

Sea Level Rise and Impact on Moushuni Island of Sundarban Delta (West bengal)—A Geospatial-Based Approach



Atashi Jana and Gouri Sankar Bhunia

Abstract Sea level rise (SLR) is one of the major threats to coastal areas across the world. According to IPCC, Sundarban delta is vulnerable due to climate change and natural disasters. This paper aims to delineate the erosional pattern and shifting of shorelines of Moushuni Island and its impact on the local livelihood pattern due to SLR. Multi-temporal Landsat data were used to identify the shoreline. The Union method was applied to demarcate erosion and accretion zone. Spatial overlay analysis is performed to determine the spatial correlation with the socio-economic characteristics within the study site. The net loss of the entire Sundarban island is 44 km² between 2001 and 2009 with an average rate of erosion of 5.5 km²/year. Coastal erosion and accretion cause shoreline dynamic in the Moushuni island. There is a rapid shifting of the shoreline on the Moushuni island. As a result, there is a progressive reduction in land area with the breaching of embankments. The land area of Moushuni island in 2000 and 2009 was 28.923 sq km and 28.283 sq km, respectively, and the total loss of land area was 0.64 sq km with 2.28% of land loss between 2001 and 2009. Out of four mouzas of Moushuni island, Baliara mouza has lost 2.4 sq km² with 157 holdings approx. About 80% population of Baliara mouza are in the most vulnerable condition. The impact of SLR decreased land holding, pressure on agriculture and increased salinity on its periphery.

Keywords Moushuni Island · Shoreline · Sea level rise · Vulnerability · Landsat

1 Introduction

Coastal environment and coastal people are vulnerable to sea level rise and other climate related natural phenomena. Since 1880, the global mean sea level (MSL) has increased 8–9 in. (21–24 cm), with about a third of it happening in the past two and a half centuries. The Rising of water level depends on melting of glaciers and ice caps and thermal expansion of seawater. The global MSL in 2019 was 3.4 in. (87.6 mm)

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higher than the 1993 average, making it the highest annual average in satellite history (1993–present). The rise of the global sea level between 2018 and 2019 was 0.24 in. (6.1 mm). Increase of population growth and change of settlement pattern, as well as anthropogenic subsidence, have all played a role in raising the exposure and susceptibility of low-lying coastal areas to sea level rise and coastal flooding.

Owing to the effects of other natural and anthropogenic factors such as infrastructural growth and human-induced habitat loss, attributing such impacts to SLR remains complex (Mimura 2013). Changes in coastal infrastructure, population livelihoods, cultivation, and habitability have all been noted to increase coastal risk (Nicholls et al. 2007). Attributing reported improvements and related risk to SLR, as it is for coastal environments, is challenging (Hazra et al. 2002). The country's 7,500-km-long coastline is considered the world's most vulnerable to climate change effects, with over 20% of India's population (approximately 250 million people) living within 50 km (31 miles) of the sea. The rate of sea level rise in Indian Sundarbans' in every year is 3 cm (1.2 in.) over the last four decades. Many of these environmental cascades are already happening on Sagar Island in the Bay of Bengal, which are predicted to intensify in the coming decades. In Sundarban southern islands are more susceptible to erosion where the rate of land loss of Moushuni island is 0.64 sq km. between 2001 and 2009 (Hazra et al. 2010). The embankments of Moushuni island were breached several times between 1995 and 2010 due to coastal erosion and storm surges. Breaching of embankments causes ingress of saline water and makes soil unproductive. There is a shifting of settlements of local inhabitant as days pass by Chandra (2014).

The embankments that have been eroded due to the recent rainy season are set in the Sundarbans' Moushuni Islands. Drought and heavy rainfall in recent decades, as well as growing soil salinity, have made it difficult to produce enough food to thrive entirely on agricultural practices. Felling of trees for fuel purpose accelerates erosional activity of this island. Based on the above observation, the present study aims to delineate the erosional pattern and shifting of shorelines of the Moushuni island due to sea level rise and its impact on the rural settlement.

2 Area and Location

Moushuni island is located in Namkhana block of the Kakdwip subdivision of South 24 Parganas district of West Bengal. It is a deltaic island consisting of 4 revenue villages (mouzas)—Moushuni, Bagdanga, Kusumtala, and Baliara. The Moushuni island is extended between 21° 36' 23'' N to 21° 43' 13'' N latitudes and 88° 11' 00'' E to 88° 13' 39'' E longitudes (Fig. 1). The total population of this island is 22,073 (Census 2011), covered with an area of 27.1 km². The Muri Ganga river is flowing in the west and north-west of Moushuni Island, Pitt's creek in the east and the Bay of Bengal in south. The physiographic features of this island include mud flats, salt marshes, sandy beaches, and dunes formed by the fluvio-marine geomorphic process. The entire island is crisscrossed by numerous tidal creeks. The soil of Moushuni

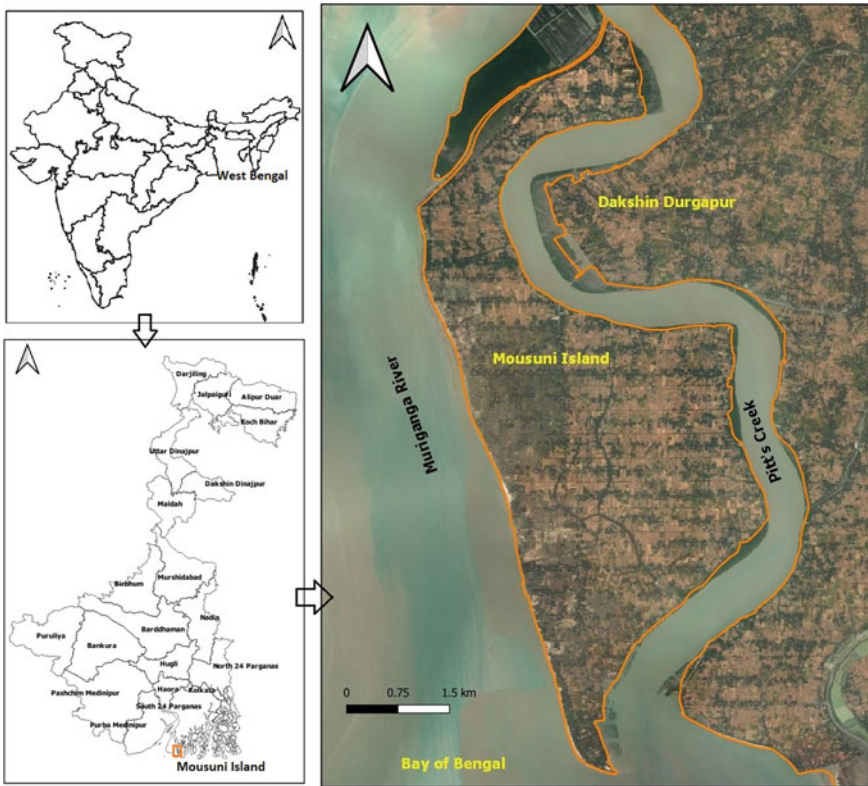


Fig. 1 The location map of the study area

island is comprised of mainly saline alluvial soil consisting of clay, silt, fine sand, and coarse sand particles. The weather of this island is almost moist with 80% humidity, annual average temperature ranges from 34 to 20 °C with extremely high rainfall. The population mainly depends on agricultural activity. In 2011, the literacy rate of this island is 80%.

3 Materials and Methods

Multi-temporal Landsat satellite data has been collected from the United States Geological Survey (USGS) Earth Explorer Community. Topographical maps (1:50,000 scale) from the Survey of India (SOI) are used as base map. Thematic mapper data for the years 1990, 2000, 2010, and 2018 were collected and registered in the UTM projection system with WGS 84 datum and the North 45 zone. Due to the differences in attitude, altitude, and velocity of the sensor platform, raw satellite images typically include several faults, such as radiometric distortion, geometric

distortion, noise, and so on. Tidal gauge data were obtained from PSMSL (Permanent Service for Mean Sea Level) for analysis of the sea level rise. Population characteristics data of the study area were collected from Census of India 2011 (<https://censusindia.gov.in/2011Census/pes/Pesreport.pdf>). Google earth data from other satellite image sensors are available in Earth Engine as well (<https://earthengine.google.com/timelapse/>), downloaded at 0.25 × to illustrate the geo-visualization of the Moushuni island at a different time interval.

Shoreline of Moushuni island has been digitized based on heads-up manual digitizing method. Polygon shapefile has been created for each year. The erosion and accretion zone have been identified based on union method. All the GIS' analyses have performed in QGIS software version 3.14. The loss of the area between 1990 and 2020 is presented by a graphical representation of Excel Spreadsheets.

4 Results and Discussions

Moushuni island has four mouzas as Moushuni, Bagdanga, Kusumtala, and Baliara where Kusumtala and Baliara are more erosion prone. The western part of Kusumtala mouza and south-western part of Baliara mouza are more susceptible to erosion. Despite the reactivated delta pro gradational phase, the island system of the Hoogly-Matla estuary is experiencing a considerable amount of net land loss, according to the current observation from 1990 to 2018. Longshore variation in net shoreline change was discovered in measurements of shoreline location from year to year (Fig. 2).

The continuous threats to island are sea level rise, shifting of shorelines, erosion responsible for the forcible shifting of landowners to relocate a new place for the hungry sea. According to satellite data in 1990 the area of this island was 29.76 km², in the year 2000 the area was 29.17 km², in 2010 it was 27.37 km², and in 2020 the area was 26 km². The loss of the land area between 1990 and 2020 is 3.76 km² (Fig. 3).

From the analysis, there is strong evidence of subduction in the northern and southern part of the Moushuni Island (Fig. 4). In the eastern part of the island, the association between the rate of sea level rise and accretion rate is exceptionally strong. In the Northern part of Moushuni island, only erosion effect has some correlation with the sea level rise. The North-western part of the island and associated Titan Island areas are progressively decreased since 1990–2018. There is another interesting finding, where the northern part of the Jambudwip island (south-west of Moushuni island) and south of the Moushuni island has also registered erosion. However, sea level rise cannot be attributed to an accretion rate in the north-western part of Jambudwip (Fig. 5), which is an accretion region. This portion concludes that sea level rise has the least effect on accretion. It is evident from this research that sea level rise has a major effect on coastal erosion. However, it's worth remembering that, in some areas, sea level rise has a major effect on accretion processes and vice versa.

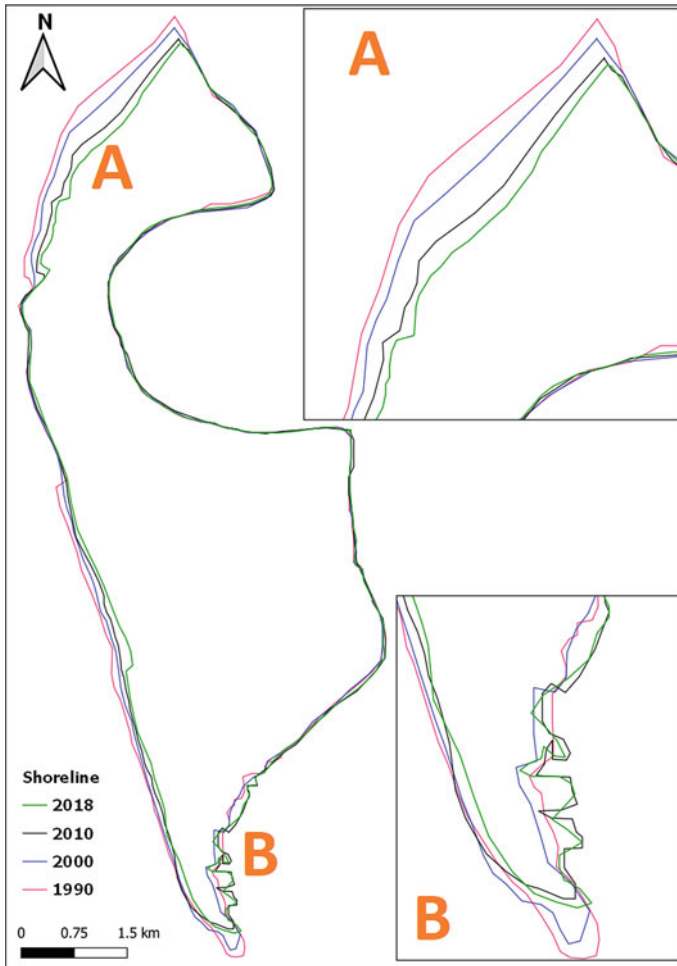


Fig. 2 Changes on shoreline in Moushuni island

5 Conclusion

Sea level rise is one of the major threats in different parts of Sundarban. Moushuni island of Sundarban is severely suffered from sea level rise, shifting of shorelines, and erosion. If this rate of erosion continues Moushuni island will sink in next 4–5 decades. According to the present study, the land loss between 1990 and 2020 is 3.76 km². The northern, north- western, and southern parts of the island are severe erosion prone and the rate of accretion is high in the eastern part of the island. Sea level rise has a bitter effect on socio-economic condition of Moushuni island and forces people to migrate for livelihoods. It also causes increase in salinity, responsible for changes in species composition of mangroves and decrease in extent of mangroves. Soil

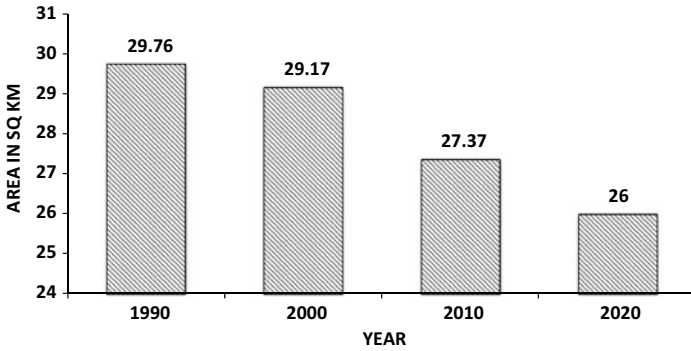


Fig. 3 Areal distribution of Moushuni island (1990–2020) estimated from Landsat Thematic Mapper data

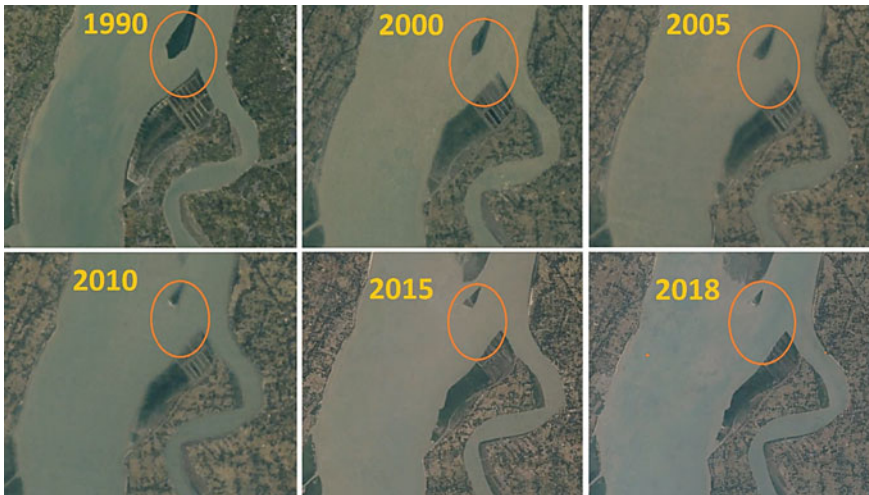


Fig. 4 Submergence of the northern part of the Moushuni island from 1990 to 2018

salinity and water logging caused by sea level rise are major problems to agricultural productivity of this island. About 89% of farming families of this island are suffered from salinization and sea water intrusion. The yield of the paddy crop is severely affected by inadequate drainage facility in the monsoon. Next to agriculture fishing is one of the major livelihoods of this region. But about 40.38% of fishing activity has been affected by engulfing of seawater. Also catch of Hilsa (*Tenulosa Ilisha*) is decreasing since the 80s due to climate change scenario. So, to save this island and dwellers need to take strategic plan for its proper planning and mitigation.



Fig. 5 Submergence of the southern part of the Moushuni island (1990–2018)

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