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A Case Study for Recent Unsteability of Tidal River Banks in Pathar Pratima Island Located in Subdarban

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ABSTRACT: Costal areas of west Bengal like Patharpratima Island, Namkhana Island, Gangasagar Island, Mousuni Island etc. are repeatedly affected once a year for the last ten years. The present study is regarding the vulnerability and risk assessment due to the recent unstable conditions of tidal river bank in Patharpratima block of South 24 Parganas district, West Bengal. In this study an attempt has been taken to bring forward how the river banks of the block is vulnerable to certain natural threats along with a few man made threats which have been clearly explained by an assessment of the risks faced by the same. The major objective of this study is to find out the vulnerability of the study area i.e Patharpratima block, both environmental and social and providing an assessment of the risks faced by the block. In this study causes of bank erosion of tidal rivers in Patharpratima block have been investigated along with questionnaire survey from the people living besides the mentioned rivers. It was found from the field visits and primary survey that, a number of initiatives have been taken on the part of the GP to protect the embankments but they are all in vain due to the incoming surges and tidal currents which is a very common feature here. It has also been assigned that though human being are continuously proving themselves better with the passage of time, still we are at the mercy of nature. Nobody can do anything when a cyclone or a flood strikes in. After finding the roots causes of bank erosion the study concludes with suggestions yield for proper protection of river bank and how to reduce the erosion under human induced impacts, with minimize cost and less environmental impact.

KEYWORDS: Natural hazard; Disaster; Man made threats; Bank erosion; Risk assessment.

I. INTRODUCTION

Human beings cannot survive without water and because of its most of the earliest civilizations began in the vicinity famous rivers. The management of water which is a gift of the Almighty must also have been very efficient as the economy is dependent on water management. Mostly non-saline water from the river Ganga, Yomuna etc. is used for cultivation, domestic uses, fisheries, industrial purpose etc. But saline water from the river flowing through the coastal area like the tidal rivers (Mridangavanga, Gobadia, Thakuran etc) in Patharpratima island mostly used for fisheries whereas saline water cannot be used for cultivation like paddy, vegetables, domestic uses etc. These are regularly affected by several causes like flood disasters and several man-made issues like building of fishires near to the bank, day by day sea level rise, heavy rain during rainy season etc. These are responsible for thousands losses.

For example in 2019 Cyclone “Bulbul” made a devastating affects near coastal area of west bengal and Bangladesh and Orissa. In year 2020 super Cyclone “Amphan” landed in the same area with double strength compare to “Bulbul” and destructed many lives, houses, animals, fishires and totally weakened the economic strength of the living people nearby the river “mridangavanga”, “Hatania Doania” etc. In the year 2021 also because of cyclone “Yaas” river water level rises approximately 4 meters above the high tide level as a result maximum villages of “Patharpratima Island”, “Namkhana island”, “Gangasagar Island” etc are again flooded. This failure of river bank results in the loss of endanger people who live near to the river.

The bank erosion along rivers depends on several factors like flow, groundwater flow, shear stress exerted by discharge flow, sediment transport, bank properties, bank material weight and texture, cohesive properties, bank height, cross-

sectional slope, groundwater level and permeability, vegetation, construction. Curved river channels shift laterally by erosion of the concave i.e. outer bank and concomitant deposition of point bar deposits at the convex i.e. inner bank. Cohesive banks having low permeability and tend to drain slowly. They become unstable under conditions of rapidly falling stage. They are subjected to sudden failure by bank caving, sloughing or sliding when the banks are under cut or saturated. Large amount of material can be eroded into the channel almost instantly. Bank height is important in assessing stability of cohesive banks because such banks tend to be more unstable than non cohesive banks or banks of low cohesion of equal height.

Non cohesive banks are subjected to surface erosion, resulting in a slow, piecemeal loss of bank material over a period. The rate of surface erosion is affected by such factors like 'Direction and magnitude of flow velocity adjacent to the bank', 'Turbulent fluctuation of the flow', 'Magnitude and fluctuation of shear on the bank', seepage, piping and wave force'.

The angle of repose is small (about 20 degrees) for soil made up of fine well-rounded particles and large (greater than 45 degrees) for coarse angular particles. Finer grained non cohesive soils drain more slowly than coarse-grained cohesion less soils and are therefore more susceptible to failure. Loose sandy material containing some fines is subjected to liquefaction failure (flow slides). When such non cohesive banks are saturated and the water level drops during low tide, pressures in the bank built up to where the sand particles slip and the soil mass acts as liquid with large quantities of bank material suddenly flow into the channel.

All river banks under Patharpratima block is non-cohesive. Recent unstable condition of tidal river bank in Patharpratima block is due to serve and repetitive cyclones along with high tide and increase in water level. Another issue beyond this is a few serious man made threats like sand extraction from river bank, deforestation, fisheries set up near the river bank and canal setup for water supply to the fisheries. Such hazardous steps are enhancing river bank instability. Hazard is an inescapable part of life. Acquaintance with hazards whether it is natural or manmade is a common affair. Many people use the term hazard and disaster synonymously. Though the two terms, hazard and disaster are closely related, they do not mean the same.

Paper is organized as follows. Section II describes the tendency of river bank erosion, root causes of erosion, mechanical and hydrological behaviour of soil particle with some natural and man-made static and dynamic causes. In section III it is shown how this is supposed to work and methodology and purpose of the study. The diagrams and some data represents what exactly the situation of river bank now a days. After detection of recent instabilities an imprinting and few cost effective techniques presents recent surveying results and few images taken that is given in Section IV. Finally, Section V presents conclusion.

II. RELATED WORK

The bank erosion along rivers depends on several factors like flow, ground water flow, shear stress exerted by discharge flow, sediment transport, bank properties, bank material weight and texture, cohesive properties, bank height, cross-sectional slope, groundwater level and permeability, vegetation, construction etc. The concept of hazards and hazards and causes of risk are introduced by several researchers. **According to Susan L. Cutter et al [1]** "There is a potential for loss derived from the interaction of society with bio-physical conditions which in turn affect the resilience of the environment to respond to the hazard or disaster as well as influence the adaptation of society to such changing conditions." **Dr Kalyan Rudra et al. [2]** Chairman of West Bengal Pollution Control Board in **2012** said Within recent 10 years several numbers of cyclones and floods occurred in this block along with high sea water level. He has explained the plight of the Sundarban in so many words, 'Water level of the Bay of Bengal is rising faster than other seas. Moreover, the regular coastal subsidence along the Bengal coastline has worsened. The coastal land is subsiding at a rate of 2.9 mm every year. When we combine the two factors of coastal land subsidence and rising of seawater level (3.6 + 2.9), we find that water in the Bay of Bengal (in Bengal Basin) is rising by 6.5 mm each year. **Kates and Kasperson, 1983 et al. [3]** explains in such way that Vulnerability of a particular region is not completely understood, until and unless an assessment of risk is performed. The two terms, vulnerability and risk assessment goes hand in hand. Risk assessment involves an identification of hazards which may lead to disaster, an estimation of the risk of such events and an evaluation of the social consequences of the risk (Kates and Kasperson, 1983). In a nutshell it can be said that we can finally have a clear idea of the fragility of the region if we follow the above mentioned steps. Risk assessment thus proves the vulnerability of a particular region. According to the **Department of the Block Development Office Patharpratima [4]**: Although the Government reports thus obtained from the Hazard and disaster management Department of the Block Development Office says that the block has also suffered from drought

too, but it has not been mentioned in this study as the impact of this hazard not that significant like the other two. The mechanics of bank erosion and the stability of protective structures subjected to hydraulic loading are a complex problem. The understanding of erosion processes and failure mechanisms of structures is still in a rudimentary stage and it is not yet possible to describe many important phenomena and their instructions by theory. For this reason only a few existing knowledge on this subject can be systematized and made available for designers and managers in this field.

The present study is regarding the vulnerability and risk assessment of the Patharpratima block of South 24 Parganas district, West Bengal. In this study an attempt has been taken to bring forward how the block is vulnerable to certain environmental threats, certain geological threats, and certain man made threats and thus river banks of such area becoming unstable recently. Finally we have suggested a few solutions so that river banks of Patharpratima Island can be protected to some extent.

III. METHODOLOGY

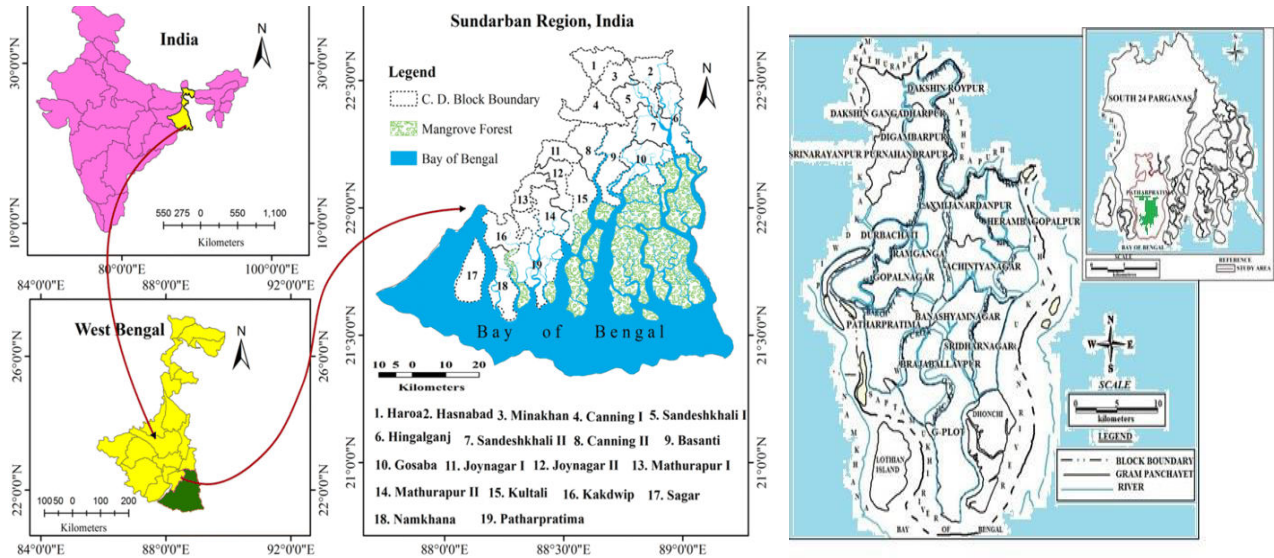
Primary data collected from the field survey through a few rivers like Mridangavanga, Gobadia, Hatania-Doania etc and some questionnaire survey from the nearby villagers. Secondary sources of data are also used for analysis and output result of the present work. Sites of embankment breaching, the length of embankment damage measured by field survey. Some data collected from the pre-existing literature and newspaper report. So pre field, field and post field method are applied here. Based on the settled objectives of the study, scheduled methods of investigation, analysis, interpretation and presentation are considered for the holistic study of the particular subjects. Basically, data and detailed reports of the hazards, collected by primary survey and partly from the Block Disaster Management Department (Patharpratima block). Specifically, an account of the history of disasters and their seasonality of occurrence in the block has been given. The major part of the study lies on risk assessment in which the explanation will be entirely rest on the details of the losses resulted due to the hazards. The consequences of the hazards have been described under the following facts considering each hazard separately.

- (i) Recent un-stability due to natural hazards and cyclones according to survey and data collected.
- (ii) Recent un-stability due to man-made effect according to data collection and survey.

Finally, impact analysis, respective presentation and inferences have been taken for suggestion

IV. CAUSES, DISCUSSIONS AND RESULTS

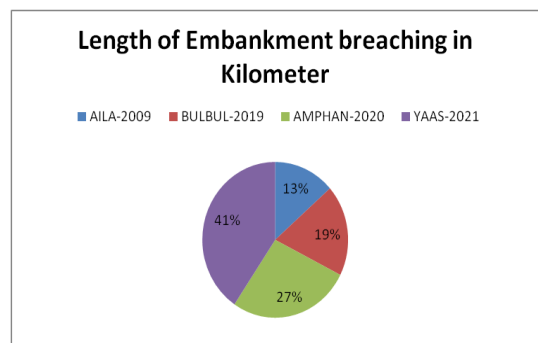
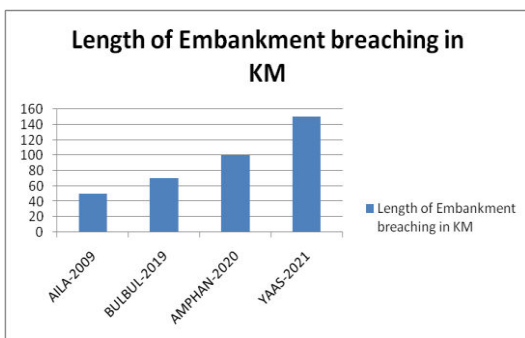
STUDY AREA:- In Patharpratima block several tidal rivers like Mridangavanga, Gobadia, Thakuran, Hatania Doania etc are flowing. They are fed by sea tides twice a day. Sea water enters more than 100 km through these estuaries and inundates the low-lying plains. Tidal effect, seasonal flooding and impact of full moon cause embankment breaching in all the river banks area. This causes serious damage to agriculture, road, etc. The Patharpratima C.D. block of Kakdwip subdivision is geographically located at the southernmost tip of West Bengal, covering an area of 484.47 square kilometer, surrounded by Namkhana, Kulpi, Mathurapur and Kakdwip blocks. The block consists of 15 GPs, 1 Panchayet Samity and 92 registered villages and is located at the lower deltaic plain with 4m height above the MSL. The GPs of the block, with its headquarter located at Ramganga and the GPs are Dakshin Roypur, Dakshin Gangadharpur, Digambarpur, Srinarayanpur, Purnachandrapur, Laxmijanardanpur, Herambagopalpur, Ramganga, Durbachati, Gopalnagar, Achintyanagar, Banashyamnagar, Patharpratima, Brajaballavpur, Sridhar agar, and G-plot. The river network forms the major transport system of this block and people are dependent on the river both for transportation and livelihood (fishing).



Location of the Study Area(Patharpratima Block)

Source: Compiled from Administrative Atlas (WB), MES&E,DPM, NATMO and Census

NATURAL HAZARDS AND CYCLONIC EFFECT:- In Patharpratima block It is seen 09 out of 15 GPs of Patharpratima block in the South 24 Parganas district have been identified to have potentially weak embankments due to natural shocks and fishery problems. The most vulnerable GPs Banashyamnagar, Brajaballavpur, Purnachandrapur, Patharpratima, Sridharnagar, Herombagopalpur and G-Plot. During the Aila cyclone in May (25-26), 2009 nearly 50 km of the total embankment of Patharpratima block were completely destroyed. The saline water caused heavy damage to agricultural field, fish farm and other man made structure (The Hindu 27may,2009). In 2019 near about 70 km of total embankment was destroyed due to cyclone 'BULBUL' whereas in 2020 super cyclone 'AMPHAN' made a total destruction of embankment near about 100 km. But recently in 2021 cyclone 'YAAS' near about 150 km of total embankment in Patharpratima block has been destructed.



The whole block is surrounded by some of the tidal rivers like Mridangabhanga, Shibua, Jagaddal, Gobadia etc. Some of the GPs are totally surrounded by rivers or any other water bodies. The following table shows the water bodies along with the respective GPs. Some of the GPs which are most unstable conditions are shown in the table below.

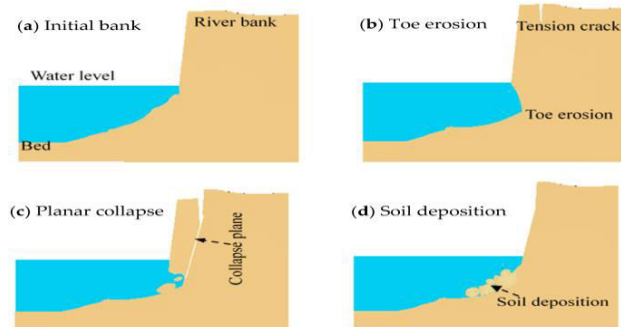
Name of the GP	Embankment condition
Dakshin Gangadharpur	Good
Achintyanagar	Good
Banashyamnagar	Moderately Poor
Brajaballavpur	Moderately Poor
Dakshin Roypur	Good
Digambarpur	Good
Durbachati	Good
G-Plot	Moderately Poor
Gopalnagar	Poor
Herambagopalpur	Moderately Poor
Laxmijanardanpur	Good
Patharpratima	Moderately Poor
Ramganga	Poor
Sridharnagar	Moderately Poor
Srinarayanpur-Purnachandrapur	Moderately Poor

Name of the rivers/creek/khals	Vulnerable GPs
Thakuran	Achintyanagar, Sridharnagar, Herambagopalpur
Mridangabhanga	Ramganga, Laxmijanardanpur, Achintyanagar, Digambarpur
Pakhirali	Sridharnagar, Achintyanagar
Gobadia	Ramganga, Patharpratima,
Barchara	Ramganga
Shukha	Ramganga
Atharogachi	Laxmijanardanpur
Pukchara	Herambagopalpur
Kakmari	Laxmijanardanpur
Kalir Khal	Herambagopalpur
Nukchara	Laxmijanardanpur
Kalna	Dakshin Gangadharpur
Bay of Bengal	G-Plot
Saptamukhi	G-Plot
Gazir Khal	G-Plot, Brajaballavpur
Chaltabunia	Patharpratima

**Table 1 & 2: Average River Bank Condition and water bodies surrounded Of the Block-Patharpratima
Compiled and drawn by Authors**

Tidal Effects:-The area is criss-crossed by numerous tidal rivers and its tributaries and distributaries. The island villages and coastal villages are protected by earthen dykes but in some vulnerable areas and sea-facing embankments daily flow of high tide and low tide source the base and side of embankments. During the months of April to October the tidal waves assume giant properties causes breach in the mud dykes. Maximum river bank of our study area is earthen with non-cohesive soil whose angle of repose is about 20 degree. Due to this low angle of repose earthen bank becomes weakens this time and slides off.

Toe and Lateral erosion Effects:- All river banks in Patharpratima block are mainly eroded by two major processes of bank erosion namely i) Toe erosion due to scour, ii) Lateral erosion. Because of scour depth near the bank increases and after certain time toe is eroded in such a way that the river bank becomes into a cantilever beam like structure. After forming cantilever beam like structure river bank collapses into the river due to gravity.



In the above picture river bank of Mridanga vanga river near Ramganga Getty is vulnerable. Near about 800 meter river bank is unstable due to several causes and one of the vital causes is River bank erosion with tidal wave effect. Bank

height of that particular area is about 4 meter from the water level where as during high tide water level rises almost 3 meters and during low tide water level goes down nearly 4 meter from the base water level. During high and low tide river bank experiences dry and wet behavior and because of that a shrinkage and expansion occurs in the bank materials. As the material is non-cohesive in category and due to this consecutive effect bank materials becomes loosen and ultimately wash out into the river.

Old River Bank erosion Effects:- Most of the embankment is very old in nature. They are constructed during the British rule .But they are not maintained regularly. So these embankments gradually becoming very weak in nature. Only medium intensity cyclone and high velocity tidal wave and heavy rainfall causes in many places breaching .In rainy season embankment breaching and flooding is a very common incident in the coastal villages.

MAN MADE EFFECT:- Nobody can prevent natural hazards but when man become hazards then it becomes unstoppable and uncontrolled situation for living hood. All we know that deforestation plays crucial role in river bank erosion and river bank un-stabilities but here are some man made causes that we have seen in this study and effect of which ultimately breaches the river bank.



Source: Photo captured by authors near Mridangabhanga River

Population on the River Bank:-According to the Department of Irrigation and waterways major causes of embankment damage in the Sundarbans are weak technological structure of embankment and high rate increase of population in river and coastal areas. Technologically the Structures of the embankments are very weak. Because the embankment constructed on the non-cohesive silt that cannot resist the tidal surges in the long term. Population pressure is increasing at rapid rate in this area specially unplanned settlements developed in concave sides of the bends of the meandering river course. These are highly unstable due to natural scouring process. The base of the river embankment gradually weakened.

Non-Scientific Sluice Construction by nearby villagers:- Embankment breaching is also linked with the proper drainage through the sluice gates in the areas. Through the narrow artificial made canal slice gates are connected. As a result earthen embankments become weaker due to flow of saline water. During rainy season local people pass excess water from agricultural field through this slice gates. Slice gates are also used for aquaculture practice. Very after rainwater accumulates in the crop fields, people make cuts on many parts of embankments for draining away the water. This process of water drawing makes the embankments more vulnerable to tidal surges and wave action.

Deforestation Of Mangroves by nearby villagers:- The mangrove forests are playing an important role by protecting the river and coastal bank erosion. But at present the local people who completely dependent on forest based resources for their livelihood collection, they cut the forests for various purposes. The mangrove trees protect the embankments from wave attack. Rapid degradation of mangrove forests cannot present the embankment breaching. So Physical and

socio- economic environmental situation are responsible for embankment breaching along the river banks as well as coastal bank areas.

Fish Farming Pond Near To the Bank: - Along the river side the prawn seed collectors trample upon the mud base embankment and this causes soil erosion. So causes of embankment breaching are multidimensional. This is from natural as well as anthropogenic factors. Sometimes they build up fisheries just close to the river bank and deforest nearby trees. They made a channel to feed the saline water into their fishing pond and throw back the used pesticide mixed water into the river. During high tide water level of river is more and water level of fishing pond is less and pressure difference occurs and because of this river bank experiences force towards fishing pond. But during low tide water level is low compared to fishing pond because of this effect river bank experiences adverse effects and experiences force from pond to the river direction. When this phenomenon occurs for a period of time river bank loses its strength. For this nonscientific channel construction ultimately river bank is converted into un-stable one.



V. CONCLUSION

After field observation and discussion it is quite clear that recent un-stability near the bank is becoming more and more crucial day by day. Main and vital cause of recent un-stability is consecutive disasters although all cyclone and floods are not always responsible for destruction. The other cause of un-stability is due to man-made effect. It was found from the field visits and primary survey that, a number of initiatives have been taken on the part of the GP to protect the embankments but they are all in vain due to the incoming surges and tidal currents which is a very common feature here. The people, whose houses were completely demolished in cyclone (Aaila), were given Government aid (financial) so that they can build their houses. But the original fact is that, they have built the same mud built straw thatched huts and sometimes they built up their houses almost on the river bank, resulting into continuation of risk of life during severe hazards. It can also be assigned that though human being are continuously proving themselves better with the passage of time, still we are at the mercy of nature. Nobody can do anything when a cyclone or a flood strikes in. But it is not possible to build and make all the river banks of this area into concrete river bank. So from government end geotextile sheet covered earthen bank can be involved which have low cost and long durability compared to simple earthen bank. But from the people end if people become aware of it and build up fisheries, houses and building from far away to the bank maintaining the Govt. protocol, stop cutting trees and allow Govt. authorities to take over some land for new and stable embankment construction then this kind of un-stability can be stopped to some extent.

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