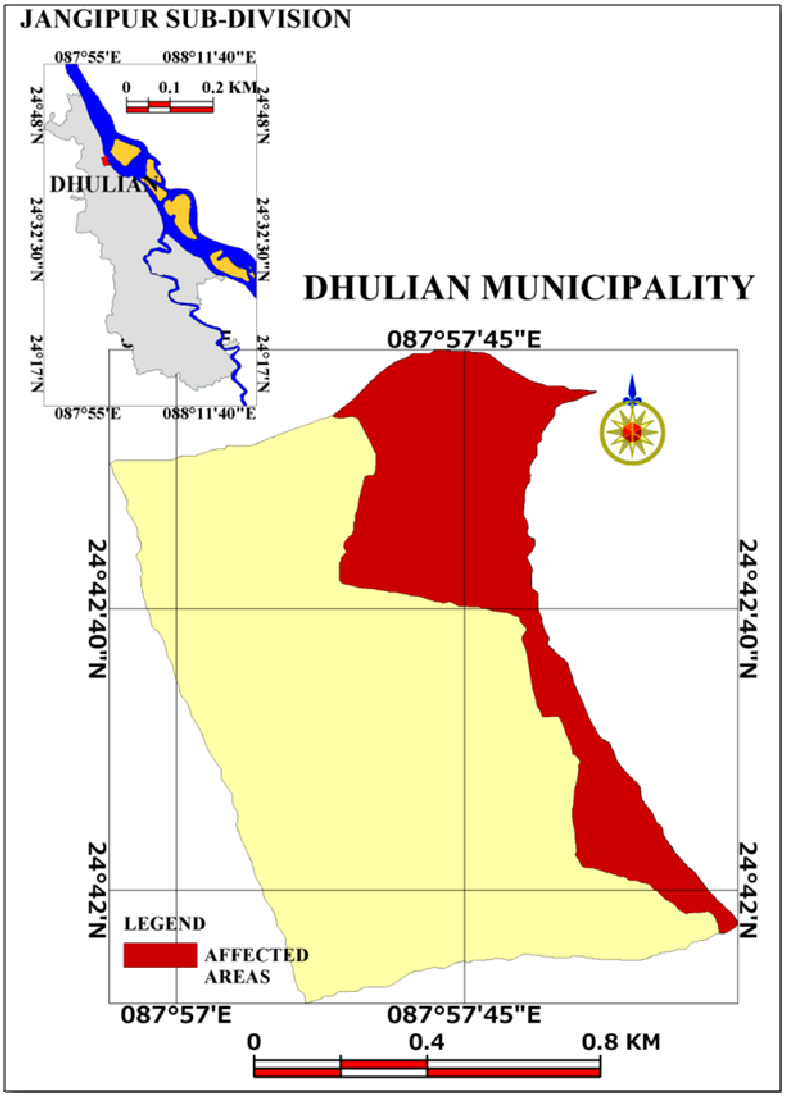
- To analysis the present condition of Dhulian in terms of vulnerability caused by river bank erosion.
- To find out the condition of people along the river bank.

2. Methodology

Simple methodology has been adopted to conduct this study. A discussion has made with the Executive Engineer, Irrigation and Waterways Department, Jangipur, West Bengal, regarding the problem of erosion in Dhulian. To know the condition of erosion victims along the river bank, a socio-economic survey (end of 2017) has been done based on simple random sample technique and the primary data has been collected by interviewing with the people of affected area. The total population of affected areas (*Ghoshpara, Lalpur, Laxminagar and Guripara)* is 13801(Flood Preparedness & Management Plan-2014, Govt. of W.B). Along the river bank 100 households have randomly selected. Secondary data have been collected from Government offices of Dhulian like Municipality office, BDO and Irrigation office. Google Earth images of 1984, 1990, 1995, 2000, 2005, 2010 and 2015 have been collected here. All bank lines of the respective years have been directly digitized from the Google Earth. After that the bank lines are superimposed with the help of RS and GIS techniques to measure the rate of erosion and deposition. Google Earth images have also been used to measure the bank line shifting. Minus value in the table related to bank line shifting indicates erosion and plus value indicates deposition over the cross sections. To find out the relationship between bank failure, bank deposition and gradual extension of area of riverine islands (Chars), Pearson's

Correlation analysis has accomplished here by using SPSS software. Other statistical techniques are used to get information regarding the condition of erosion victims in this area.

Figure 1. Location of study area



Infrastructural index propounded by United Nations Developmental Programme (UNDP) (2011) has been calculated to identify the level of development of erosion victims in respect of infrastructural facility. The parameters for calculating Infrastructural Index for the study area is dissimilar from Infrastructural Index propounded by UNDP. We have selected the following parameters for calculation Infrastructural index-

INFRASTRUCTURAL INDEX :{ Per-Capita Small Savings Index (in Rs/Month) + Toilet Facility Index + Household Having Electric Facility Index + Drinking Water Facility Index + Doctors Facility Index}/5.

Dimension Index: (Actual Value-minimum Value/Maximum Value-minimum Value).

Per Capita Small Savings (in Rs/Month): Total small savings of each area/total population of the area.

Toilet Facility Index: (total no. of toilets in the area / total no. of population of the area)

Household Having Electric Facility Index: (total no. of household having electricity facility / total no. of household)

Drinking Water Facility Index: total no. of tube-well in the area / total population of the area.

Doctors Facility Index: Total No. of Doctors of the area/ Total population of the area

To categories the level of infrastructural development in the study area , the UNDP (2011) categorization has followed here i.e., less than 0.5 indicates Low Human Development,0.5-0.7

indicate Medium Development, 0.7-0.8 indicates High Human Development, 0.8 – above indicate very High Human Development.

3. Results and discussion

Bank erosion problem and vulnerability

Dhulian has been facing severe bank erosion problem by river Ganga from past decades (Table 1 and Figure no. 2) but it can be found that the erosion is accelerated after the construction of Farakka Barrage due to limited functioning of barrage gates and concentration of flow along the right bank (Banerjee, 1999). Dhulian and its adjoining areas were badly affected in the mid of the 1970s (Rudra, 1992). Dhulian has been continuously affected by bank failure. The entire area of Dhulian is lying under a threat of erosion. It can be observed that total area of Dhulian, especially along the river bank, is in a vulnerable condition. Thousands of lives are in a highly risky situation because the distance of their households from the bank line is not more than five meters (Fig. 3). It can be stated by observing the shifting of the river Ganges over the cross sections viz., 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 that the right bank line is not shifted remarkably than left bank line because the over populated right bank is protected but the left remains unprotected. Negative shifting (Erosion) has been increased for the last five years on the both bank (Table 2 and Figure 4). We can't considered Dhulian as a protected place and free from severe bank failure. Shifting of the river Ganges is a continuous process and moreover formation of mid channel bars and shoal on the left bank from Farakka towards Dhulian (Figure 5) may help to increase the pressure of water in both banks of Ganges which ensures active erosion and vulnerability. To find out any connection with bank failure and gradual areal extension of the Char's, Pearson's correlation analysis has used here. The correlation between 'erosion' and 'change in area of the riverine island' stands positive and the correlation value is 0.451 (Table no.5). So, it can be concluded that there is a positive relationship between river bank erosion and gradual extension in the area of the Chars. Continuous shifting of bank line results more active erosion along right bank of river and Dhulian is one of the worst effected zone lying on the right bank.

Table 1. History of erosion in Dhulian

Years	1984-1990		1990-2000		2000-2010		2010-2013		2013-2017	
	Erosion	Deposition	Erosion	Deposition	Erosion	Deposition	Erosion	Deposition	Erosion	Deposition
Total in sq. m	9540	51600	30310	13200	105720	0	17739.7	15121.9	3548	12375
Annual rate in sq. m.	1590	8600	3031	1320	10572	0	5913.23	5040.6	507	1767.9

Table 2. Shifting of bank line over the cross sections based on figure no. 4

Cross sections	1984-1990		1990-2000		2000-2010		2010-2013		2013-2017	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
1	18.45	95.57	2.4	-62.5	-19.1	-649.56	2.62	-239.73	-3.55	-242.52
2	16.33	-87.7	-24.8	-127.39	-5.6	-446.4	3.61	-36.42	-6.35	-18.631
3	14.76	498.05	-61.2	-516.16	-34.95	121.87	-1.49	-259.9	-1.193	-122.4
4	-10.94	779.6	-19.74	-429.3	-9.1	-102.93	11.48	-177.37	-4.224	-339.9
5	-13.97	40.25	-61.59	-108.5	-9.53	-207.81	1.484	-246.91	-17.96	-515.52
6	-7.021	177.43	-153.4	-77.54	-13.44	68.176	18.023	-67.41	-33.71	-611.524
7	24.9	-55.484	30.268	48.212	-42.86	101.76	19.71	-21.46	-9.34	-165.81
8	-14.7	73.02	4.52	-325.63	-5.32	56.414	15.58	236.302	-4.2428	-311.025
9	2.57	24.99	38.82	-290.64	3.268	-46.29	-40.913	15.57	-18.401	-37.534
10	-9.004	48.31	-122.02	14.4	10.6	-254.5	82.24	-1.2009	-34.33	30.718

Table 3. Gradual areal extension of char lands on Ganga river in the years of 2010, 2013 and 2017.

YEARS	2010		2013		2017	
CHAR LANDS	NAMES	AREA IN SQ. KM	NAMES	AREA IN SQ. KM	NAMES	AREA IN SQ. KM
	A	7.63558149	A	3.63770507	A	8.67826551
	B	0.3622186	B	3.41361881	B	3.84309728
	C	0.52487250	C	4.18216510	C	4.27253614
	D	0.02054730	D	13.80308345	D	6.35049960
	E	0.94485600	-	-	E	1.4667749
	F	0.12370926	-	-	-	-
	G	1.36343724	-	-	-	-
TOTAL		10.9752223		25.03657243		24.8121469

Table 5. Correlations analysis

		Erosion in sq. km.	Deposition in sq. km.	Change in char area in sq. km.
Erosion in sq. km.	Pearson Correlation	1	-.730	.451
	Sig. (2-tailed)		.099	.369
Deposition in sq. km.	Pearson Correlation	-.730	1	-.100
	Sig. (2-tailed)	.099		.850
Change in char area in sq. km.	Pearson Correlation	.451	-.100	1
	Sig. (2-tailed)	.369	.850	

Figure 2. Erosion and Deposition in Dhulian

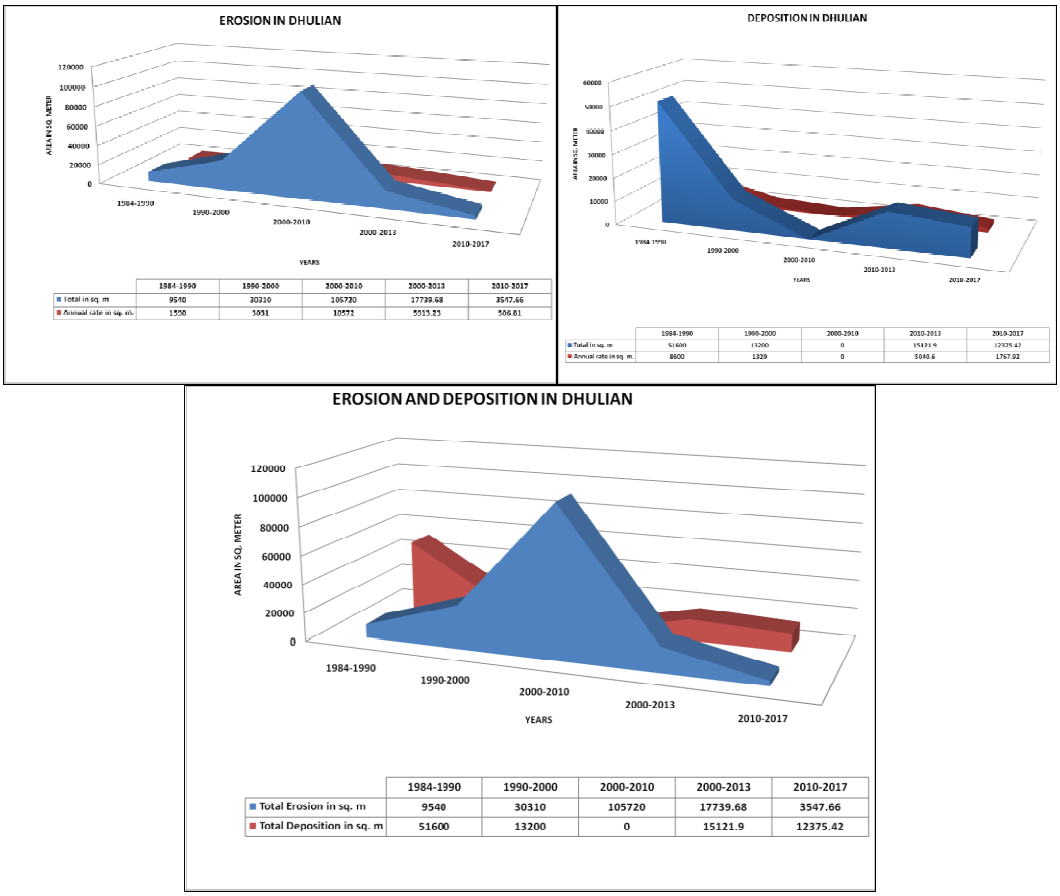


Figure 3. A vulnerable pocket at Dhulian Municipality (2017)

Figure 4. Shifting of river Ganga (Based on Google Earth Images).

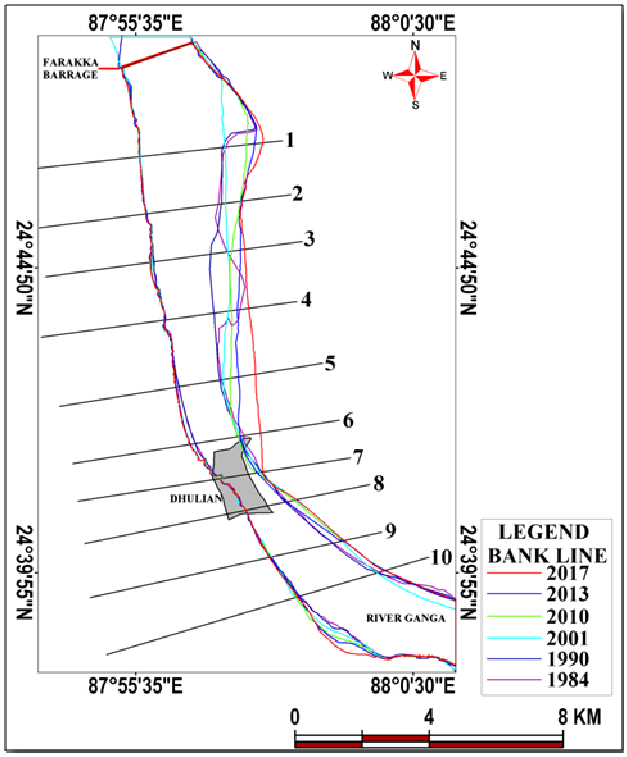
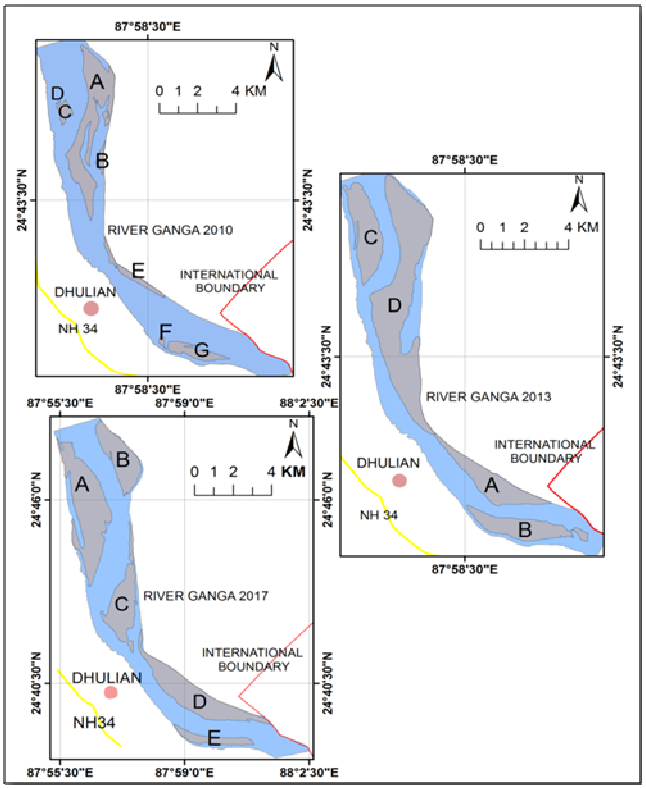


Figure 5. Gradual areal extension of Chars on Ganga based on Google Earth images



4. Condition of people along the river bank in Dhulian

The people living along the bank of Ganga in Dhulian is also suffering by erosion induced problems from past decades. During the erosion of 1950 and 1970 huge number of population was shifted backward. According to Rudra (1992) in mid 1970s, near about 50,000 people become homeless due to devastating erosion in Dhulian. Again Rudra (1996) stated that the problem of erosion and population displacement is not less in the downstream section of Farakka Barrage. Displacement can be found due to erosion in Dhulian, where the number of displacement of 55 percent, 25 percent and 10 percent out of total people are 6 times, 3times and 1 time respectively and rest are not displaced till now (Table 6). They have been facing the problem of displacement from before 80 years to till now due to Ganga river bank failure. Continuous population displacement along the river bank introduces very high density of population i.e., 15,314 person /sq. km. (where according to 2011 census report, the population density of the state, West Bengal, is 1029 person /sq. km. and the district Murshidabad is 1334 person / sq.km.) and increasing the number of slums (Table 7). Due to backward shifting of huge population caused by river bank erosion very much congested (Table 8), unhygienic and unplanned habitation has been developed along the bank where 25-35 people are living togetherly within a small room in a very poor condition. In Dhulian town high percentage of people living in a slum area and most of them are living along the river bank in a very bad condition.

Table 6. Percentage of displaced population and frequency of displacement based on field survey, 2017.

Percentage of displaced population	No. of displacement (frequency)
55	6
25	3
10	1
10	NA

Source: field survey, 2017.

Table 7. Distribution of population in Dhulian municipality during 2011.

Census report	Year 2011
Total population	95706
Total male population	47635
Total female population	48071
Total number of slum	128
Slum population	62210 (65%)
Population density per sq.km	15314

Source: census of India, 2011.

Table 8. Condition of habitation based on field survey, 2017.

No. of families with in average extension (m)	Number of family members with in a family	Total people living within 15-20 meters extension
4-5 families within 15-20meters	6 to 7	24 to 35

Source: field survey, 2017

This erosion induced displacement also ensures loss of properties which is a continuous process.

Table 9. Average amount of land loss due to erosion.

Percentage of surveyed population	Average amount of land loss in Bigha
48	>10
18	5-10
34	<5

Source: field survey, 2017

Table 10. Loss of properties due to erosion.

Type of loss	Percentage of surveyed population
Land + cattle + house	40
House + cattle	35
House	25

Source: field survey, 2017

To know the present condition of the erosion victims, combined infrastructural index (CII) has been computed. The value of CII is **0.23008** which indicates low category of development along the river bank area. From the combined infrastructural index, it can be stated that people along the river bank or the erosion victims do not get basic enough facilities in respect of drinking water, toilet and doctor facility and economically they are also very depressed. Poor erosion victims also suffer from health insecurity due to lack of basic infrastructures.

Table 11. Calculation of infrastructural index based on data collected from field survey, 2015

Electricity facility index	Toilet facility index	Drinking water facility index	Doctors facility index	Per-capita small savings index	Combined infrastructural index
0.75	0.022	0.0555	0.00740	0.316	0.23008

5. Conclusion

After 1980s devastating erosion is not occurred in Dhulian but erosion is still active and no one can say properly about the fore coming days. By observing the river path (river is continuously shifting towards right bank or towards Dhulian and its adjoining area) (Figure 5), it can be stated that Dhulian lies in a denunciation of erosion and thousands of people are living within a highly risky zone. A long term effect of erosion can be found on occupation, education and health. And ultimately bank failure increases socio-economic vulnerability of people specially, along the river bank. The value of combined infrastructural index in study area is 0.23008 which means low category of development in terms of infrastructure. We can fight against erosion in some extent if management plan will be more improved by-

- Construction of concrete bolder jacketing instead of using sand bags to safe the highly populated right bank.
- To fight against erosion as well as to protect the Bed Bars (S1, N2, N3) which are constructed to save the populated right bank, the attention should to pay for their maintenance purposes immediately.
- Plantation of trees should to do along the river bank by considering the active role of trees in protection of erosion.
- And it is important to take the steps to protect the problem areas before monsoon season.

Though it is also not enough because erosion is a natural and inevitable phenomenon of river but concrete bolder jacketing is more erosion resistance than other. And also give more longevity. But we can able to compensate the loss of society caused by erosion by-

- Arranging rehabilitation package for the erosion victims
- Employment for erosion victims to combat against the economic distress
- Arranging adequate drinking water facility, toilet facility, doctor's facility for the poor erosion victims through proper channel.

So, development in the society can be brought by implementing the stated remedies.

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References

Anand, S., Sen, A. 1994. "Human development index: methodology and measurement". http://hdr.undp.org/en/content/ human-development-index-methodology-and-measurement

Banerjee, M. 1999. "A report on the impact of Farakka Barrage on the human fabric, South Asian Network on Dams, rivers and people (SANDRP)". http://sandrp.in/dams/impct_frka_wcd.pdf.

Chakrabarti, P., Nag, S. 2015. "River of West Bengal changing scenario. Geoinformatic and Remote Sensing Cell West Bengal State Council of Science and Technology, Govt. of West Bengal", pp. 62-66.

Chatterjee, S., Mistri, B., 2013. "The impact of river bank erosion on human life: A case study in SantipurBlock , Nadia District , West Benga". http://ijhssi.org/papers/v2 (8)/Version-3/Q028301080111.pdf.

Das, T. K., Halder, S. K., et al 2014. "River bank erosion induced human displacement and its consequences". Living Rev. Landscape Res 8, (2014), 3. http:/www.livingreviews.org/lrlr-2014-3.

"Government of West Bengal, Flood Preparedness & Management Plan-2014".

"Government of West Bengal (2004) West Bengal human development report (2004), development and planning department, Government Of West Bengal, Kolkata".

Khullar, D. R., 2006. "India A Comprehensive Geography", Kalyani Publisher, India, pp. 224-250.

Rudra, K. 1996. "Problems of river bank erosion along Ganga in Murshidabad district of west Bengal, India". Journal of Geography and Environment ,Vidyasagar University, West Bengal 1:25-32

Rudra, K. 2006. “Shifting of the Ganga and land erosion in West Bengal/ A socio-ecological viewpoint”. CDEP Occational paper-8, Indaian Institute of Management Calcutta, pp.1-43.

Rudra, K. 2009. “Dynamics of the Ganga in West Bengal (1764–2007): implications for science–policy interaction”. Quatern Int 227(2):161–169

Sen, M. 2010. “Block level disparities in human development: Birbhum District, West Bengal”. Indian Journal of Landscape System and Ecological Studies, 1:423-434.

UNDP bureau for crisis prevention and recovery. 200. “Reducing disaster risk a challenge for development: A global report”, New York.

‘United Nations Development Programme.2010. “Human development report 2010, The real wealth of nations: Pathways to human development, UNDP”.