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Coastal Erosion and Accretion on the Island of Bhola, Bangladesh

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Coastal erosion is a significant and global issue. Bhola Island is vulnerable tocoastal erosion on the east and accretion on the north. With the help of Landsat image, GIS and remote sensing techniquesalongside the application of the Modified Normalized Difference Water Index (MNDWI) algorithm, the erosion and accretion rate of the Island of Bhola has been calculated. Over the 28 year time period, the approximate erosion and accretion rate is 3.85 km^2/year and 1 km^2/year respectively. Majority of the erosion and accretion occurred between 1996 and 2004.

Keywords: Erosion, accretion, Bhola Island, Coastal, GIS, Remote Sensing, MNDWI

1. Introduction

Coastal zones contain some of the world's most diverse and dynamic resources. They include extensive areas of complex and specialized ecosystems. Coastal zones are currently being progressively perceived as utilitarian regions facing escalated regular and anthropogenic unsettling impacts including ocean level ascent, seaside disintegration and sedimentation, and over-abuse of resources. At least 70% of coastlines around the world areprone to erosion (Bird, 1985).

In general terms,coastline is defined as the interface between land and water bodies at one instant in time. It is a strip of land and sea of varying width depending on the nature of the environment and management needs. It seldom corresponds to existing administrative or planning units. Coastal zones are continually changing because of adirect result of the dynamic cooperation between the seas and the land. Waves and winds along the coast are both eroding rock and depositing sediment on a continuous basis, and rates of disintegration and statement fluctuate significantly from everyday along such zones (Lavalle et al., 2011).

Bhola is the largest island of the country located in the most southern part of Bangladesh in the Bay of Bengal. It is surrounded by the Meghna River on the north and east, the Tetulia River on the west and the Bay of Bengal on the south (Salam et al., 2003). The island of Bhola is very flat, the highest peak is around 3 meters above

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the sea level. There are some hills on the island, but many of these are man-made, for example, embankments, roads, pond etc. The northern part has more hills than the southern part of the island. This could be a result of the erosion and accretion.

2. Literature Review

Determination of coastal erosion can be done from satellite imagesusing Modified Normalized Difference Water Index (MNDWI) algorithm. Ghosh, Kumar& Roy (2015)in their research, utilized integrated techniques of remote sensing and geographic information system (GIS) to monitor coastline changes ofHatiya Island, Bangladesh from 1989 to 2010. Their results showed that erosion andaccretion processes played an active role in the changes of the coastline of Hatiya Island. Krantz, M. (1999) studied coastal transformations and its influence on the people of the island of Bhola. His results showed a total erosion of 7.5 to 10.4 centimeters during the field studyof over 24 days and 68.4 meters/year or 4.3 km^2 over 5 years. Theaccretion was 20.9 km^2 during the same period. So it is clear that for Bhola Island the erosion is much higher than the accretion.

According to Xu, H. (2006) the modified NDWI (MNDWI) can improvewater features while proficiently suppressing and even removing built-up land noise as well as vegetation and soil noise. The enhanced water information using the NDWI is often mixed with built-up land noise and the area of extracted water is thus overestimated. Therefore, the MNDWI is more appropriate for enhancing and extracting water information for a water region with a background dominated by built-up land areas because of its advantage in reducing and even removing built-up land noise over the NDWI.

The unique geographic location, low topography, relatively higher population density as well as overwhelming dependence on natural resources made Bangladesh one of the most vulnerable countries exposed to the impacts of global warming and climate change. Climate change and its undesirable adverse outcomes resulted to storm surge, flooding and erosion (Islam, 2015).Shamsuddoha (2007) addressed these problems for coastline erosion and suggested capacity building alongside infrastructural measures for solving the situation at hand.

3. Methods

3.1 Study Area

Bhola Island is the largest island of Bangladesh with an area of 1441 km^2. Geographical coordinates of Bhola Island (WGS84): (lat.): 22° 41' 0" N (22.6833), (long.): 90° 39' 0" E (90.65). Most of the land area of Bhola District is under the administrative rule of Barisal Division. It is situated at the mouth of the Meghna River. The Island is 130 kilometers (81 miles) long and has a population of 1.7 million. The shape of Bhola Island is

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elongated because of erosion by the Meghna River. It is only 6 feet above ocean level at the most elevated point (Doyle, 2015).

The Island of Bhola is situated in an area categorized as estuarine floodplains. Estuarine floodplains contrast from meander floodplains in being practically level, lacking meander scars and abandoned channels, and having almost uniform side and vertical silty deposits. There are a couple of minor streams, but most of the drainage of older landscapes are affected through manmade canals (khals). Tidal creeks are confined to the seaward margins of young estuarine formations (Brammer, 1996).

The soil of Bhola Island is a calcareous alluvium. It is saline in nature because it is seasonally flooded, poorly drained and settled in very young medium textured deposits. It occurs comprehensively on the young lower Meghna Estuarine floodplain (Brammer 1996).

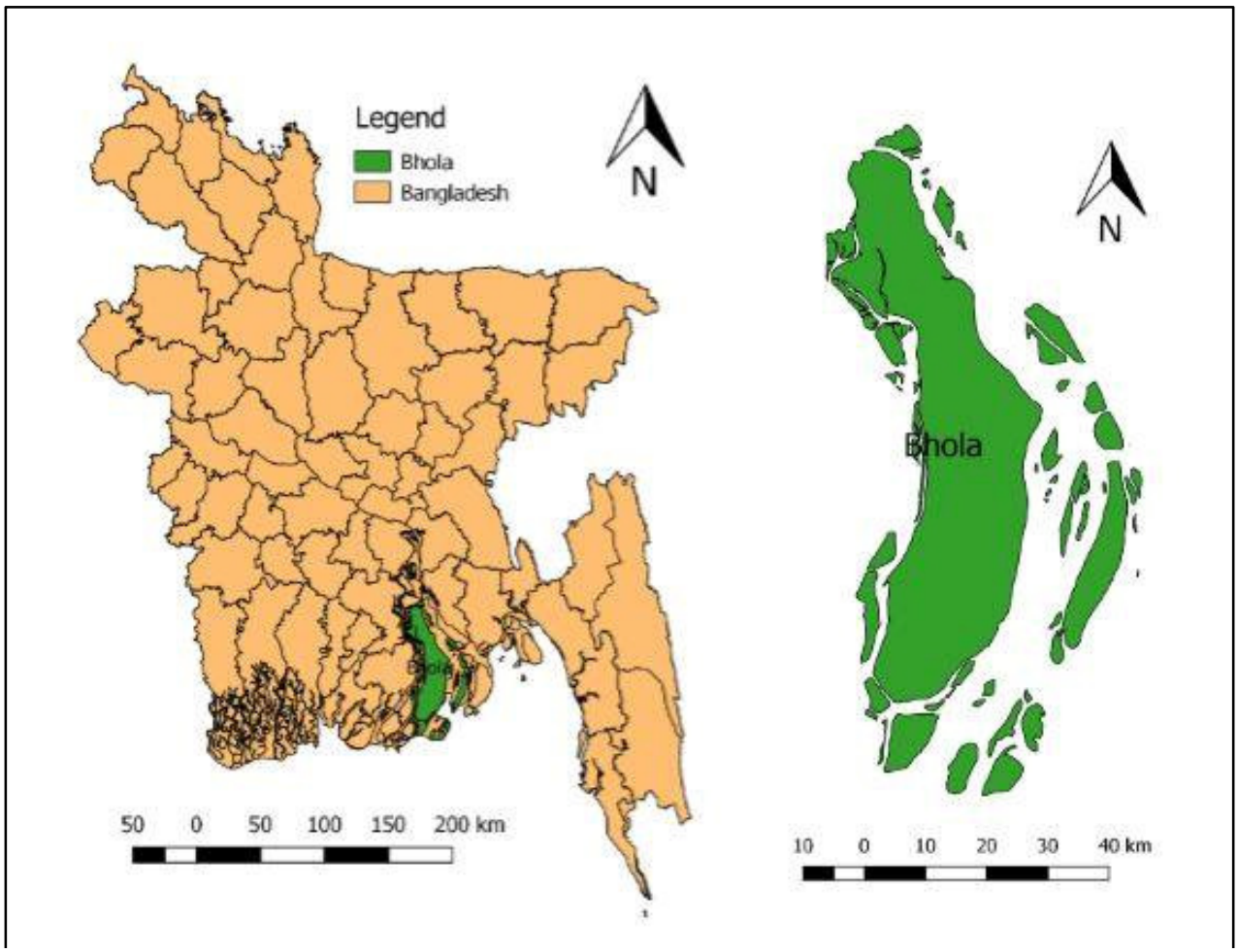

Figure1: Location of the Island of Bhola

ISBN: 978-1-925488-52-4

3.2 Image used

Images for Bhola were collected during the month of November, due to low cloud cover disrupting the image. The images were collected for the year 1989, 1996, 2004, 2010 and 2016. Landsat 5 TM image files were used for all the years, with the exception of 2016 for which the Landsat 8 OLI was used. The Landsat images for the Path: 137, Row:44 and Path:137, Row:45 were implemented. These images were projected to World Geographic System 84 (WGS84).

3.3 Image Processing

The Landsat images for each year were initially merged to cover the entire island of Bhola, as it falls into both images. The Modified Normalized Difference Water Index (MNDWI) from Landsat image was calculated using the formula:

$$MNDWI = (\rho_{Green} - \rho_{SWIR}) / (\rho_{Green} - \rho_{SWIR})$$

Where ρ_{Green} represents the surface reflectance of the green band and ρ_{SWIR} represents the surface reflectance of the short wave infra-red (SWIR) band (Singh et. al, 2015).
The MNDWI allows the land and water bodies to be separated into distinct values. The water surface tends to have positive values, where the land surface has negative values. Since the purpose of this study is to separate Bhola (i.e. land), the negative values are extracted. The same process is repeated for all time periods. Thus, the shapefiles of Bhola is generated for the aforementioned years.

3.4 Change Detection

The shapefiles of the different periods are used to estimate the erosion and sedimentation occurring on Bhola. To locate the extent of erosion, the landmass of Bhola in a subsequent year must be erased from that of a previous year. On the other hand, to distinguish the accreted area, the landmass of a year must be erased from that of a subsequent year.

The erosion and accretion of the Bholawere distinguished in two different ways for the purpose of the study. One way is to take 1989 as the base year and find the erosion and accretion of the others with respect to 1989. The other way is to find the erosion and accretion that takes place between two consecutive chosen periods.

In the first method, all the other years are paired with 1989. The output of this process illustrates the cumulative effect of erosion and accretion on Bhola throughout the years. For the second method, the erosion and accretion of the pairs 1989-1996, 1996-2004, 2004-2010 and 2010-2016 were computed. This erosion and accretion within these years display the rate at which erosion and accretion are occurring.

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The maps generated from these procedures also show the areas where erosion and accretion are taking place, which may help to understand the landform change dynamics and detect areas that need to be managed.

4. Results

This section contains the analysis regarding the erosion and accretion of Bhola Island. The most dominant eroding and accreting location are analyzed in detail.

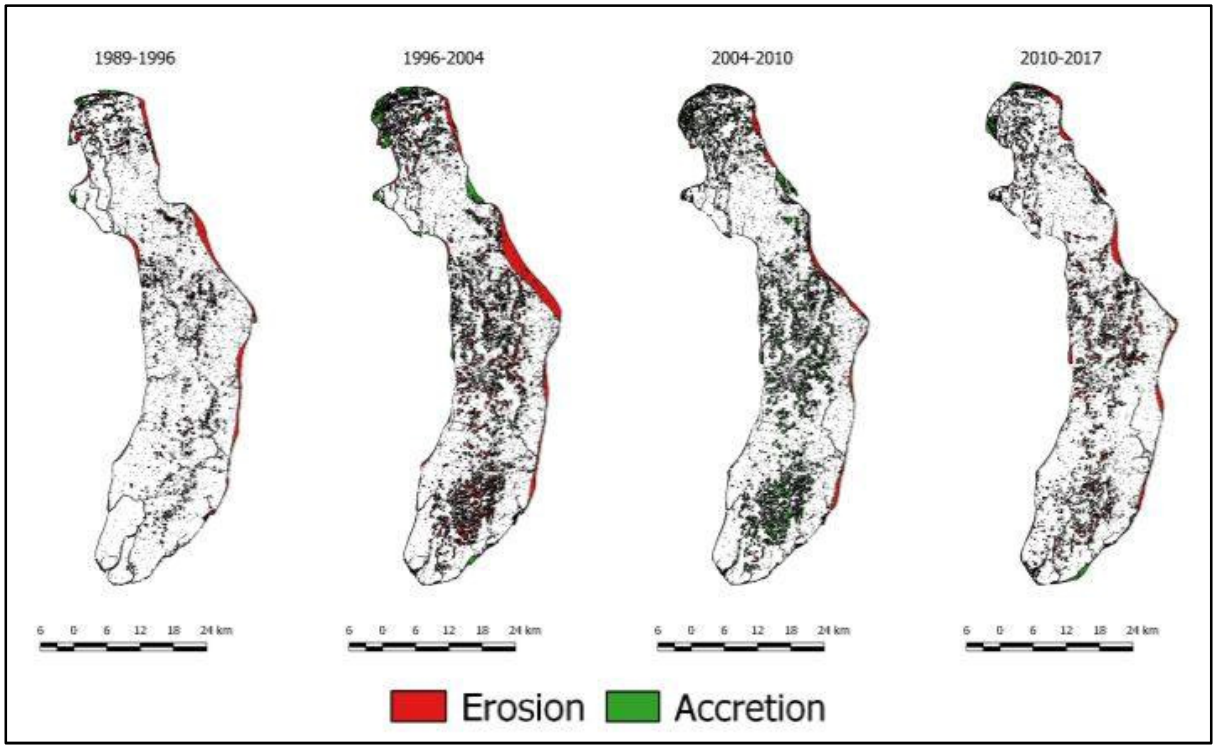

Figure 2: Erosion and Accretion between two consecutive selected years

From the study of erosion and accretion on the Bhola Island, the accretion seems to be insignificant in comparison to the erosion. The erosion seems to be mostly occurring on the east. Majority of the erosion seems to take place between the years 1996-2004, happening in an unceasing manner at varying rates. The accretion seems to be the greatest between 1996 and 2004 as well, on the northern boundary of Bhola.

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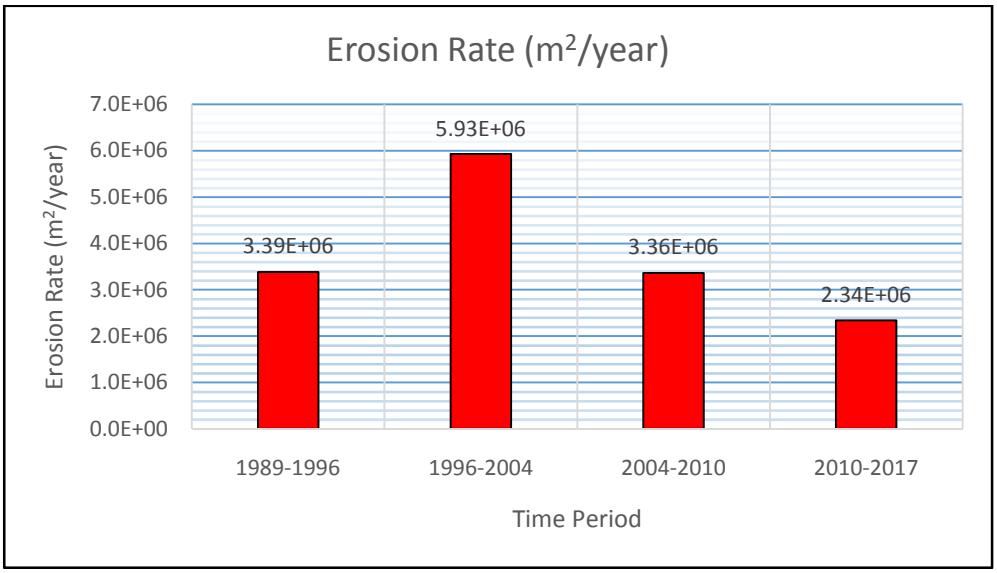

Figure 3: Erosion Rates on the Eastern Side of Bhola

The erosion rate on the east is between the years 1996 and 2004 with a high value of 5.93 km^2/year. This may be assumed to be the average erosion rate for Bhola as themajority of eroded region is accounted for. Whereas, the average erosion rate of Bhola is 3.85 km^2/year. Though it seems that the erosion rate seems to be reducing with time (Figure 3).

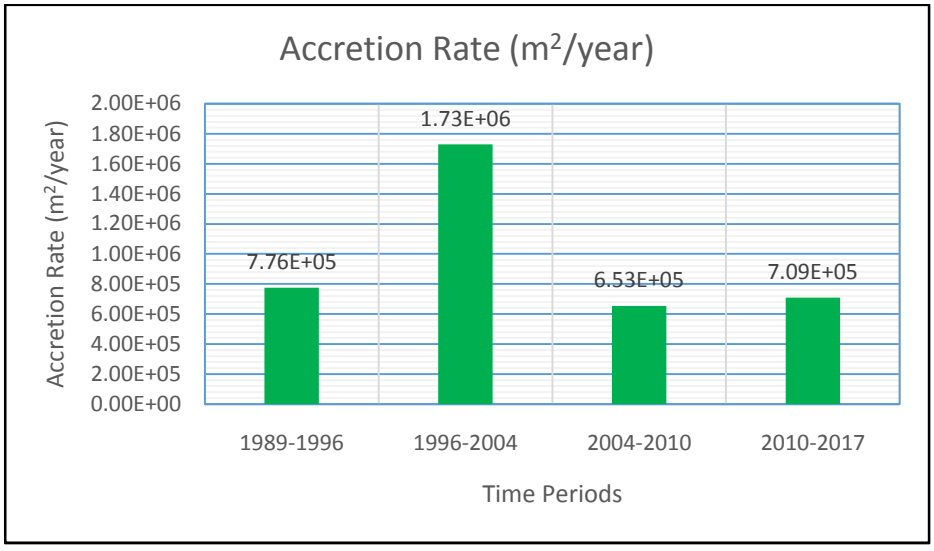

Figure 4: Accretion Rates on the Northern Side of Bhola

The accretion rate on the north is between the years 1996 and 2004 with a high value of 1.73 km^2/year, which is 0.13% of the total area of Bhola at present. Whereas, the average accretion rate of Bhola is 1 km^2/year. This may be assumed to be the average

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accretion rate for Bhola as themajority of the accretion is accounted for. The accretion rate is relatively constant and the time period 1996-2004 may a rare situation (Figure 4).

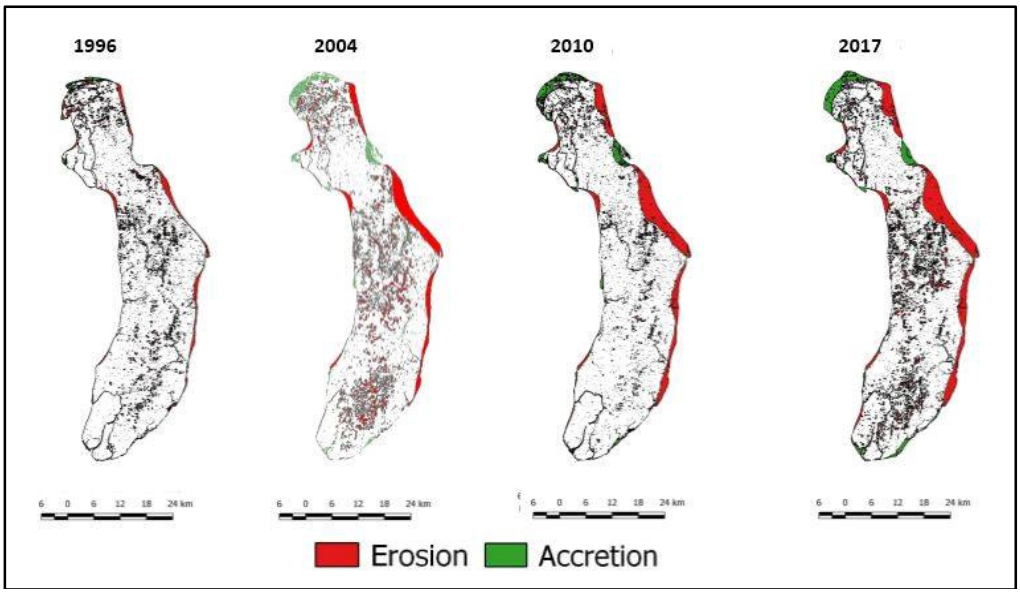

Figure 5: Cumulative erosion and accretion on Bhola for different years with respect to 1989.

In the figure above, the cumulative erosion and accretion are more noticeable. It illustrates that the boundary on the east side of Bhola is still eroding, and erosion is greater than accretion. The main accretion occurs on the northern boundary of Bhola. There is also some minor accretion on the Upper East side of Bhola. According to the calculations, about 7.47% and 1.95% of the current area of Bhola has eroded and accreted respectively.

Overall, it seems the erosion and accretion occurred excessively between 1996 and 2004, and even though it has reduced to some extent now, it should be properly managed in order to prevent any future problem.

5. Discussion

Coastal erosion has huge socio-economic consequences and causes migration of people from affected areas. In the case of the island of Bhola, the effects of the erosion are quite significant. Erosion depends on the different vegetation cover, shoreline slope gradient, soil compaction and the grade of influence by human beings. Poverty causes the incompetent to migrate to areas that are not vulnerable to coastal erosion.

From the results shown above, it is certain that from the year 1989 to 2017, the cumulative quantity of erosion is increasing as well as accretion, but the rate of erosion

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is much higher than accretion, which could result in aserious socio-economic problem for the local population as well as environment.

There are very few initiatives taken to stop the erosion in the Bay of Bengal region especially for the island of Bhola. In the end of the fifties, the government of Bangladesh built a cross-dam between the Noakhali mainland and Ramgati Island to protect the island from erosion. This initiative is successful as accretion occurred making the island bigger in size (Alam, 1996). There have been some thoughts in the eighties about a cross-dam between the Island of Bhola and the mainland nothing much has happened with this cross-dam since.

6. Conclusion

Bangladesh being one of the highly populated countries with 1115 people living in per square kilometer and a riverine country, its people are vulnerable to riverbank and coastal erosion. The country is agricultural and very reliant on farming and fishing, causing a major part of the population to live in the coastal area and near the rivers. As a result when erosion occurs, loss of agricultural land results in devastating effects. The Island of Bhola is an ideal representative of this situation. The aim of this study was to investigate coastal erosion and accretion process on the Island of Bhola over the year 1989 to 2017. In the results, it is seen that the rate of erosion is much higher than accretion resulting a serious effect on the inhabitants' socio-economic condition. There is hardly any government initiative to stop the erosion. There are some NGO-ventures going ahead, on the Island of Bhola at the present time, however, it will take quite a long while before the outcome can be perceived. There are no answers for managing these issues currently, ideally something will happen soon.

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