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Morphological Changes of the Offshore Islands of Western Part of Meghna Estuary over the Years

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Meghna Estuary is one of the most dynamically deforming estuaries on earth. The present study focuses on the morphological changes of the offshore islands of western part of Meghna estuary over a time span of 1993 to 2017 based on the satellite images of the study area collected from USGS website. Then using ArcGIS 10.2.2 the images of 1993, 2002, 2007 and 2017 were digitized and the changes of morphology were analysed. It has been found from the analyses that net area of concerned islands increased gradually over 24 years of time at the rate of 3.19 Sq. Km. per year. Highest deposition occurred during 1993-2002 period (103 Sq.Km.). Highest erosion occurred during 2007-2017 period (64.7 Sq.Km.). It showed a sign of declination in net accretion in the later portion of the study period. It has also been found that the major islands like Hatiya and Monpura are shifting in south direction. This dynamic nature of our study area have significant impacts on the local community and so proper planning and a decent amount of investment are required to make these morphological changes working in our favour.

1. Introduction

1.1 Background of the study:

An estuary is a partially enclosed coastal body of water with one or more rivers or streams flowing into it, and with a free connection to the open sea (Pritchard 1967). Estuaries form a transition zone between river environments and maritime environments. They are subject both to marine influences such as tides, waves, and the influx of saline water and to riverine influences such as flows of fresh water and sediment. The inflows of both sea water and fresh water provide high levels of nutrients both in the water column and in sediment, making estuaries among the most productive natural habitats in the world (McLusky& Elliott 2004).

The banks of many estuaries are amongst the most heavily populated areas of the world, with about 60% of the world's population living along estuaries and the coast. As a result, many estuaries suffer degradation by many factors, including sedimentation from soil erosion from deforestation, overgrazing, and other poor farming practices; overfishing; drainage and filling of wetlands; eutrophication due to excessive nutrients from sewage and animal wastes; pollutants including heavy metals, polychlorinated biphenyls, radionuclides and hydrocarbons from sewage inputs; and diking or damming for flood control or water diversion (Wolanski 2007, *Silva* et al. 2017).

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Meghna Estuary is located in the south of Bangladesh and is one of the most dynamically deforming estuaries on the earth. The Ganges, the Brahmaputra, and the Meghnajoin together and find their way to the Bay of Bengal through Meghna Estuary. These rivers have enormous catchment area and, consequently, huge amount of sediment is carried and flowed into Meghna Estuary, especially during the monsoon due to heavy rainfall. It results in high accretion rate in this area. Moreover, coastline is being eroded by strong waves from the Bay of Bengal. These strong accretion-erosion processes have significant influence on the shape of coastlines of Meghna Estuary.

The process of land accretion is dominant in the region of the Meghna Estuary. About one fifth of the original supply of 1,100 million tons is retained in the Meghna Estuary and forms the material for land accretion in the central part of the coastal zone (de Wilde 2011). This area is also subject to natural disasters, e.g. floods, cyclones and storm surges.

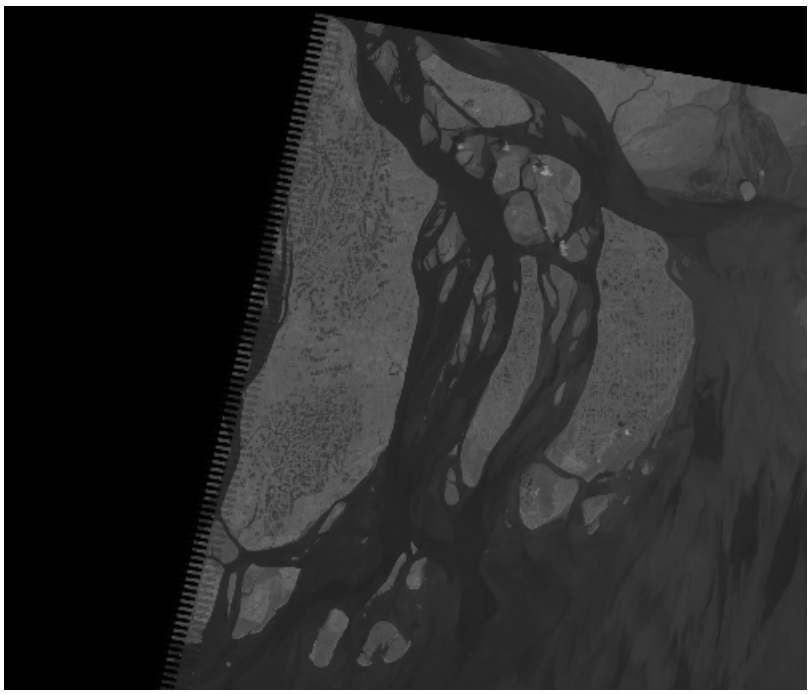
In this study we wanted to assess the morphological changes of specifically of offshore islands of Meghna estuary. Details findings are discussed in the result section.

Section 1 of the paper deals with Introduction and Section 2 discusses the general characteristics of the study area. Section 3 focuses on Literature Review and Section 4 contains Data Collection and Methodology. Results are provided in Section 5 and Discussions & Conclusion in the Section 6.

1.2 Study Area:

The area under this study covers the offshore islands of the western part of Meghna Estuary (Fig-1).

Figure 1: Study Area: Offshore Islands of Meghna Estuary (West part)



1.3 Objectives of the Study:

The main objectives of the study are-

1. To determine the situation of the change of morphology of the study area over the years in terms of area changedand shifting of the area.
2. To asses general characteristics of the study area.
3. To find out the possible impacts of these changes on the locality.
4. To find out the possible solution/management of the problem.

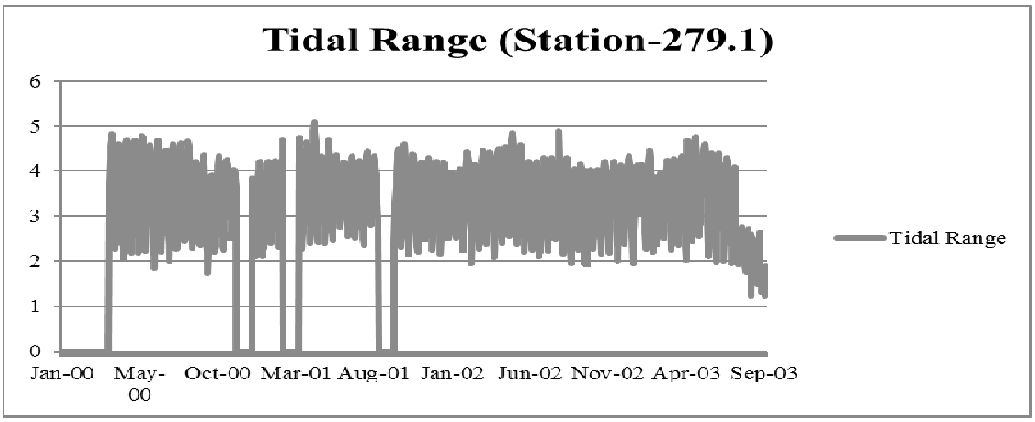
2. General Characteristics of the Study Area

To understand any problem it is necessary to understand the characteristics of the area. Here is some general characteristics of the study area.

2.1 Tidal Range:

Previous studies show that the maximum tidal range of the area varies from 4m to 4.5m along the area. Fig-2 shows the tidal ranges of Char Fasson station (Station-279.1).

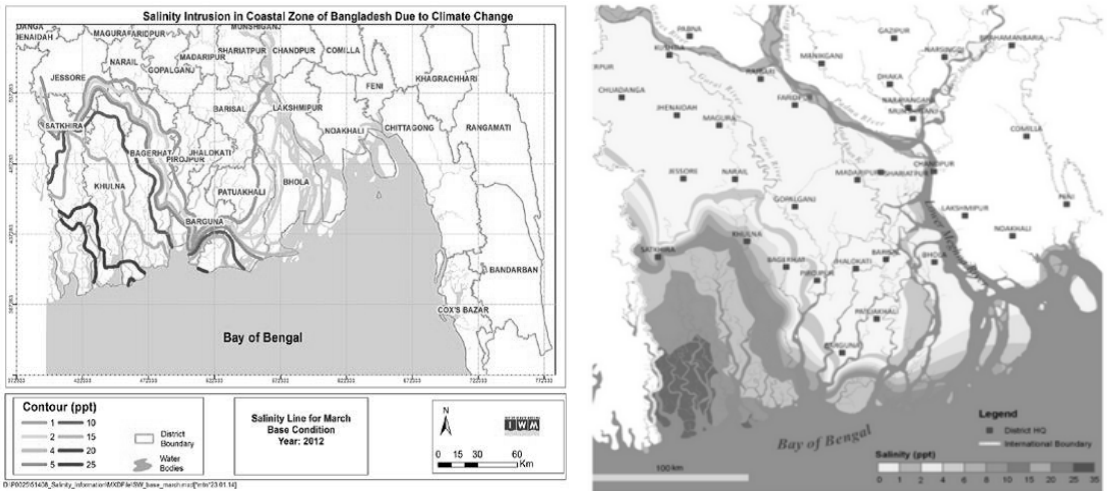
Figure 2: Tidal Range (Char Fasson station : Source WAARPO)



2.2 Salinity:

Due to the huge inflow from Lower Meghna River, the salinity is significantly lower than the usual salinity values of the other coastal zones of Bangladesh. Study shows that the study area falls under the region of 2 ppt to 6 ppt in general (Khan 2012).

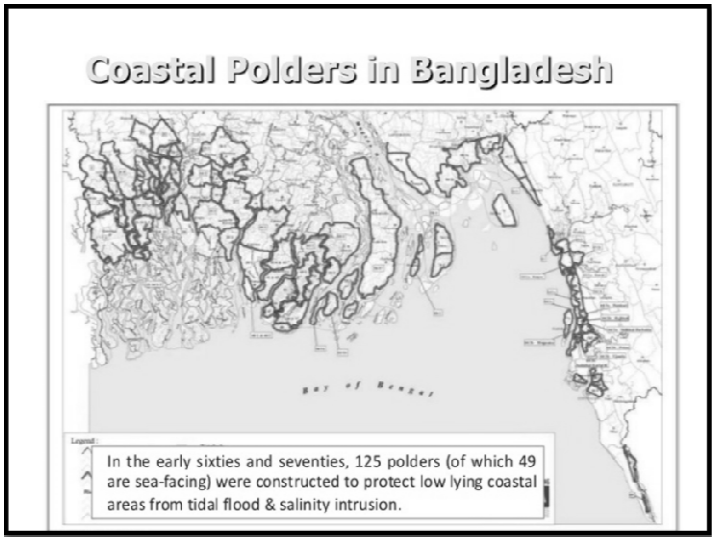
Figure 3: SW salinity Coastal Region in March 2012 (Source: IWM)



2.3 Polders:

The major two islands of the study area are Hatiya and Monpura. Both are polder protected. But rests of the island of the area are not.

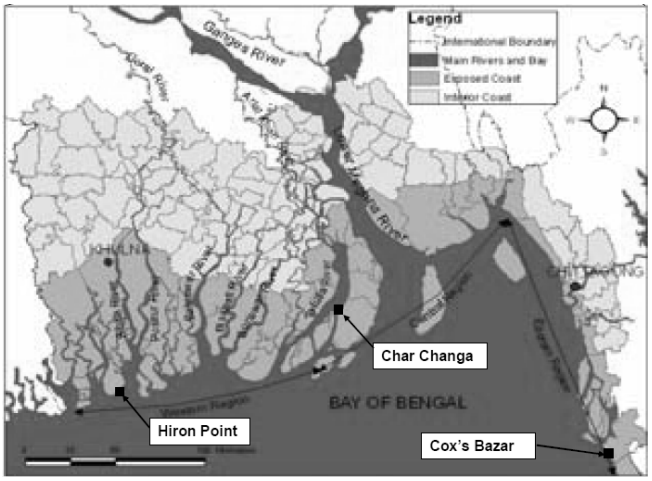
Figure 4: Locations of Coastal Polders (Source: IWM).



2.4 Sea Level Rise:

The SAARC Meteorological Research Council (SMRC) carried out a study on relative sea level rise in the Bangladesh coast based on the measured water level for 22 years (1977 to 1998) at three gauge stations(Hiron Point, Char Changa, Cox's Bazar) (SMRC 2003). The study shows that the SLR of this period is about **6 mm/yr** at Char Changa station (which is near our study area).

Figure 5: Location of Hiron point, Char Changa and Cox's Bazar.



3. Literature Review

A number of studies have been performed on various parts of Meghna Estuary and surrounding areas. Some of the studies put emphasis on very local scale and some on more broad scale. The findings of different studies also vary depending on method of analysis and time frame of the study.In this section findings of some of the previous studies have been analyzed.

3.1 Rates of Shoreline Change along the Coast of Bangladesh (Sarwar & Woodroffe 2013):

There has been a recent research on Rates of shoreline change along the coast of Bangladesh bySarwar, M. & Woodroffe, C. D. (Sarwar & Woodroffe 2013).They reported a systematic assessment of rates of shoreline change over a 20-year period from 1989 to 2009, using Landsat satellite images with pixel resolution of 30 m on the ground.

Figure 6: Intensity Shoreline Change from the Analysis

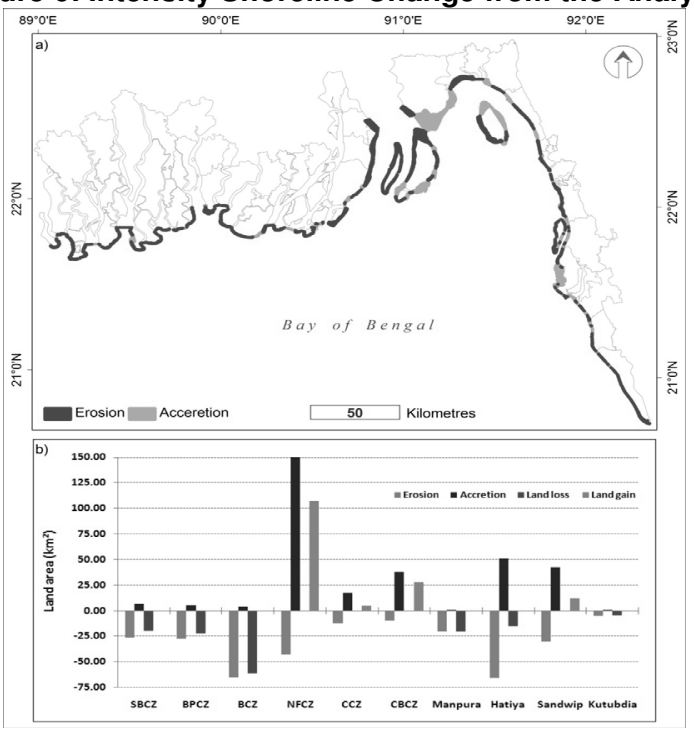


Table 1: Length and Change in Area along the Shoreline of Bangladesh, 1989 to 2009

Shoreline	Length in 1989 (km)	Length in 2009 (km)	Change in shoreline (km)	% change
Shoreline of mainland	823.70	845.24	21.54	2.62
Manpura	73.66	66.69	-6.97	-9.46
Hatiya	128.07	144.15	16.08	12.56
Sandwip	65.04	78.16	13.12	20.17
Kutubdia	49.40	46.61	-2.79	-5.65
Total	**1139.87**	**1180.85**	**40.98**	**3.60**

The study showed that Islands in the Meghna estuary were especially dynamic; Hatiya Island accreted along some of its shoreline by 50 sq. km between 1989 and 2009, but lost 65 sq. km through erosion elsewhere, resulting in the island moving south. Similar trends were observed on adjacent islands. Table-1 shows the details results of the study.

3.2A Study of Morphological Changes in the Coastal Areas and Offshore Islands of Bangladesh using Remote Sensing (Alam & Uddin 2013):

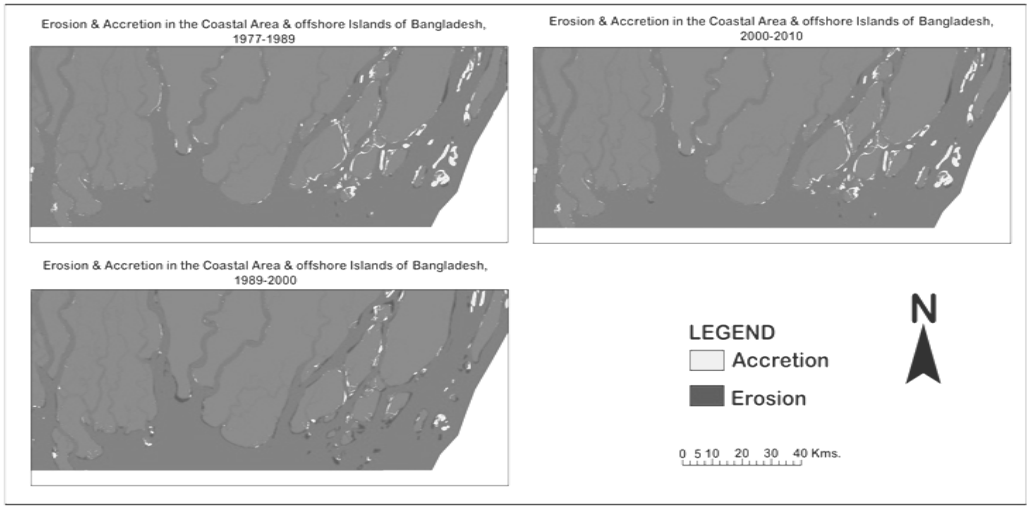
Another similar study was performed by M. Shamsul Alam & Kabir Uddin (2013) on morphological changes in the coastal areas and offshore islands of Bangladesh. They used remote sensing technique to find out the erosion and accretion from 1977 to 2010. Table-2 shows the detailed findings of the study.

Table 2: Erosion and Land Accretion in the Coastal and Offshore Islands Areas of Bangladesh, 1977-2010:

Erosion and Accretion	1977-1989	1989-2000	2000-2010	Total
Erosion in sq. km.	92	269	130	491
Accretion in sq. km.	359	74	197	630

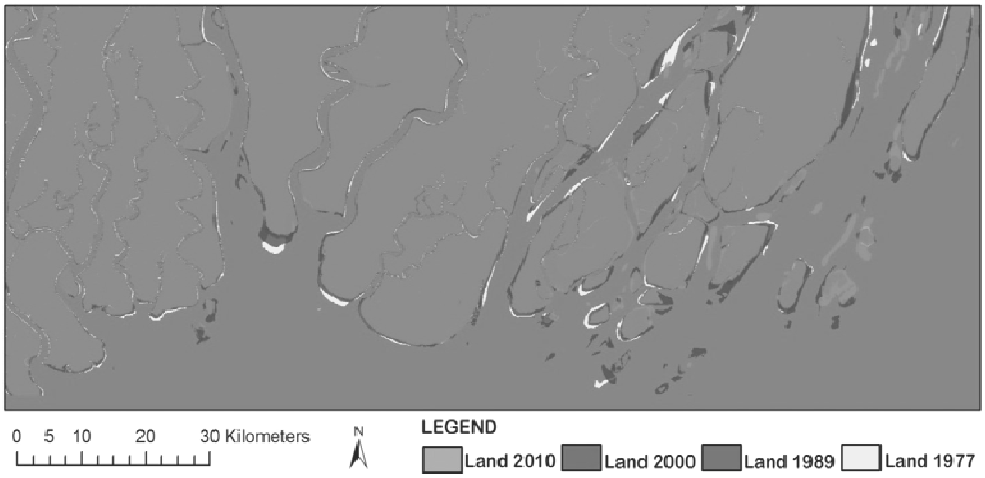
Following figure shows the details erosion and accretion of the study area from 1977 to 2010.

Figure 7: Erosion and Accretion in the Coastal Areas of Bangladesh, 1977-2010 Period



Finally figure-8 shows the morphological change of the study area from 1977 to 2010.

Figure 8: Morphological Changes in the Coastal Areas of Bangladesh, 1977-2010



4. Data Collection and Analysis

4.1 Data collection

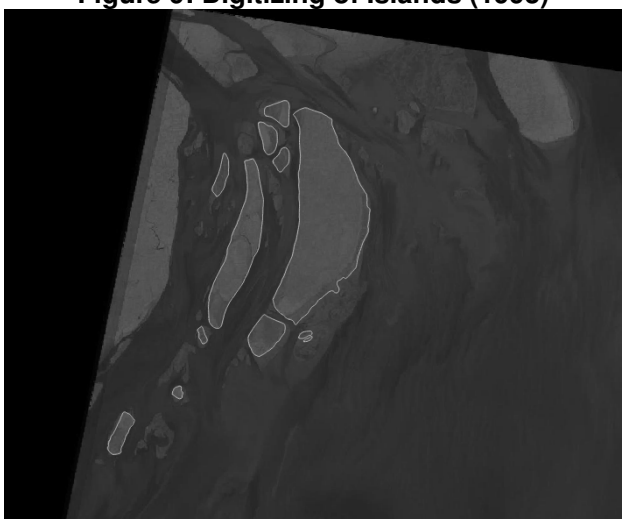
Satellite images of the study area were collected from USGS website (U.S. Geological Survey 2017) from the year 1993 to 2017. Images of 1993, 2002, 2007 and 2017 have been used for this study. To maintain uniformity the images from late January have been used.

4.2 Methodology

Application of GIS tool is the most efficient and reliable method of analyzing morphological changes of any river or coastal system. So for this study ArcGIS-10.2.2 had been used to analyze the images collected from USGS.

The basic method was simple. The collected images from USGS were already Georeferenced (WGS 1984). The coordinate system was transformed from WGS 1984 to BTM. Then the islands were digitized using ArcGIS tool.

Figure 9: Digitizing of Islands (1993)



Repeating the same procedure the images of 1993, 2002, 2007 and 2017 were digitized. Then using the ArcGIS 10.2.2 the changes of morphology were analyzed. It should be noted that the areas of permanent vagitation were considered only, meaning that the areas which were shallow and become submerged for a time were kept out of consideration.

5. Results

In this study the morphological changes were analyzed from two different angles. The first one is in terms of changed area. That includes the eroded and deposited area of the islands.

The second one is the shifting of the major islands like Hatiya and Monpura etc. The aim was to compare the result with the previous studies.

5.1 Changes in Terms of Area:

The analysis shows that net area of the concerned islands increased gradually over 24 years of time. Table-3 and Table-4 show the details of the findings.

Table 3: Net Area of the Islands over the Year

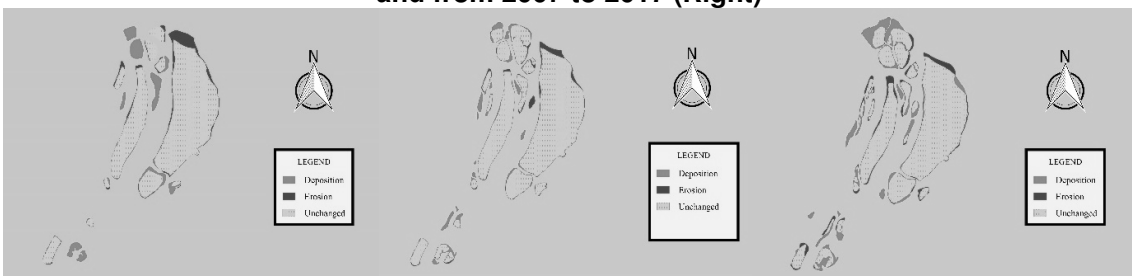
Year	1993	2002	2007	2017
Area (Sq. Km.)	647	693	709	741

Table 4: Net Erosion and Deposition of the Study Area

Year	Erosion (Sq. Km.)	Deposition (Sq. Km.)
From 1993 to 2002	57.5	103.2
From 2002 to 2007	41.9	58.1
From 2007 to 2017	64.7	96.7

Following figures show the details of the finding.

Figure 10: Morphological Changes from 1993 to 2002 (Left), from 2002 to 2007 (Middle) and from 2007 to 2017 (Right)

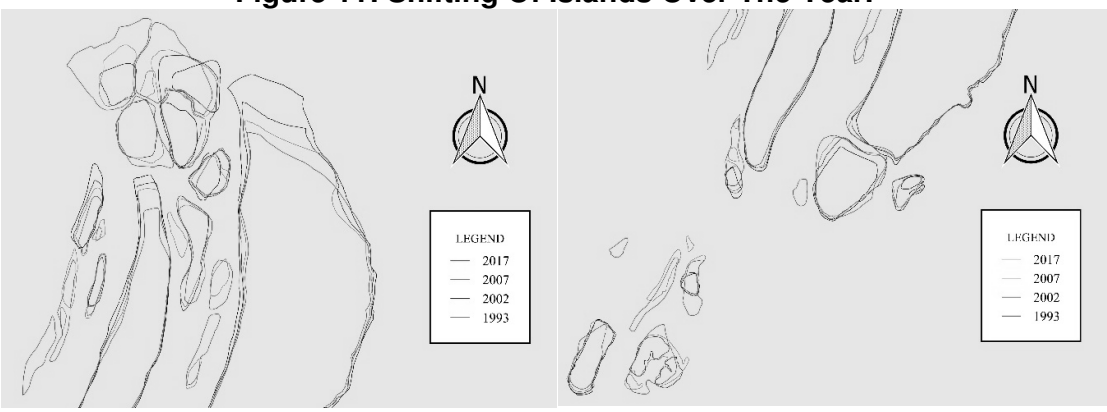


This findings are very similar to the findings of previous studies. The eroded and deposited area are also in a similar location.

5.2 Changes in terms of shifting islands:

The study shows that the major islands like Hatiya and Monpura is shifting in south direction due to the constant erosion and deposition over the years.

Figure 11: Shifting Of Islands Over The Year.



This finding is also similar to the previous studies.

6. Discussions and Conclusion

6.1Impacts of Morphological Changes:

We can clearly see the dynamic nature of the Meghna Estuary and its offshore islands from this and previous studies. These changeshave significant impacts on the local community or the locality. Followings are some of the impacts in brief-

- Constant erosion and deposition makes it difficult for human settlement in some portion of the study area.
- Though the net area is increasing over the years. The newly emerged lands are not suitable for agricultural purpose for a long time due to lackof fertility and high salinity.
- These changes sometimes force huge investment on protection works which adds pressure to the economy.

6.2 Management of the problem:

Through proper planning and decent amount of investment we can make this changes working in our favour.

- It is possible to accelerate the deposition rate and reclaim huge amount of lands through some land reclamation projects. Submerged breakwater and cross dams can play a key part in this.
- Some portion of offshore islands can be connected to mainland through land reclamation in 20 to 30 years of time if planned properly.
- Whatever step we take, it should be kept in mind that GBM basin supply huge amount of water and sediment through Lower Meghna River to the system. So it won't be wise to go totally against the fury of nature.

6.3 Conclusion:

The findings of this study can be helpful in future projects involving these islands. As it has been found that this area is prone to massive deposition and shifting, any land reclamation or land improvement project should keep these factors in mind.

The main difference with other studies involving this area is that majority of them are based on specific islands or overall coastal zone. But in this paper, major islands of Meghna estuary and surrounding small islands were also studied.

The image quality before 1990s was sometimes not up to the mark. This was a major limitation of this study.

6.4 Recommendation:

For any future studies, it is recommended to use better quality images if possible. Similar studies on some other area are also possible in the future.

In this study morphological change from 1993 to 2017 has been studied. Further studies from 1960s to date are advised for better understandings of the morphological changes.

Shorter interval of analysis (like 5 year or 3 year) is also recommended to understand the overall erosion and deposition correlation or pattern.

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