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Assessment of Riverbank Erosion and Accretion and its Impact on the People of Chairman Ghat, Noakhali, Bangladesh

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Abstract: Nestled within the vastness of the Meghna deltaic plain, Noakhali, and in particular, Chairman Ghat, stand as poignant examples of Bangladesh's intricate relationship with environmental challenges. The significance of the Meghna deltaic plain cannot be overstated, as it shapes the very fabric of the nation's landscape. However, this geographic richness comes hand-in-hand with vulnerability, and nowhere is this more apparent than in the relentless grip of riverbank erosion. Chairman Ghat, in Noakhali, epitomizes the struggle against this natural force, making it a focal point for understanding and addressing the profound impact of riverbank erosion in the region. The primary objective of this research work is to assessing river bank erosion & accretion and examine its the potential impact in the chairman Ghat area. In order to achieve this goal, this study employs remote sensing and GIS techniques to assess the erosion and accretion rates of Chairman Ghat on the Noakhali coast from 2000 to 2022 and conduct household survey to examine the socioeconomic impacts of river erosion on the local population. The findings revealed that Over the past 22 years, the Meghna estuary experienced a total of 667.0 km2 of erosion and 689.1 km2 of accretion. Chairman Ghat area alone witnessed a net erosion rate of 4.2 km2 per year during the specified period, resulting in a loss of 117.7 km2 of land, while only 25.3 km2 of new land was added. From household survey it is found that the adverse effects of riverbank erosion on the local community are evident, leading to the loss of vital agricultural lands, homesteads, and property damage that cannot be easily recovered. Consequently, a significant portion of the affected population is compelled to migrate, thereby exacerbating their socio-economic plight as they are forced to change professions. This research sheds light on the extent of riverbank erosion in Chairman Ghat, Noakhali, and elucidates its profound socioeconomic implications on the lives of the local inhabitants. The findings of the study will help to enhance our understanding of the specific impact of river erosion enabling the development of targeted strategies to protect vulnerable communities' lives, livelihoods, and environments. It will also promote cohesive coastal zone management, implementing robust measures that counteract the destructive consequences of riverbank erosion, thereby ensuring the sustainable development and resilience of these crucial ecosystems.

Keywords: *Accretion, Erosion, Impact of Erosion, Migration, Remote sensing, River Bank*

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1. Introduction

Bangladesh, situated within the vast Ganges-Brahmaputra-Meghna Delta, grapples with pronounced vulnerability to environmental challenges, with riverbank erosion emerging as a critical and severe issue. The expansive delta, spanning approximately 100,000 km^2, not only makes Bangladesh Asia's largest delta but also the most densely populated in the world. The nation's landscape intricately intertwines with 700 rivers, heightening susceptibility to the adverse impacts of climate change and environmental stressors (Alom & Rahman, 2020). The intricate interplay of Bangladesh's rivers creates a delicate balance that, when disrupted, exposes the nation to heightened risks associated with climate change. Climate change can affect many aspects of our lives, for example, health and environment, access

to natural resources, safety and security, agriculture and food production (Kibria, Pavel, Miah & Islam, 2022). As global climate patterns evolve, the monsoons in Bangladesh intensify, magnifying the severity and frequency of riverbank erosion. The Ganges-Brahmaputra-Meghna (GBM) River systems, with their voluminous discharge and sediment transfer of nearly 1.1 billion tons annually, become a force driving the destructive impact of riverbank erosion (Ghosh, 2022). During the monsoons, the recurrent onslaught of heavy rainfall and increased river flow exacerbates the erosive forces, leading to dire consequences. Riverbank erosion, characterized by substantial land loss, population displacement, disrupted communication networks, and severe damage to crops and infrastructure, becomes a persistent threat echoing across Bangladesh's coastal areas and the entire nation (Hamide & Karim, 2017). Shockingly, one million individuals in Bangladesh experience riverbank erosion's devastating impact each year, leaving them landless and homeless (Mahmud et al., 2020). Notably, river erosion is distinct from headline-grabbing hazards like cyclones and floods due to its insidious and gradual nature, leading to long-term and destructive consequences (Hamide & Karim, 2017). Looking ahead, projections indicate an alarming surge in riverbank erosion, with an anticipated increase of 13% by 2050 and 18% by 2100 (Ghosh, 2022). This grim reality is further exacerbated by the unique aspects of riverbank erosion, where people do not merely lose their homes and properties but also their very lands, (Howlader & Rahman, 2016) resulting in widespread displacement and a myriad of personal, domestic, and social challenges (Hamide & Karim, 2017). The central coastal region of Bangladesh, including the Noakhali district, stands at the forefront of this battle against riverbank erosion (Ahmad, 2019) (Sultana et al., 2023). Residents of this area have been grappling with the issue for several decades, posing a severe threat to both their well-being and the local economy (Alom & Rahman, 2020). In this context, riverbank erosion stands out as a poignant manifestation of Bangladesh's susceptibility to the changing climate, representing a pressing environmental challenge with far-reaching socio-economic implications. Understanding and mitigating the impacts of riverbank erosion during the monsoons are crucial steps in safeguarding the nation's communities and infrastructure from the escalating threats posed by climate change. Although extensive research has been undertaken on coastal erosion and accretion across Bangladesh, remarkably limited work has been conducted on river erosion's specific impact in the Noakhali district individually. In particular, this type of work has never been done before in this specific Chairman Ghat area. Therefore, this study aims to address this gap by assessing erosion & accretion trends from 2000 to 2022 and examining the potential impacts of riverbank erosion in Chairman Ghat area. This study holds substantial significance, given the escalating trends of riverbank erosion predicted for the future. The findings of this research will contribute to a deeper understanding of river erosion's localized impact and pave the way for targeted strategies to safeguard the lives, livelihoods, and environments of vulnerable communities in Noakhali and similar regions worldwide. The ultimate goal is to foster cohesive coastal zone management and develop robust measures to counter the devastating effects of riverbank erosion, ensuring the sustainable development and resilience of these vital ecosystems.

2. Materials and methods

Chairman Ghat under Hatiya Upazila, located on the Noakhali coast. It is placed in the central coastal zone of Bangladesh, which is found between latitudes 22^0 31' N and longitude 91^0 05' E. It is encircled by the Subarnachar Upazila to its north, Ramgati Upazila to its northwest, the Bay of Bengal to the southeast and the Meghna River to its southwest. At the 2011 Bangladesh census, Hatiya Upazila had a population of 452,463. It had an average literacy rate of 34.21%. Noakhali's 75-km-long coastline consists of muddy and sandy shores, with intertidal mud flats extending from 200 m to 4 km. Degradation is occurring in the southwestern region due to strong upstream flows from the Ganga-Brahmaputra-Meghna River basin. The Noakhali coastline has a strong tidal range, from 0.43 m during low tide to 4.44 m during spring tide. The coastal region of Noakhali is characterized by deltaic lands and alluvial soils of excellent agronomic value, with elevations varying mainly between 2 and 10 m. The seasonal monsoon winds affect the area, like the rest of Bangladesh. The average annual rainfall in the study area is 2547 mm, more than 95% of which falls during the monsoon season. The average annual minimum and maximum temperatures are 23 and 31 °C, respectively, with a maximum of 33 °C between March and June (Hossain & Das, 2012). 80% of the people living there depend on agriculture, the main livelihood source in Noakhali district. The district is a lowland area rich in fisheries, which are very important to the local economy.

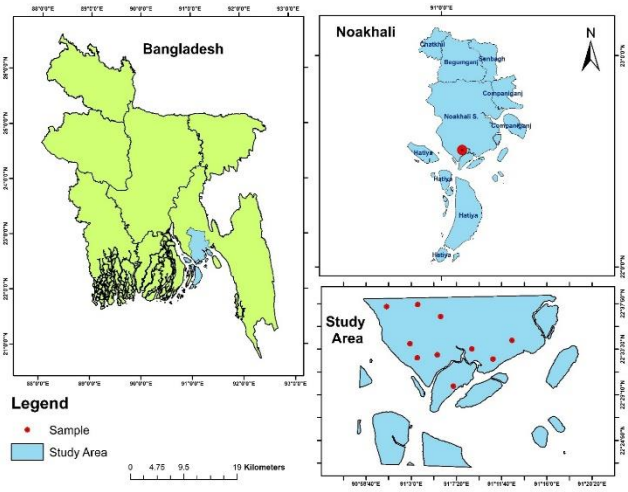

Figure 1: Location of the Study area.

Due to its geographic position, the people of the Noakhali coast are most vulnerable and in danger from natural disasters. River erosion is a regular occurrence in southern Noakhali, making it a normal feature of life there. Between 1988 and 2016, erosion occurred in the southeastern portion of Noakhali because the seawater flows in the opposite direction through the Sandwip Channel (Hassan et al., 2017).

Remotely sensed data is used to estimate the erosion and accretion of the Meghna River, which is acquired from Landsat satellites and digitized these images in ArcGIS 10.8. The images obtained from Landsat paths 137, row 044; 136, row 044; and 136, row 045 are suitable for evaluating the study area. We have chosen a 22-year timeframe to assess shoreline changes, ranging from 2000 to 2022. The Landsat 5 Thematic Mapper (TM) sensor captured images for 2000 and 2008, while the others from 2015 and 2022 were acquired by Landsat 8 and Landsat 9, using the Thermal Infrared Sensor (TIRS) and Operational Land Imager (OLI), respectively. The necessary information was extracted from the United States Geological Survey (USGS) website (https://earthexplorer.usgs.gov/), with a minimum of 10 percent cloud cover and the period between October to December during post-monsoon. Maximum cloud cover can significantly affect the quality and accuracy of the data. Cloud-free Landsat images from 2000, 2008, 2015 and 2022 were downloaded for free from Earth Explorer. The availability of cloud-free Landsat images varies from year to year, and the selected years have a high percentage of cloud-free images during the post-monsoon season. The monsoon season can cause flooding and landslides, which can damage infrastructure and alter the landscape. In contrast, the post-monsoon season is generally more stable, making it easier to interpret satellite imagery and track changes over time.

After image processing, we extracted our AOI for separating the river area and calculated erosion and accretion. The images were analyzed using supervised classification to differentiate between land and water features, as well as to mark out the banks of rivers from the water.

Classified images were converted to polygon shape files for quantification. The transformed layers of the classified images from 2000, 2008, 2015, and 2022 were visually interpreted to determine the river boundaries. The unchanged area was calculated by intersecting the previous year and the next year. For erosion, the unchanged area was subtracted from the river area in 2008, 2015 and 2022 respectively. To quantify the amount of degraded land cover from 2000–2008, 2008–2015, 2015–2022, and 2000–2022, attribute tables of these unchanged areas were summarized.

Accreted land covers are arranged according to the same procedure. In the case of deposition, the unchanged area was subtracted from the river area in 2000, 2008 and 2015 respectively. To calculate the total quantity of accreted land cover between 2000–2008, 2008–2015, 2015–2022, and 2000–2022, attribute tables for the unchanged areas were compiled.

For primary data, a questionnaire survey method is followed, which is a low-cost, fast and competent way of assembling huge quantities of data. The field survey was conducted by randomly selecting 50 households. We emphasized male respondents because they are the chief decision-makers in their households and are capable of providing more details than females. We questioned a female member in the absence of a male family member. The survey contained about 21 questions related to the impact of river erosion. Analyzing these data using SPSS and Microsoft Excel, we acquired our outcomes, which abetted us to comprehend the influence of river erosion in our study area.

3. Results and discussion

3.1. Erosion and accretion in Noakhali coastal zone

The erosion and accretion of the Meghna estuary for different time intervals (2000-2008, 2008-2015, 2015-2022, 2000-2022) is shown in the following figure.

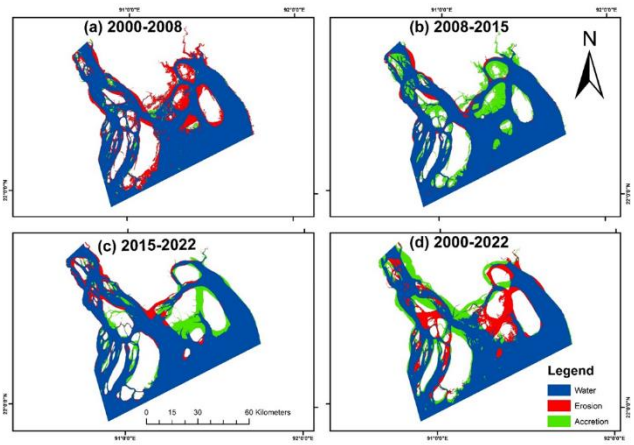

Figure 2: Erosion and accretion of Meghna estuary during the last 22 years (2000-2022).

From 2000-2008, it can be seen that river bank erode extensively compare to the accretion. The islands of the lower Meghna River are very unstable. Most of the erosion has occurred in in the north and southeast portions of the Hatiya Islands. Sandwip, Urir Char, and Jahajer Char. During 2008-2015, accretion was higher than erosion on the Noakhali coast and it moved southward. High accretion was seen in the Hatiya, Bhola, Urir Char and Sandwip islands. Some erosion also be seen in the north of Hatiya, but the south and southeast parts of this island were accreted. Due to accretion the morphology of Urir Char, Sandwip and Jahajer Char changed. The Noakhali shoreline was eroded once again between 2015 and 2022; however, Sandwip and Jahajer Char were accreted; only a portion of these islands experienced erosion. It is ssen that In Urir Char, erosion and accretion were about to equal.

The trend of erosion and deposition in the estuary of Meghna indicates that the central coastal zone is very unstable. From the overall scenario of 2000-2022, we can see that in the Meghna estuary, the accretion process is prominent. During the monsoons, heavy rainfall causes large amounts of sediment to flow into the Meghna Estuary. This may be the cause of the high rate of accretion in this region. The Meghna estuary experienced severe erosion, possibly as a consequence of the impact of high river currents.

Table 1: Erosion and Accretion in the Meghna Estuary of Bangladesh

Duration	Accretion (km^2)	Erosion (km^2)	Net Erosion/Accretion (km^2)	Rate of net Erosion /Accretion (km^2 per year)
2000-2008	91.1	945.3	-854.2	-106.8
2008-2015	852.2	192.4	659.8	94.3
2015-2022	507.4	291.0	216.4	30.9
2000-2022	689.1	667.0	22.1	1.0

The Meghna Estuary has seen natural erosion and accretion during the past 22 years, from 2000 to 2022, with a net land gain rate of 1.0 km2 per year. The findings are shown in the table above. The net erosion of land during the first assessment period (2000-2008) was 106.8 km2 per year. Strong waves from the Bay of Bengal are eroding the coastline. After that period, during (2008-2015) and (2015-2022) net accretion of 94.3 km2 per year and 30.9 km2 per year are observed respectively.

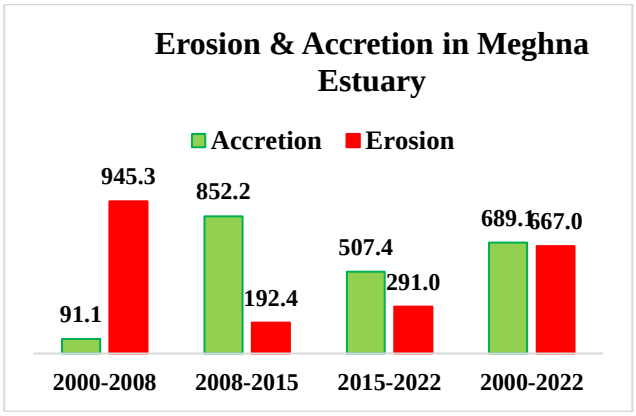

Figure 3: Erosion and accretion in Meghna Estuary (2000-2022).

The proportion of accretion and erosion in the Meghna Estuary was observed through the analysis of four different Landsat images from 2000 to 2022. From 2000 to 2008, 945.3 km2 of land was most heavily eroded, in which the north and southeast parts of Hatiya island, Urir Char, Jahajer Char, Sandwip, and the southeast part of Noakhali were highly eroded areas, and the erosion rate was 106.8 km2 per year. Between 2008 and 2015, there was the greatest amount of accretion (852.2 km2), which occurred in the southeast part of Hatiya and Noakhali, Urir Char, Jahajer Char, and Sandwip islands. The accretion rate was 94.3 km2 per year. During 2015–2022, accretion was observed in the surroundings of Jahajer Char, Sandwip Island, Urir Char, and the eastern part of Hatiya Island, and erosion also occurred in the south part of Noakhali, the northern part of Hatiya Island, and some parts of Jahajer Char and Urir Char. Figure 3 depicts the degradation and deposition of the Meghna Estuary from 2000 to 2022. The rates of erosion and accretion vary depending on the location, which indicates the Meghna estuary is very unstable and dynamic.

3.2. Erosion and accretion in the study area

The erosion and accretion of Chairman Ghat for different time intervals (2000-2008, 2008-2015, 2015-2022, 2000-2022) is shown in the following figure.

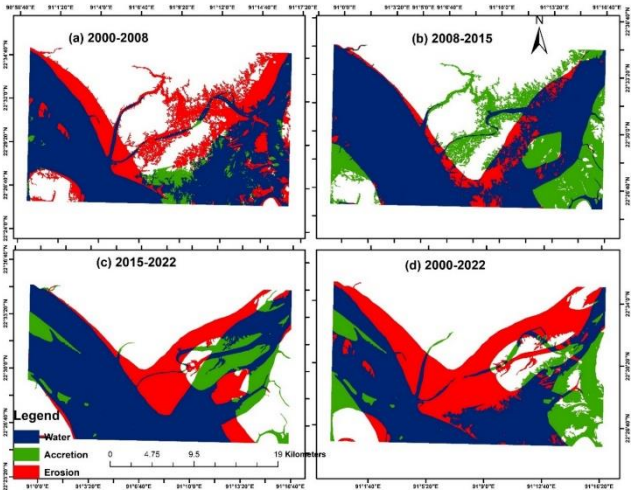

Figure 4: Erosion and accretion of Chairman Ghat during the last 22 years (2000-2022).

The central region of the Meghna Estuary altered extensively between 2000 and 2008. Seasonal events, such as hydrological and meteorological driving variables, can affect the erosion-accretion process in addition to the yearly variation in land formation processes. Our study area is Chairman Ghat, located on the Noakhali coast. Net accretion dominated in the Noakhali district from 2008 to 2015, as shown in Figure 4. The tidal circulation process can be the main contributor to net land formation.

Chairman Ghat faces more erosion even if accretion is prevalent in the Meghna estuary.

An analysis of erosion and accretion in the whole coastal region from 1973 to 2016 reveals that the net accretion rate was 31.8 km2 per year over 43 years. Between 1988 and 2016, erosion happened in the southeast of Noakhali, in Urirchar, and close to the Feni River's mouth due to the northward reverse flow of seawater through the Sandwip Channel.

A study of the historical trends of the coastline between 1985 and 2021 shows that the central coast is accreting to the south and eroding to the north. Most of the central coast is undergoing significant changes due to erosion and accretion. Most accretion happened at Noakhali-Feni, on the headland between the Feni River estuary and the main river estuaries, with the fastest rates exceeding 195.42 m/yr.

Another study in the Meghna estuary reveals that it was in a gaining phase during 1977–2010. During this time, the Meghna Estuary and its surroundings have expanded by 769.4 km2. During the period, the southern part of Noakhali Sadar, southeast and extreme south of the Hatiya island have been highly accreted, whereas the north and northeast of Hatiya island have been highly eroded.

Table 2: Erosion and Accretion of the Study Area

Duration	Accretion (km^2)	Erosion (km^2)	Net Erosion/Accretion (km^2)	Rate of net Erosion/Accretion (km^2 per year)
2000-2008	16.3	104.1	-87.8	-11.0
2008-2015	57.4	28.0	29.4	4.2
2015-2022	34.8	68.9	-34.1	-4.9
2000-2022	25.3	117.7	-92.4	-4.2

The outcomes of natural accretion and erosion during the last 22 years, from 2000 to 2022, in the study area are presented in the table above, where the net erosion was 4.2 km2 per year. The net erosion of land during the first assessment period (2000-2008) was 11.0 km2 per year. After that period, during 2008-2015 the rate of net accretion was 4.2 km2 per year. During the period 2015-2022 again a net erosion of 4.9 km2 per year has been observed.

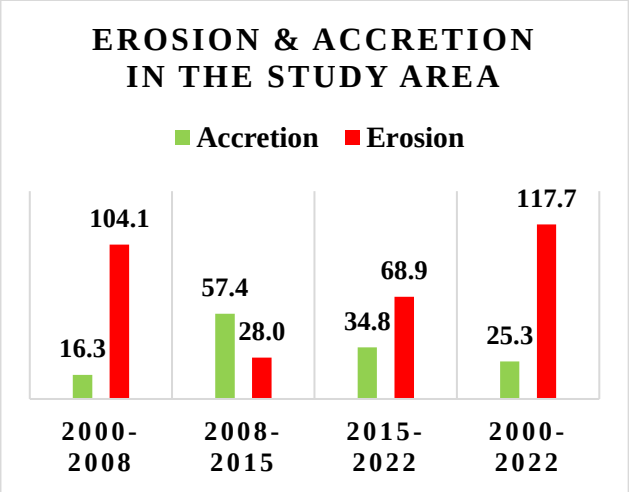

Figure 5: Erosion and accretion in Chairman Ghat from 2000-2022.

The amount of accretion and erosion in our study location were observed by analyzing Landsat images of 2000, 2008, 2015 and 2022. The highest eroded area is 104.1 km2 from 2000 to 2008 and the highest accreted area is 57.4 km2 in the period 2008 to 2015.

People in the study area have to deal with some problems caused by erosion, such as diminishing agricultural land, food shortages, and livelihood insecurity. Reduced arable land influences crop production, which in turn has an impact on the local economy. Original stable agricultural land has a high value and is used for many different purposes. In contrast, the newly accreted land (sand char) has limited utility and poor economic value because of its fragile texture. Each year, these char areas are submerged in floodwaters and yield fewer crops. No development or industry has been established in this region due to the risk of erosion. The livelihood of the people mostly depends on agriculture or agricultural labor. Erosion affects this vulnerable sector, and the number of people employed in agriculture is also declining. As a result, many of them changed occupations and moved to other locations.

3.3. Impacts of river erosion

River bank erosion creates obstacles in the development process. River bank erosion has a wide range of effects, including social, economic, health, educational, and even political ones. The most significant social effect is homelessness brought on by land erosion, which forces people to relocate. This compelled displacement leads to economic crises such as loss of occupation and property which increases the chance of being poor and, in certain cases, an attachment to crimes. Other consequences of bank erosion include a lack of adequate medical and educational services. As medical care units are damaged on eroded land, people are not able to get proper treatment, the same is the case with education. Even if they have access to educational and medical amenities in their newly occupied areas, they find it difficult to expend money on

items other than necessities like accommodation and sustenance due to the loss of their jobs. As a result, they are feeling sick and their children are illiterate (Das et al., 2014). Socioeconomic advancement comprises demographic features, economic development, educational opportunities, women's status, medical facilities, nourishment, housing quality, and infrastructural amenities, all impacting many aspects of society (Mustaquim, & Islam, 2014).

3.4. Demographics condition

Socioeconomic and livelihood characteristics are crucial for understanding the entire socio-economic status of the families in the study area (Das & Samanta, 2022). We've received responses from 78% of men and 22% of women. Most of the responses are in the 35 to 45 age range, including the majority of the age group and consider how they think about migration and non-migration. The educational attainments among the sampled inhabitants are extremely poor in the study area. 64% of people are illiterate. Approximately 20% of respondents have attended high school, whereas 16% attended primary school. Low literacy levels have negative impacts on individuals (such as children, youth, adults and seniors), health and well-being, community participation, training, labour force, employment, productivity, and economic development (Islam & Aliah, 2015). This low rate of literacy is responsible for their inadequate knowledge about hazards and their impact on the environment, human health, agriculture etc. (Islam et al., 2017)

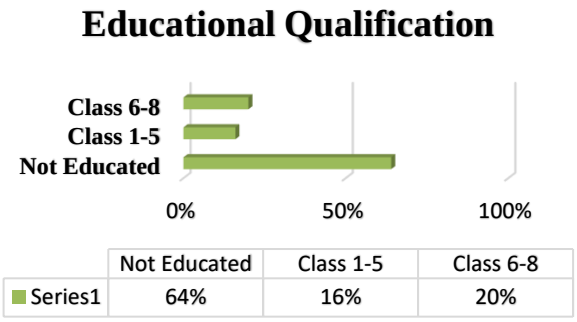

Figure 6: Population literacy rates in the study area.

3.5. Occupation

From our survey, it is found that the dependency ratio is very high in the village. Most households have only one earning member and they do not have a secondary or seasonal occupation. 34% of the people are farmers and involved in agricultural activities. It is a key economic activity in the coastal zone because coastal areas offer very favourable environmental conditions for agriculture. Such areas have alluvial fertile soil and more humid climate which make lands more suitable and productive for cultivation. 12% of household heads are engaged in fishing, whereas the amount of day labour is 16%. Other people are engaged in different professions like boatmen, shopkeepers, porters, rickshaw pullers etc.

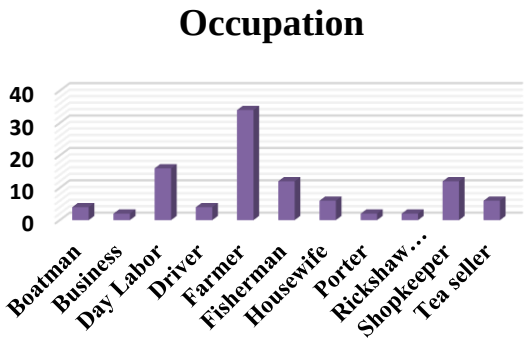

Figure 7: Occupation of the Local People

3.6. Income level

The lifestyle of individuals is widely dependent on their economic status. The average income of the people in this area is poor. This study reveals that most of the people occupy farming, fishing, day labor, boatman etc. As all these are low-income generating sources, they can't lead a harmonious life. The survey shows that they have very low incomes. The following graph shows the economic status of this study area. The surveyed data indicates that the economic condition of 44% of people is low and their monthly family incomes are below 10,000 takas, whereas the middle class encompasses 54% earning less than 20,000 takas monthly. Only 2% of people exists in better-off condition.

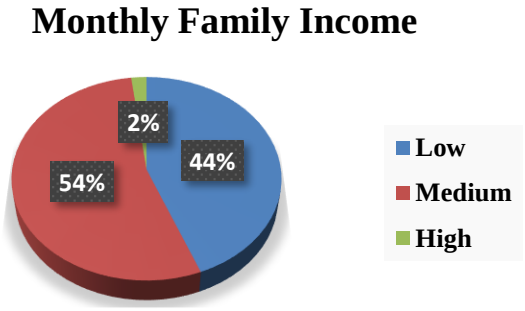

Figure 8: Economic Well-Being Status of the Households

3.7. Migration due to erosion

As the study area is very vulnerable to erosion, most of the people in that area have faced riverbank erosion in their lifetime. From the following graph, we can see that, 50% of people being victims of river erosion more than 6 times. Among the rest, 12% and 38% of inhabitants have faced erosion 4-6 times and less than 4 times respectively.

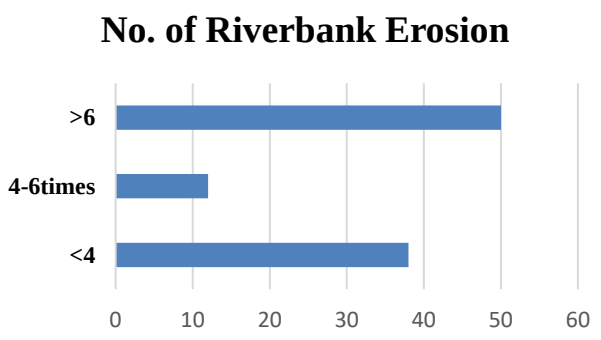

Figure 9: Number of riverbank erosion

There is a close link between riverbank erosion and migration. One of the most serious concerns with river erosion is migration. Due to river erosion, people become homeless and migrate from one affected place to another for safety and food (Tripathy & Mondal, 2019). Because of their misery, the victims are forced to relocate. Even though the majority of people's work is associated with rivers and agricultural land, most people choose temporary migration. However, when severe consequences arise, such as the loss of their possessions, properties, and cultivable lands, the majority of people move permanently (Islam et al., 2017). Riverbank erosion is a contributing factor to migration, as the following graph demonstrates that the majority of victims in the affected area have moved as a result of erosion.

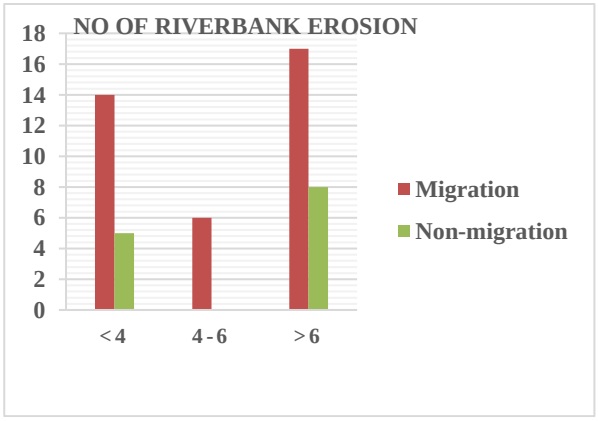

Figure 9: Number of Riverbank Erosion

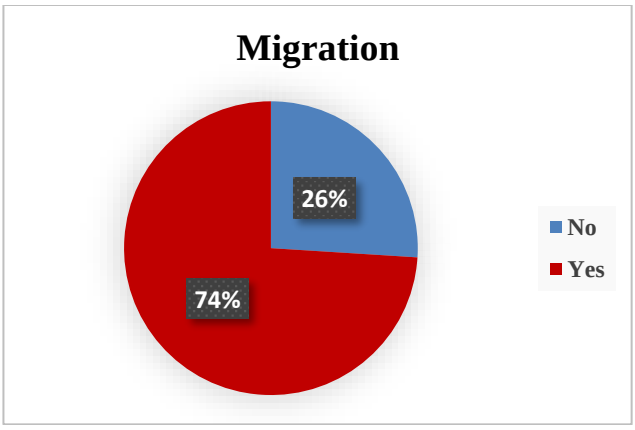

Figure 10: Migration due to erosion.

Understanding the interplay between riverbank erosion and migration involves considering various socioeconomic, demographic, and environmental factors. Key socioeconomic factors, such as occupation, farmland, and livestock, influence people's decisions to relocate when affected. Environmental issues, including natural disasters like riverbank erosion, impact these socioeconomic elements, leading to significant consequences such as the loss of cultivable land. This, in turn, affects food production, livestock populations, and the income sources of rural populations, compelling them to seek alternative means of livelihood, shelter, and sustenance. Additionally, demographic indicators like sex ratio, population growth, and literacy rates are also influenced by the impacts of riverbank. (Dekaraja & Mahanta, 2021)

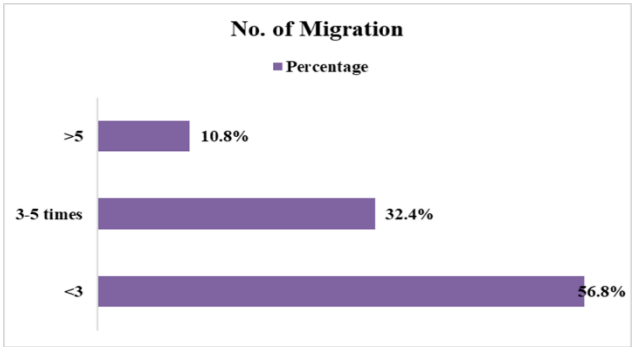

Figure 11: Number of Migration due to erosion

Our survey reveals that approximately 74% of people, a major part of that area have migrated due to riverbank erosion. Of them 56.8% of victims have migrated less than 3 times. These people have a deeper attachment to their homeland; they may not have the best option to relocate permanently to a safer location. Their livelihoods and way of life are centered around rivers; therefore, they are forced to remain near rivers. Initially, people relocate to nearby areas and seek employment to sustain their lives. These displacements mostly occur at the local level; as large-scale migration requires funds that individuals may not always have. As a result, they shift their homesteads and resettle in neighboring areas while being further

displaced by riverbank erosion, which is the cause of their frequent migration. It is seen that 10.8% of people have migrated more than 5 times and the rest 32.4% inhabitants have shifted their homestead 3-5 times This frequent migration hampers their educational attainment. Approximately 38% of the respondents replied that their children dropped out of schooling due to migration. Most of the time, people relocate after losing their house, and for that reason, their children cannot attend the same school. They are unable to continue their studies because of frequent movement. Riverbank erosion also impedes educational facilities in the study area, which is another major cause of school dropout.

After losing livelihood, homestead, and farmed land when people become destitute, they engage their children in work to fight against poverty. The literacy rate is extremely low in the study area, and riverbank erosion exacerbates the issue.

3.8. Change of profession

The effects of erosion have mostly changed the occupational pattern. People who lose ownership of their property are compelled to shift their homes and reside in other locations, especially closer to recently formed chars and embankments. They lose their source of earnings after being shifted. Consequently, they have to change their profession (Das & Samanta, 2022). It is found that 44% of people have changed their occupation due to erosion.

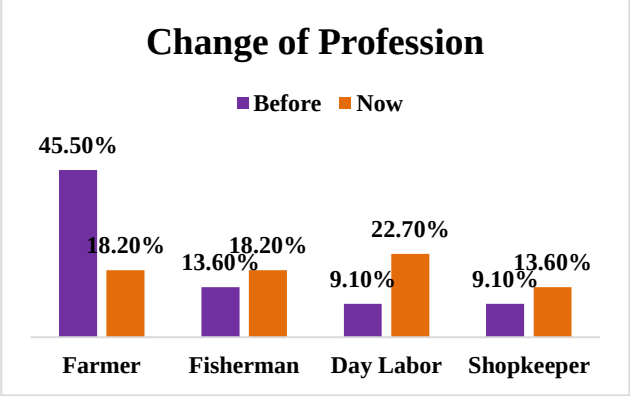

Figure 12: Occupational Change due to erosion in the study area.

From the graph, it can be seen that 45.50% of people were farmers before erosion, now the amount is only 18.20%. The major reason behind this change is the loss of farming land caused by river erosion. The decline in farmers and agricultural labourers is proof that migration and livelihood problems are on the rise. Farming families that have been relocated lose their familiar and major source of income (Das & Samanta, 2022). The number of fishermen, day laborers and shopkeeper have increased because victims shifted their occupation from the agricultural sector to other sectors. 76% of respondents reported that their income did not increase due to a change of profession, which means that their socio-economic conditions have not changed at all. From our study, we can see that river erosion changes occupation patterns because after erosion most people lose their farming lands and become helpless. This is the main reason for increasing non-farming activity, day labor etc in this place.

3.9. Land loss

The land is the most valuable resource of rural residents, which is destroyed by riverbank erosion. Land loss caused by riverbank erosion has long-lasting economic consequences, whereas the impacts of other hazards are temporary.

Most of the respondents have lost their land both agricultural and household lands, either totally or partially. As most people depend on agriculture, agricultural land is the most important resource for them, especially those who live in rural areas and on the side of the river. Due to the loss of household land, people lose their homesteads and become homeless. It is found that 88% of people have lost their agricultural land and 80% have lost household land, indicating a great economic loss in the affected area. Because more than 75% and 65% of people's farms and homes, respectively, were located within one kilometer of a river.

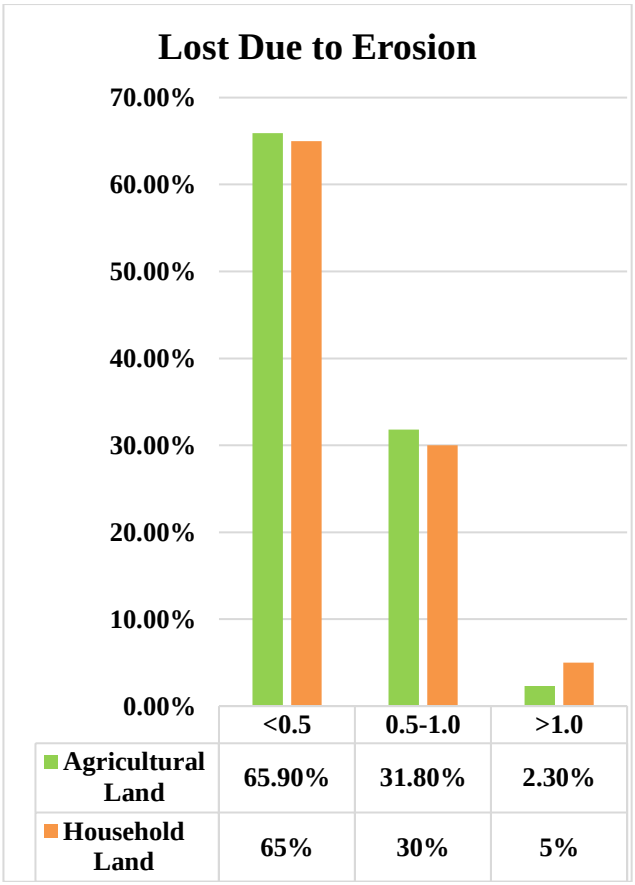

Figure 13: Lands loss due to erosion.

The above table shows the amount of lost land both agricultural and household due to river erosion. Approximately 65.90% and 65% of the total population lost less than 0.5 acres of agricultural and domestic land, respectively. 31.80% of the population lost 0.5-1.0 acres of agricultural land, while 30% lost the same amount of household land. The following table shows the distance from the river to affected lands due to riverbank erosion. Accreted lands, or "chars," continuously provide substantial amounts of new land for habitation and farming. However, living and working conditions in these newly emerging lands are harsh because they are poorly connected to the mainland and prone to severe erosion and flooding, making residents vulnerable. This is why, land less than one kilometre from the river is of poor quality. Most people have lost their agricultural and homelands since they were less than one kilometre from the riverbed.

3.10. Food availability

It means having enough food production from households, various domestic output, commercial imports or food assistance. Each of us needs food as a basic necessity, and the availability of food is a key indicator of social and economic development. Food availability depends on the level of income (Mustaquim, & Ismail, 2013). Riverine communities face difficulties with food availability as a result of riverbank erosion. This survey reveals that 50% of people faced trouble for getting food during erosion and 72% of respondents said that they have poor supplements of food. Because a major portion has lost their agricultural land and means of livelihood. So, it was very difficult for them to manage adequate food. Here, access to drinking water is easy, though it is a coastal area and rivers are contaminated by salinity. 62% of respondents reported that they had access to drinking water during erosion and the water source was a tube well.

3.11. Impact on health

River erosion affects the psychological, financial and social well-being of people who live near the riverside or bank line.

Riverbank erosion increases threats to human health both physical and mental well-being. Respondents stated that they have suffered different diseases from being displaced due to erosion. It is seen that around 44.9% people of in this area suffer malnutrition because of their low income and insufficient food availability. Approximately 43.5% of people have skin diseases due to the use of saline water, 4.3% of residents suffer from diarrhoea and 5.8% of people suffer from other ailments. It also hampers the mental health of affected people. 1.4% of people suffered mental problems owing to erosion. When asked about medical care, 96% of the respondents said they called the village doctor, while 4% received treatment from kobiraz.

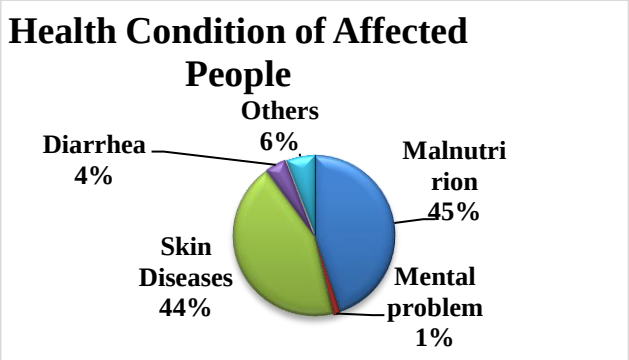

Figure 14: Status of health condition in the Affected Area

In the research area, only 2% of people get injured or die due to erosion, which is quite low. Despite its potential impact, riverbank erosion isn't considered a massive disaster due to its low death rate compared to earthquakes and cyclones.

3.12. Structural damage

River erosion may physically harm infrastructure by damaging structures, including roads, buildings, and other types of construction, which incur significant expenses. It is observed that besides agricultural and household land losses, other structural damages also occurred in the study area. 90% of respondents said that their locality had structural damage due to erosion. About 18% of people's residences have been damaged by river erosion. Roads in that area were the most affected, with around 37% of respondents agreeing. The transportation network plays a vital role in everyday economies as it facilitates trade and the movement of people. Transport infrastructure also plays an essential role in rescue and evacuation operations, in case of emergencies caused by extreme weather events. Therefore, damaging the road is a major loss for the people of Chairman Ghat, as it is the only route for getting in touch with the rest of the city. Other infrastructural damages include school buildings, health care and temples/mosques.

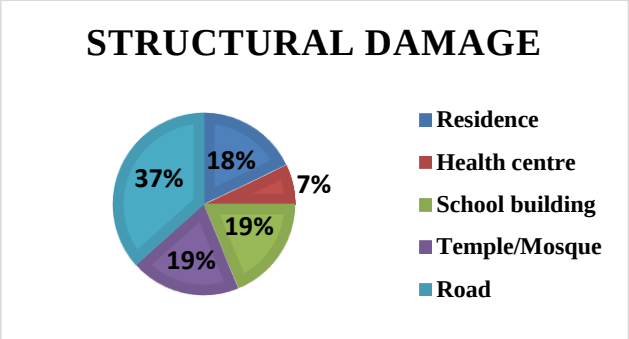

Figure 15: Structural damages due to erosion.

3.13. Relief and Benefits for Erosion

Relief services and facilities are available to river erosion victims, as shown in Figure. At around 85%, a

large proportion of residents received no help from the government or other NGOs. 13% received relief services and only 2% received govt. help. Recently, a small embankment of mud, clay, and bamboo was constructed to protect this area from tidal flooding and saline water intrusion. However, human settlements can be seen on both sides of the embankment. People living near the riverside are vulnerable to erosion and tidal inundation. Their residences become flooded during high tides. The government of Bangladesh has never placed a high priority on resettling families that have been impacted by erosion or who have been displaced. Families displaced by erosion live near embankments because they have no other option. As the embankment is not so strong and durable, it is likely to be damaged after a few years and needs to be repaired. As a coastal location, no government initiatives or measures are visible in this area to protect the land or the local people. This area is not well protected from erosion by any means.

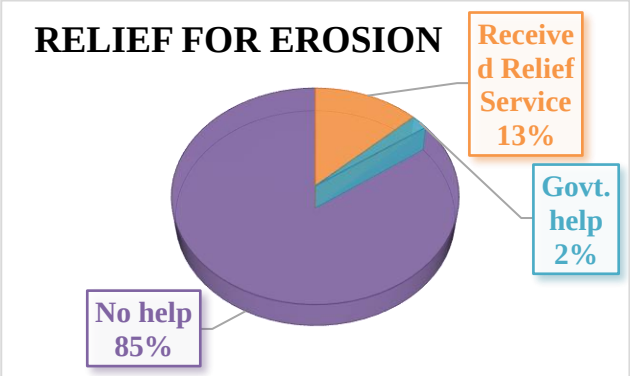

Figure 17: Relief and Benefit for Erosion

4. Conclusion

This study investigated the riverbank erosion dynamics in the Noakhali district, a coastal area exposed to the Bay of Bengal and prone to the forces of the Meghna estuary. By analyzing Landsat images from 2000 to 2022, we assessed the variation of riverbank erosion in Chairman Ghat. The findings revealed that the rate of eroding land was higher from 2000 to 2008 compared to 2015-2022 with a period of accretion observed from 2008-2015 over the last 22 years. The Meghna estuary region demonstrated a pattern of land accretion, but it was overshadowed by the significantly higher rate of erosion, a common phenomenon experienced by the inhabitants of this region. The consequences of riverbank erosion extended beyond displacement, impacting food security and health in the region. People faced difficulties obtaining food, leading to health risks and diseases such as malnutrition, skin diseases, and diarrhoea. Additionally, the erosion resulted in damage to households and infrastructure, including severely damaged roads. While it is challenging to completely prevent riverbank erosion as a natural catastrophe, we can mitigate its harmful effects through effective governance mechanisms. Adequate measures and support from the government and NGOs are essential to assist the affected population in times of crisis. Developing strategies for resilient resettlement and livelihood options can help alleviate the suffering caused by river erosion-induced displacement. Furthermore, proactive planning and early warning systems can help identify areas at risk and implement appropriate mitigation measures. Moreover, the tragedy and devastation brought about by riverbank erosion in the Noakhali district call for comprehensive and coordinated efforts from all stakeholders to protect the livelihoods and well-being of the affected communities. By prioritizing effective governance and implementing targeted interventions, we can reduce the adverse impacts of riverbank erosion and build a more resilient and secure future for the vulnerable populations in erosion-prone regions.

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