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EROSION ACCRETION ASSESSMENT OF KUAKATA BEACH USING HISTORICAL SATELLITE IMAGERIES AND BATHYMETRY DATA ADOPTING RS-GIS TECHNIQUE

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ABSTRACT

This study work has been conducted for erosion and deposition analysis of Kuakata beach and quantifying eroded and accreted volume using bathymetry data through remote sensing and GIS technique. Satellite images of coastline during the period of 1978 to 2020 have been collected and analyzed using ArcGIS software. 24 km long Kuakata beach is subdivided into three parts like Lebur Char (13 km), Gangamatir Char (4 km) and Kawar Char (7 km) stretching from west to east. From Satellite image analysis, it is evident that Lebur Char (west part) is vulnerable to erosion, middle part of the Kuakata beach i.e., Gangamatir Char is almost stable, and Kawar Char (east part) is accreting day by day. It is seen that 13 km long coastline has been eroded having an area of 4.8 km^2 and 7 km coastline has been accreted having an area of 3.7 km^2 has been accreted in last 42 years. During this period the average erosion rate and accretion rate are 9 m/yr and 12.2 m/yr respectively and for last it was 10 years 11.7 m/yr and 21.2 m/yr respectively. Coastline evolution model has been simulated over the year 2010 to 2018 for erosion prone area of Kuakata. It is observed that coastline is moving towards land with time. Erosion rate found from the model also conforms the result of coastline shifting analysis by GIS.

KEYWORDS: Beach Erosion, Satellite images, GIS, Coastline shifting, Erosion accretion.

INTRODUCTION

The Bay of Bengal (BoB) is bordered by eastern coast of Srilanka and India on the west, Bangladesh coast to the north, western coast of Myanmar (formerly known as Burma) and northwestern part of Malay Peninsula to the east (Uddin et al., 2014). There is a submarine canyon, also known as swatch of no ground, in the central northern part of the BoB. Coastal zone of Bangladesh is located in the northern part of BoB. There are 19 districts in the coastal zone. Coastal zone of Bangladesh is very important due to biodiversity and economic aspects (Islam and Ahmad, 2004).

Coastal erosion is one of the big challenges in Bangladesh. Many reasons are responsible for coastal erosion, among them strong tidal current, wave action, cyclonic storm surge and human interventions are prime reasons. Erosion has been happening in some places along the coastline of Bangladesh. Kuakata is one of those. There has been happening erosion along the main beach of Kuakata for last decades. This study has been conducted to analyze and assess erosion-accretion.

This study is conducted for Kukata beach area and coastline. Kuakata is located in the southern part of Banaladesh and northern part of BoB. It is situated 320 km south of capital city Dhaka and 70 km away from Patuakhali district headquarter. The area lies between latitudes $21^0 48'$ and $21^0 55'$ N and longitudes $90^0 03'$ and $90^0 15'$ E. Kuakata is under Kalapara upazila of Patuakhali district. Study area (Kuakata) is shown in the **Figure 0.1**.

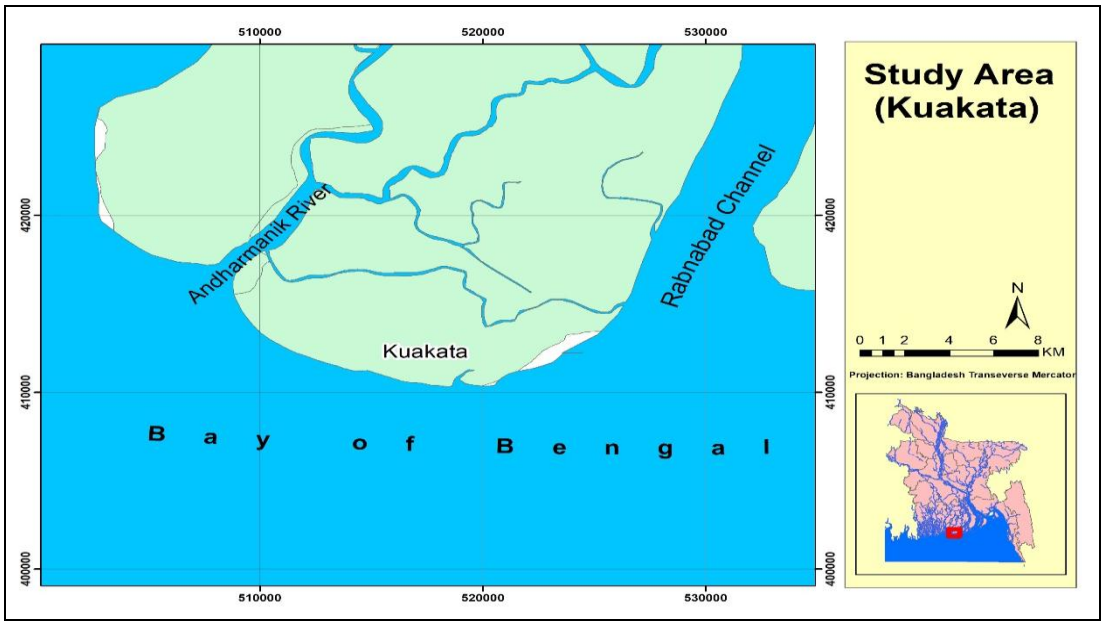

Figure 0.1: Map showing study area.

Bangladesh has an area of about 1,47,570 square kilometers and a population of more than 160 million, of which 32% of the total population lives in the coastal region. About 710 km long coast of Bangladesh comprising the complex delta of the Ganges-Brahmaputra-Meghna River system has immense resources for development. Kuakata, also popularly known as Sagar Kannya (daughter of sea queen), located on the coastal zone of Bangladesh. It is the only place of Bangladesh from where sun set, and sun rise can be enjoyed.

Kuakata beach is an important place for tourism and thereby plays a vital role for national economy. But beach erosion is becoming a serious problem day by day. Kuakata beach is about 24 km long stretching from west to east. West part of the beach, named Lebur Char which is the main attractive place of the tourists has been suffering from erosion for last few decades. Middle part, named Gangamatir Char is relatively stable. Whereas, the east part of the beach, named Kawar Char has been accreting for last few decades. The beach is bounded by the Andharmanik river estuary at the west and Rabnabad river estuary at the east. There are 139 polders in the coastal zone of Bangladesh to protect the area from tidal flooding and salinity intrusion. Kuakata is under polder-48.

A long narrow linear beach present in Kuakata. Kuakata beach is characterized by ridge and runnel topography. Deposits of the beach are mostly composed of sand. A dominant strong wind is present toward the onshore direction. A well-developed dune is present in Kawar Char area (Rashid and Mahmud, 2011).

Kuakata beach is facing significant amount of erosion. This study aims to assess erosion coastline shifting. Historical satellite images have been analyzed to understand erosion, accretion and shifting of coastline. Moreover, changing in the seabed level over a period of time in the nearshore area using open-source bathymetry data is also another objective of this study. This study will assist coast management authorities, where to take action to combat erosion and provide numerical values to have an idea about erosion problem to the researcher or coastal manager.

MATERIALS AND METHOD

Methodology comprises literature review related to this study and data collection like bathymetry and historical satellite images etc. Detail methodology is described in this chapter regarding this study.

1.1 Data Collection

Open-source data have been used for this research work. Data type, location, period, and source are shown in the following Table 0.1.

Table 0.1: List of data collection.

Data type	Place/Location	Year/Period	Data source
Satellite Imageries (Resolution 30mx30m)	Kukata area	1978-2020	USGS
Sea Bathymetry	BoB	2007 and 2014	IWM, GEBCO

1.1.1 Satellite Images

Satellite images for different year have been downloaded from USGS as listed in the **Table 0.2** and shown in the **Figure 0.1.** All the images are captured by Landsat satellite. Long term (10 years) shifting has been taken under consideration for coastline shifting assessment.

Table 0.2: List of satellite images.

SL	Year	Satellite	Resolution
1	1978	LANDSAT	30x30 m
2	1988	LANDSAT	30x30 m
3	1998	LANDSAT	30x30 m
4	2008	LANDSAT	30x30 m
5	2018	LANDSAT	30x30 m
6	2020	LANDSAT	30x30 m

All satellite images are geo-referenced. Total 6 number of satellite images are used in this research works.

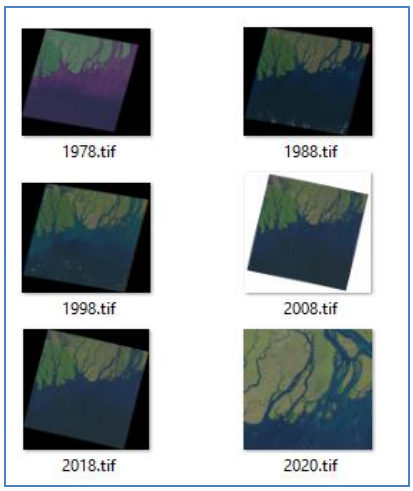

Figure 0.1: Satellite images of different year.

First 6 images are used for coastline shifting assessment and quantifying erosion and accretion which are coarser resolution. As 30 x 30-meter resolution images have been used in this study, so it can be said that accuracy level of the coastline shifting is 30 m.

1.1.2 Bathymetry Data

To find the change in the bathymetry (i.e., seabed level) over a period of time, opensource bathymetry data have been used in this regard. IWM does have BoB model, a 2D hydrodynamic model. Near Kuakata area C-Map bathymetry of year 2007 is used. From that bathymetry file of BoB model, bathymetry of Kuakata beach area has been extracted which represents the bathymetry of the year 2007. Another source of sea bathymetry could be GEBCO. Bathymetry of Kuakata beach area has been downloaded for the year 2014. By the help of these two (2) sets of bathymetry changes in seabed within the range of 7 years.

2 Data Analysis, Result and Discussion

In this chapter erosion analysis (i.e., coastline shifting, quantifying erosion-accretion area, bathymetry comparison), explained in the following sections.

2.1 Analysis of Shoreline and Bathymetry Change

Shoreline analysis for Kuakata beach is carried out by historical satellite imegaries (1978-2020) using ArcGIS tool. As bathymetry for the sea for year 2007 and 2014 have been collected so bathymetry change over the year is also observed. Bathymetry change in the vicinity of Kuakata beach and shoreline change are interrelated to each which will be critically discussed in the subsequent article.

2.1.1 Historical Shoreline Change

Kuakata beach is 24 Kilometer long. The whole Kuakata beach can be subdivided into three parts by location. The western side is known as Lebur Char, the middle portion is known as Gangamatir Char and the eastern side is known as Kawar Char. The subdivisions of Kuakata beach are illustrated by **Figure 2.1**. In this study shoreline is subdivided into 24 divisions by 1 km chainage interval. Long term (10 years) shifting is measured in each chainage.

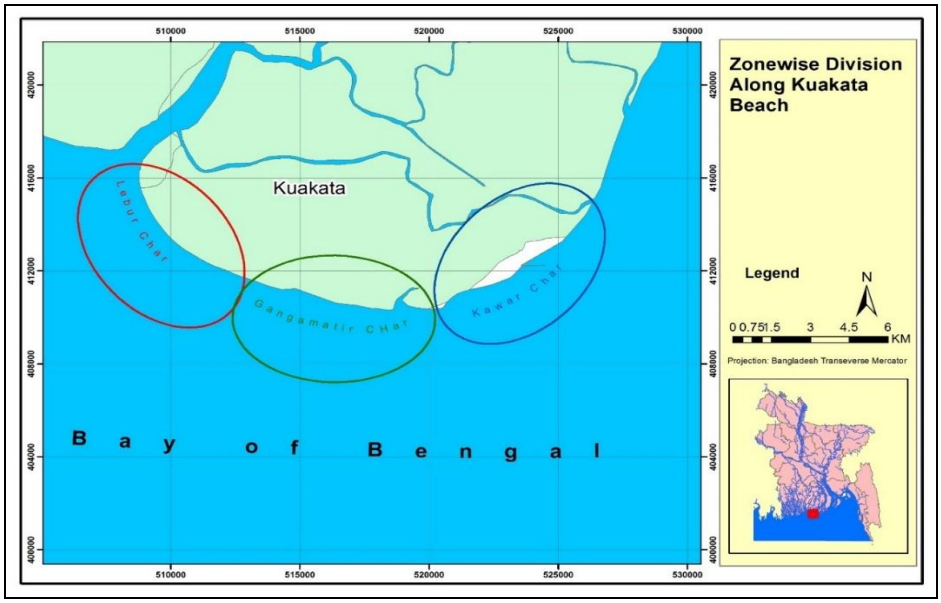

Figure 2.1: Zone wise division along Kuakata beach.

As it is mentioned earlier in Chapter 3 that all images are of 30 m resolution. All satellite images are downloaded with the assistance predicted tide by global tide model, essentially in dry season and low tide time which will give accurate coastline line position. Though 30 m resolution imageries can introduce up to 30 m erroneous result, yet it is acceptable for research purpose. Now a days 10 m resolution sentinel images are available by which coastline shifting assessment can be accomplished more correctly. Commercially available high-resolution images can also be used depending on the purpose.

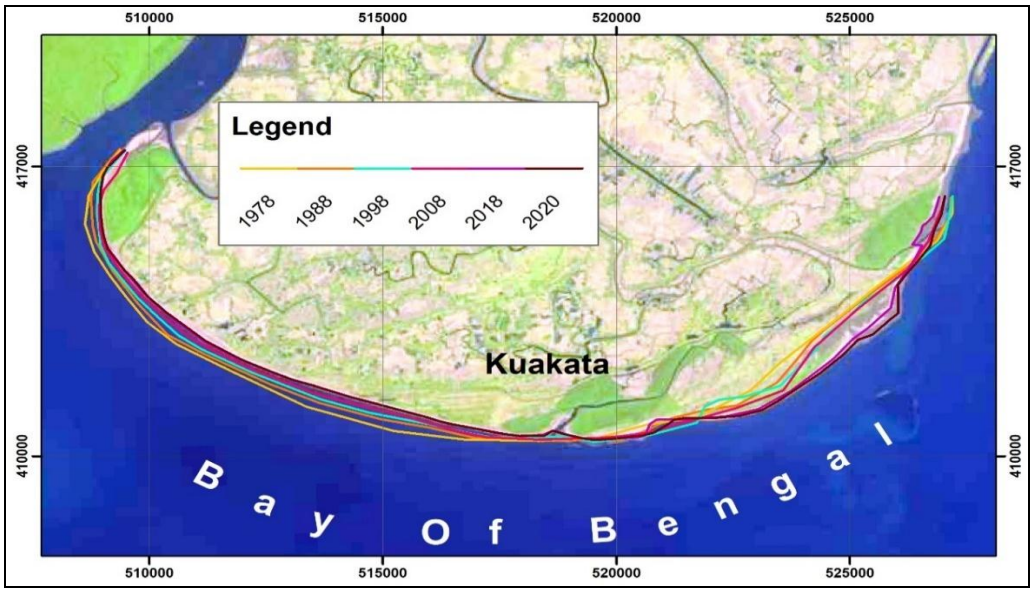

Figure 2.2: Coastline shifting (1978-2020) of Kuakata beach.

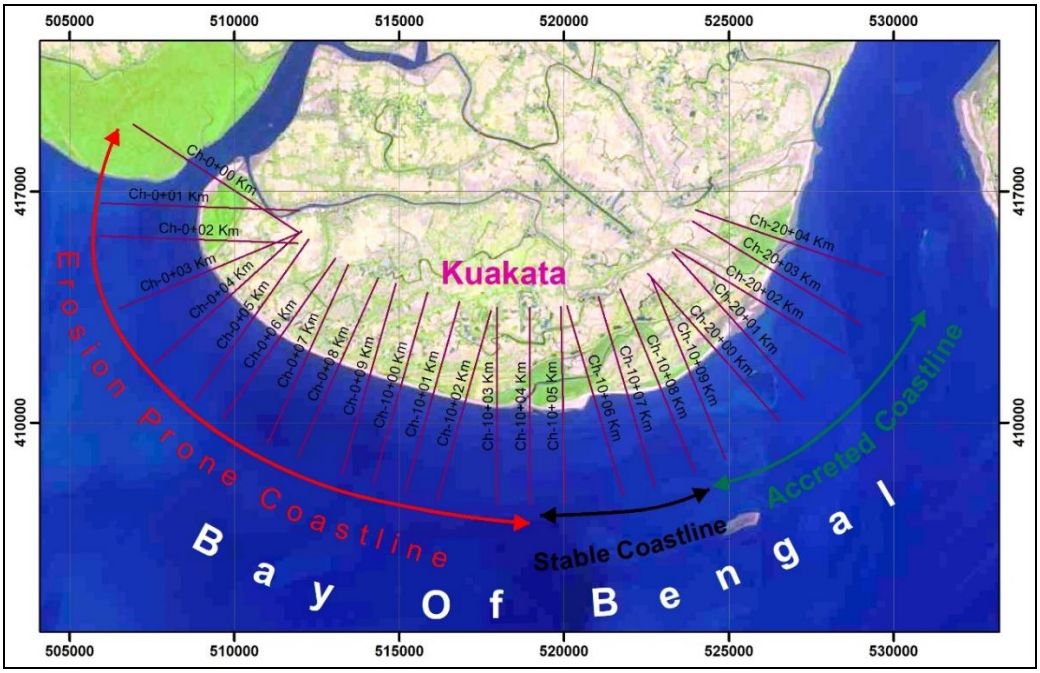

Figure 2.3: Erosion vulnerability of Kuakata beach with chainage.

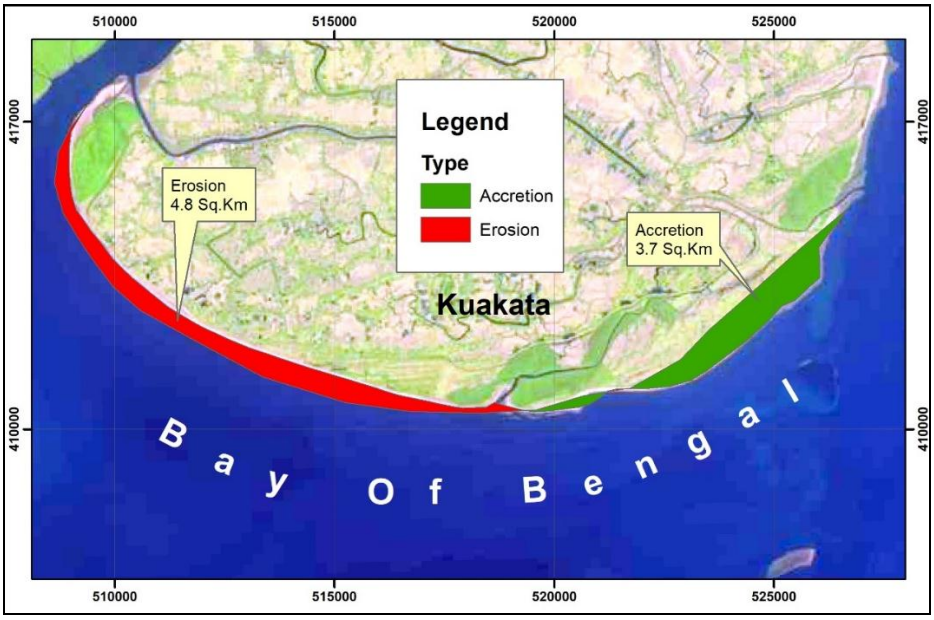

Figure 2.4: Total erosion and accretion of Kuakata beach.

From the **Figure 2.3**. It is seen that left portion (Chainage-0 to chainage-13 km) is erosion prone coastline, Chainage 13 km to Chainage-17 km is almost stable over the time and Chainage-17 to Chainage-24 is accreted coastline. Total Erosion and accretion area have also been found out from 1978 to 2020. From **Figure 2.4** it is seen that 4.8 sq. km has been eroded and 3.7 sq. km has been accreted in 42 years. So, the erosion rate and accretion rate are 9

m/yr and 12.2 m/yr respectively. Though erosion area is higher than the accretion, but erosion rate is comparatively lesser than the accretion in Kawarchar area.

Table 2.1: Changes in shorelines in different locations.

Chainage (km)	Change (m) (1978-1988)	Change (m) (1988-1998)	Change (m) (1998-2008)	Change (m) (2008-2018)	Change (m) (2018-2020)
0	18	-117	-66	100	-7
1	45	-143	-170	116	-6
2	-150	-125	-30	-40	-9
3	-112	-31	-111	-62	-11
4	-105	-87	-100	-83	-5
5	-57	-153	-106	-111	-25
6	-91	-75	-85	-86	-28
7	-115	-72	-65	-107	-10
8	-171	-92	-68	-139	0
9	-184	-80	-90	-127	-6
10	-202	-92	-89	-128	-5
11	-186	-82	-20	-116	-6
12	-50	-77	0	-150	-3
13	0	-43	-33	-30	-4
14	22	-97	58	-91	3
15	192	-40	-71	50	-7
16	32	190	-64	-245	40
17	-80	0	163	25	0
18	172	-95	194	197	42
19	273	139	93	203	43
20	74	184	0	430	67
21	0	147	0	442	140
22	50	63	22	393	160
23	67	52	-41	0	63
24	-48	123	-286	-240	270
NB: Positive Value and Green Colour denotes Deposition and Negative Value, and Red Color denotes Erosion.					

From **Table 2.1** it is seen that erosion occurs at Lebur Char area which is up to chainage-13 km. In the middle portion or Gangamatir Char bankline is bit dynamic, sometimes it is characterized by erosion and sometimes by accretion. In the east side of Kuakata, Kawar char, is characterized by accretion. Erosion rate is found from table for last 10 years is 11.7 m/yr where accretion in Kawarchar area is 21.2 m/yr. This phenomenon can be depicted from the **Figure 2.5** and **Figure 2.6** as well.

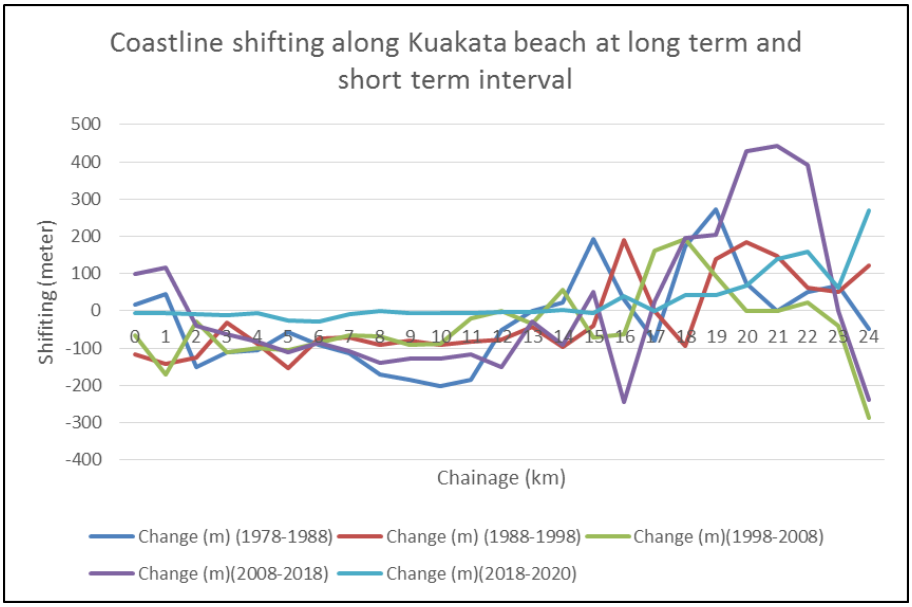

Figure 2.5: Coastline shifting along Kuakata beach at different term.

Figure 2.5 revealed that that western side of Kuakata beach has long history of erosion. Significant accretion is also happening over time in the eastern side. But this can be identified only by long term analysis for course resolution satellite images. In case of short term (2018-2020, 2 years) true result cannot be interpreted because of low resolution. High resolution commercial satellite images are desired for this kind short term analysis.

From the **Figure 2.6** it is evident that during the decade (2008-2018), western side of Kuakata eroded most and maximum erosion (i.e., 128 meter) occurred at chainage 10 + 000 m (10 km). On the other hand, maximum accretion occurred at 21 + 000 m chainage which is about 442 m. Erosion phenomenon is dominant in the western side whereas accretion governs in eastern side along the beach.

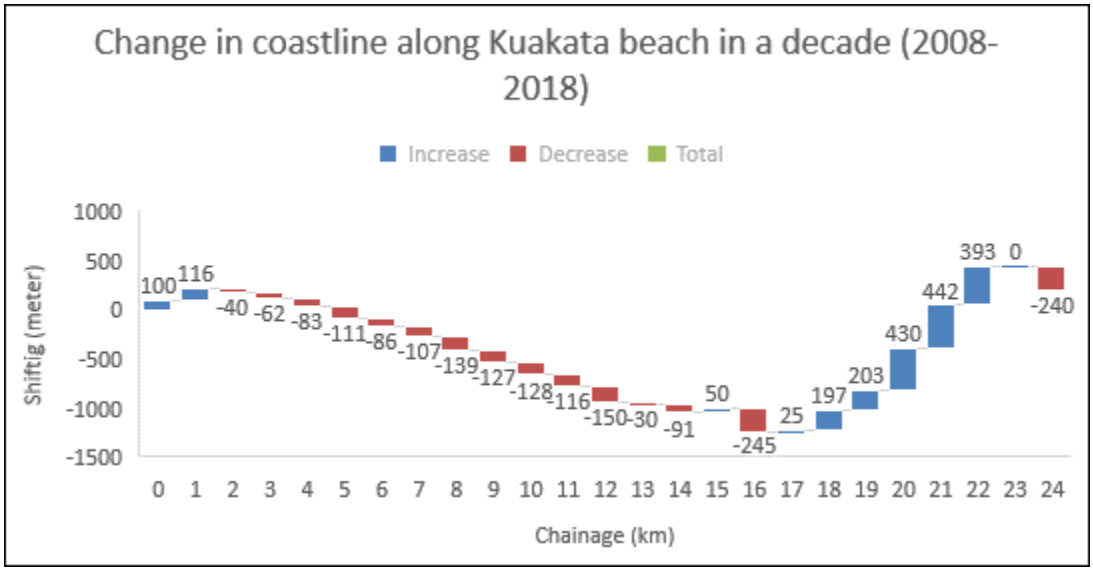

Figure 2.6: Change in coastline along Kuakata beach in a decade (2008-2018).

2.1.2 Historical Bathymetry Change

Bathymetry of Kuakata beach area has been collected for two years. Bathymetric data for 2007 from C-Map and for year 2014 from GEBCO are superimposed on each other. Using bathymetry data 2007 a raster surface is created by IDW tool of GIS and same thing is done for GEBCO bathymetry data for the year 2014. Raster of 2007 is subtracted from the raster 2014 by raster calculator in GIS which eventually results another new raster and represents the bathymetry change in seven years in the vicinity of Kuakata beach.

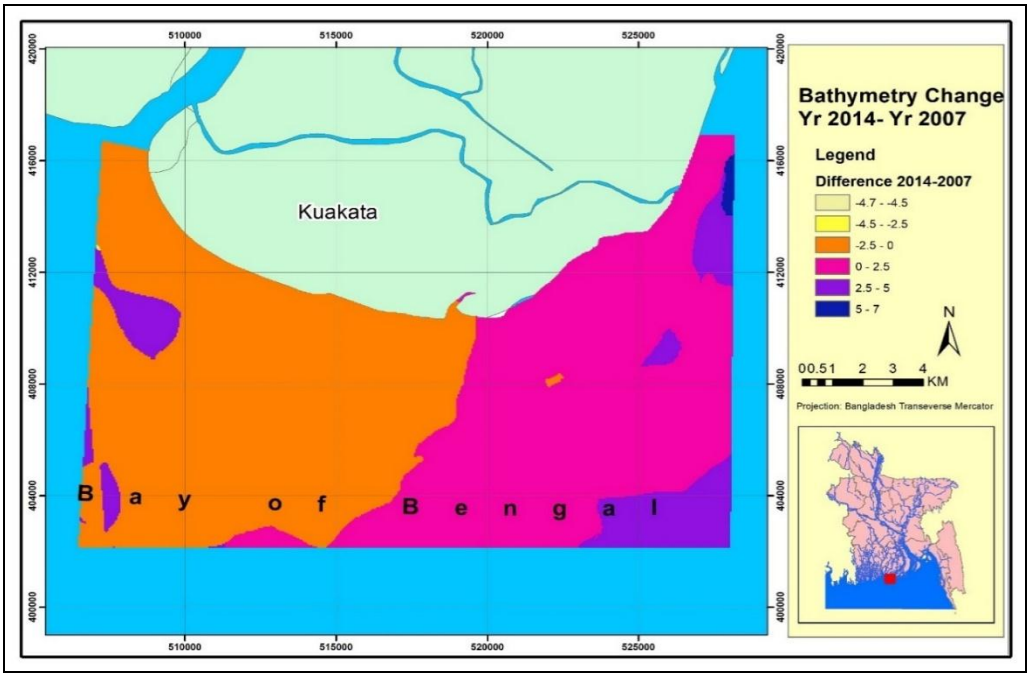

Figure 2.7: Bathymetry change year 2014- year 2007 in the vicinity of Kuakata beach.

From the **Figure 2.7** it is identified that negative value indicates erosion whereas positive value indicates deposition. So, it can be said that western side is dominated by negative value and thus vulnerable to erosion which is shown by yellow color. On the other hand, eastern side is dominated by positive value and thus inclined to deposition phenomena which is shown by pink color. From the bathymetry change it is evident that in the western side of the beach erosion is occurring and on the other hand in eastern side sedimentation occurs which also conforms the result of satellite images analysis.

From historical satellite images analysis, it can be concluded that significant amount of erosion is occurring in the western Kuakata beach and deposition occurs in eastern part which confirms with bathymetry changes of the beach including nearshore. Maximum erosion occurs 202 m and maximum deposition occurs up to 442 m over different decade.

It is estimated for future shoreline simulation that shoreline will move further 9.6 m/year in next 5 years.

3 DISCUSSION

Following major findings have been found from this study:

1. By satellite images analysis, amount erosion and accretion in the Kuakata beach are quantified. By using bank line of year-1978 and year-2020 erosion is 4.8 km^2 and accretion is 3.7 km^2. Most of the erosion occurred in Lebur Char area and accretion occurred in Kawar Char area.
2. Long-term (10 years) bankline shifting has been also analyzed. It is seen that chainage 0+00 to chainage 13 km (west part of beach) is erosion prone coastline. Chainage 13 Km to chainage-17 km is almost stable coastline which is the middle portion of the kuakata. And in rest of the part (i.e., chainage-17 km to Chainage-24, east part) sedimentation occurs.
3. Chainage wise changes of shorelines in different location have been estimated. Erosion rate is found from analysis for last 10 years is 11.7 m/yr where accretion in Kawarchar area is 21.2 m/yr.

CONCLUSION

Erosion and accretion along Kuakata beach have been analyzed by Landsat satellite images.

Following major findings have been found from the current study

1. Around 13 km western side of Kuakata beach (i.e., Lebur Char) faces serious erosion and on the other hand 7 km eastern side (i.e., Kawar Char) accretes over the last 4 decades which is found from historical satellite images.
2. Coastline evolution model simulated for eroding western side of Kuakata beach and it is verified with real satellite images coastline where same wave climate is used as in littoral drift model which conforms the accuracy of longshore sediment transport estimation. At the same time future shoreline simulation is done where it is seen that eroding beach will erode further at 9.6 m/yr.

Based on this study some recommendations have been summarized below:

1. Coarser bathymetry is used from C-map and GEBCO in the vicinity of Kuakata beach. Better result can be expected if fine bathymetry would be used. Further study can be carried out using fine bathymetry (if available) and compared with present result.
2. Coastline shifting assessment could be determined if high resolution imageries were used. Further study can be carried out taking under consideration of commercially available very high-resolution satellite images.

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REFERENCES

1. Bushra, N. “Detecting changes of shoreline at kuakata coast using RS-GIS techniques and participatory approach”, *M.Sc. Thesis*, IWFM, BUET, Dhaka, Bangladeh, 2013.
2. Corbella, S. and Stretch, D. D. “Predicting coastal erosion trends using non-stationary statistics and process-based models”, *Coastal Engineering*, 2012; 70: 40-49.
3. Hendriyono, W., Wibowo, M., Hakim, B.A., and Istiyanto, D.C. "Modeling of sediment transport affecting the coastline changes due to infrastructures in Batang - Central Java, Procedia”, *Earth and Planetary Science*, 2015; 14: 166-178.

4. Hossain, S. "Assessment of sediment movement pattern along nearshore coastal water of cox's bazar", *M.Sc. Engg. Thesis*, Department of Water Resources Engineering, BUET, Dhaka, Bangladesh, 2015.
5. Islam, M.R. and Ahmad, M. *Living in the coast: Problems, opportunities and challenges*, Working Paper WP011, PDO-ICZMP, Dhaka, 2004.
6. Paul, B. K. "Human injuries caused by Bangladesh's cyclone sidr: an empirical study", *Natural Hazards*, 2009; *54*(2): 483-495.
7. Kobayashi, N., Agarwal, A. and Johnson, B. "Longshore current and sediment transport on beaches", *Journal of Waterway, Port, Coastal and Ocean Engineering*, 2007; 133(4): 296-304.
8. Rahman, M.A., Mitra, M.C., and Akter, A. "Investigation on erosion of Kuakata sea beach and its protection by artificial beach nourishment", *Journal of Civil Engineering (IEB)*, 2013; 41(1): 1-12.
9. Rashid, M.B., and Mahmud, A. "Longshore currents and its effect on Kuakata beach, Bangladesh." *Bangladesh Journal of Geology*, 2011; 29-30: 30-40.
10. Hoque, M.A.-A.; Ahmed, N.; Pradhan, B.; Roy, S. Assessment of coastal vulnerability to multi-hazardous events using geospatial techniques along the eastern coast of Bangladesh. Ocean Coast. Manag, 2019; 181: 104898.
11. Ahmed, N.; Howlader, N.; Hoque, M.A.-A.; Pradhan, B. "Coastal erosion vulnerability assessment along the eastern coast of Bangladesh using geospatial techniques", Ocean Coast. Manag, 2021; 199: 105408.
12. Hossain, M.A., et al., Assessing morphological changes of the Ganges River using satellite images, Quaternary International http://dx.doi.org/10.1016/j.quaint. 2013.03.028, 2013.
13. Baki, A.B.M., Gan, T.Y., "Riverbank migration and island dynamics of the braided Jamuna River of the GangeseBrahmaputra basin using multi-temporal Landsat images", Quaternary International, 2012; 263(2012): 148-161.