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MINI REVIEW

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A Study on bank erosion in the southern part of Majuli Island, Assam

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ABSTRACT

Majuli is the largest river island in the world, located on the Brahmaputra River in Assam. The entire area of Majuli is 1250 km^2. However, it is now only 421.65km^2 after suffering severe erosion-related losses. Majuli has long been renowned for its rich cultural history. Furthermore, it is a hotspot for flora and fauna, home to numerous rare and endangered bird species, including migratory birds like the Whistling Teal, Pelican, Siberian Crane, and Greater Adjutant Stork. Because there aren't any factories or industries that emit pollutants, the island is supposedly pollution-free. However, severe flooding and bank erosion are the two natural hazards that it is currently facing. Each year, erosion and deposition put both island's banks in grave danger. The south bank has a higher average rate of maximum shift that causes erosion over all time periods, ranging from 0.004 to 0.48 km/year, than the north bank, which has an average rate of 0.009 to 0.4 km/year. The goal of this paper is to examine the causes and effects of the changing Brahmaputra south bank on Majuli River Island in the modern era. The type of changes and effects have been observed using both primary and secondary data. It is anticipated that the current study will undoubtedly be beneficial to geographers, engineers, planners, etc.

KEY WORDS

Avifauna; Flood; Erosion; Deposition; Natural hazards

ARTICLE HISTORY

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Introduction

Majuli Island, located in the Brahmaputra River in Assam, India, holds the distinction of being one of the largest inhabited riverine islands in the world [1]. Known for its rich cultural heritage, ecological diversity, and socio-economic significance, Majuli has long been a focal point of geographic and environmental studies. However, in recent decades, the island has faced an escalating threat from riverbank erosion, a dynamic and destructive natural process that has significantly reduced its landmass and displaced thousands of inhabitants [2].

The southern part of Majuli Island, being directly exposed to the shifting courses of the Brahmaputra River and its distributaries, is particularly vulnerable to severe bank erosion [3]. The high-energy fluvial environment, combined with monsoonal rainfall, sediment deposition, and anthropogenic pressures, has led to frequent and large-scale erosion events in this region. These events not only impact the physical landscape but also severely affect the livelihoods, agriculture, infrastructure, and cultural heritage of the local communities [4].

This study aims to investigate the patterns, causes, and consequences of bank erosion in the southern part of Majuli Island. By analyzing temporal changes in riverbank position, identifying erosion-prone zones, and assessing the socio-economic impacts on affected populations, the study seeks to contribute to a more comprehensive understanding of the erosion dynamics in this unique fluvial environment [5]. The findings are expected to inform sustainable land management practices and policy measures for erosion control and disaster mitigation in the region.

Geographical location

Majuli Island is situated in the upper reaches of the Brahmaputra River in the Indian state of Assam, between latitudes 26°45′N to 27°12′N and longitudes 93°39′E to 94°35′E. The island lies within the districts of Majuli and parts of the Lakhimpur and Jorhat districts. It spans a total area of approximately 352 square kilometres (subject to change due to ongoing erosion), although it was once much larger in extent.

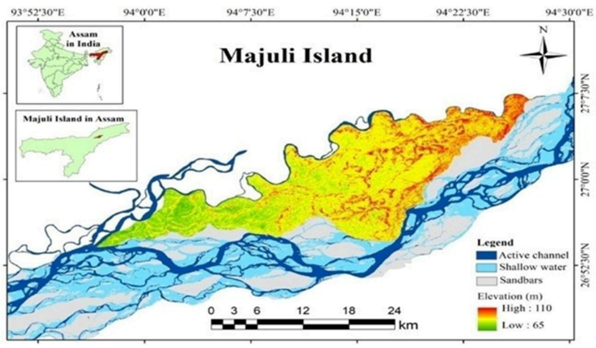

Figure 1. Study area map.

The study area focuses on the southern sector of Majuli, a large, inhabited river island situated within the Brahmaputra River basin in Assam, India [6]. This region lies along the immediate interface with the active main channel of the Brahmaputra, making it one of the most erosion-prone zones of the island.

Geomorphologically, the southern part of Majuli is composed of low-elevation alluvial plains formed by recent fluvial deposits, predominantly sand and silt. These unconsolidated sediments are highly susceptible to hydraulic action and bank failure [7]. The river system in this stretch exhibits a braided morphology, with multiple shifting channels, mid-channel bars, and frequent meander cut-offs, contributing to lateral channel migration and bankline instability [8].

The area is bounded by the main Brahmaputra channel to the south, while the relatively stable central upland of Majuli lies to

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the north. Its eastern and western extents are influenced by distributaries and tributaries such as the Subansiri River and Kherkatia Suti, which further complicate local hydrodynamics [9]. Seasonal wetlands, floodplains, and cultivated agricultural lands dominate the landscape, interspersed with dispersed rural settlements.

The villages including Salmora, Ahotguri, and Kamlabari, fall within this high-risk belt. These settlements experience recurrent bank erosion and land loss, particularly during the monsoon season (June–September), when discharge and sediment load in the Brahmaputra peak [10]. The spatial setting of the southern Majuli region, marked by high flow, channel instability, and the absence of robust bank protection measures, establishes it as a critical zone for investigating fluvial erosion dynamics and associated socio-environmental impacts.

Objective of the study

The present study focuses on understanding the spatial extent and severity of riverbank erosion along the southern margins of Majuli Island, located within the dynamic floodplain of the Brahmaputra River [11]. Given the island's continuous exposure to high-energy fluvial processes, the first objective is to systematically identify and delineate erosion-prone zones using available secondary data sources such as satellite imagery, historical maps, government reports, and previous scientific studies. Attention is given to temporal changes in channel morphology and bankline shifts to highlight areas experiencing persistent land loss [12].

The second objective is to propose context-specific and technically feasible mitigation strategies grounded in the analysis of existing literature, policy documents, and case studies from comparable riverine environments [13]. These recommendations aim to balance structural interventions such as embankments, revetments, and geotextile applications with non-structural approaches, including vegetation-based stabilization and community-driven adaptation measures. Emphasis is placed on selecting interventions that are not only effective in controlling erosion but also sustainable in terms of environmental impact, economic feasibility, and long-term resilience [14].

By integrating spatial assessment with evidence-based mitigation planning, the study seeks to contribute to ongoing efforts for safeguarding livelihoods, agricultural land, and cultural heritage in Majuli. The findings are intended to support policymakers, planners, and local stakeholders in making informed decisions for riverbank management in one of the most erosion-vulnerable regions of India [15].

Methodology

This study adopts a secondary data–driven approach to examine the spatial and temporal dynamics of riverbank erosion in the southern part of Majuli Island [16]. Multi-source geospatial and archival datasets were integrated to ensure both temporal depth and spatial accuracy. Historical satellite imagery from platforms such as Landsat (USGS) and Sentinel (ESA) was used to map shoreline changes over multiple decades. These images were selected for comparable seasonal windows to minimize hydrological variability [17]. Topographic sheets (Survey of India) and earlier geomorphological maps were georeferenced and overlaid within a GIS environment (ArcGIS/QGIS) to delineate riverbank migration patterns. Bankline positions were digitized for different time periods, and erosion/accretion rates were quantified using transect-based and polygon overlay techniques.

Land use/land cover (LULC) changes were assessed through supervised classification of satellite data, followed by accuracy assessment using available ground-referenced datasets from published studies [18]. This enabled identification of erosion-prone zones in relation to vegetation loss, agricultural expansion, and settlement shifts. Hydrological and geomorphological drivers were analyzed using secondary datasets obtained from the Central Water Commission and the Brahmaputra Board. Parameters such as annual discharge variability, sediment load, channel morphology, and flood frequency were compiled and correlated with observed erosion patterns [19]. Relevant peer-reviewed literature and government reports were critically reviewed to contextualize these findings.

Spatial analysis involved overlaying erosion hotspots with hydrological indicators to identify cause–and–effect relationships. Temporal trends were interpreted using decadal comparisons, highlighting phases of intensified erosion. The integration of remote sensing, GIS-based spatial analysis, and validated secondary datasets provides a consistent framework to understand erosion processes without relying on primary field measurements, while maintaining analytical robustness.

Significance of the study

This study adopts an integrated approach combining geospatial analysis, field-based observations, and socio-economic assessment to examine riverbank erosion in Majuli Island along the Brahmaputra River [8]. Multi-temporal satellite imagery (e.g., Landsat and Sentinel datasets) was used to assess shoreline changes over time. Images from different years were processed using GIS software (ArcGIS/QGIS) to delineate riverbank positions and quantify erosion and accretion patterns, with particular emphasis on the southern bank. Change detection techniques and overlay analysis were applied to estimate land loss rates and spatial variability.

Field surveys were conducted in erosion-prone villages to validate remote sensing outputs and document present ground conditions. GPS-based mapping helped in identifying active erosion sites, embankment conditions, and vulnerable zones [4,17]. Observations on sediment characteristics, flow direction, and bank stability were also recorded to understand geomorphic processes.

To evaluate socio-economic impacts, primary data were collected through structured questionnaires and semi-structured interviews with affected households. Information related to land loss, livelihood disruption, displacement history, and adaptation strategies was gathered. Key informant interviews with local authorities and community leaders supplemented household-level data.

Secondary data, including historical records, government reports, and published literature, were reviewed to contextualize long-term erosion trends and policy responses. Relevant frameworks related to river dynamics and climate variability were considered to interpret findings. The combined analysis of spatial, environmental, and social data enabled a comprehensive understanding of erosion dynamics and their implications. This triangulated methodology ensures both quantitative accuracy and contextual depth, making the findings relevant for planning, risk mitigation, and sustainable management of riverine landscapes.

Literature Review

Bank erosion in riverine islands like Majuli has been a subject of growing academic and policy interest due to its complex environmental, socio-economic, and cultural implications. The literature review that follows looks at important academic publications, official documents, and pertinent case studies, research on the erosion of Majuli's riverbanks and the larger Brahmaputra basin.

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Several researchers have extensively studied the Brahmaputra River, known for its dynamic and braided nature. Goswami emphasized the high sediment load and frequent channel shifting of the Brahmaputra, which contribute significantly to riverbank erosion [20]. Phukan et al. highlighted the river's tendency to erode its banks during monsoon due to intense rainfall, heavy flow velocity, and unstable geomorphology, making erosion a continuous and complex process [21].

Majuli has witnessed severe bank erosion over the decades, leading to a drastic reduction in its area from approximately 1,250 sq. km in the early 20th century to less than 500 sq. km today. Nayak et al. documented the morphological changes of Majuli using satellite imagery and found that the island's southern part is the most vulnerable to erosion [22]. Bhagabati et al. noted that anthropogenic interventions such as deforestation, sand mining, and poorly planned embankments have aggravated the problem [23]. Recent studies also link increased riverbank erosion to climate change. Chakraborty et al. reported changes in rainfall patterns and glacial melt upstream contributing to greater discharge variability in the Brahmaputra [24]. ICIMOD Reports emphasize that Himalayan Rivers are highly sensitive to climatic variations, thereby increasing erosion risk downstream, including Majuli [20].

Geomorphological Processes in Riverbank Erosion

Erosional work of rivers is of three types: vertical, headward, and lateral [24]. Vertical erosion leads to deepening, headward erosion makes the river channel longer (valley lengthening), and lateral erosion makes the riverbanks wider (valley broadening). Riverbank erosion is generally associated with the lateral erosional work of rivers. In lateral erosion, the bank of a river is divided into three classes: toe zone, bank zone and overbank zone based on the intensity and frequency of erosion.

The Toe Zone is the part of the bank that lies between the high-water level and the low-water level. Bank Zone is the part that lies between the high-water level and the areas that are inundated in normal floods. The Overbank Zone is that part of the bank that is subject to erosion and flooding in the most extreme cases of floods only, and in normal years, it remains as a refuge against the approaching river.

Lateral erosion of riverbanks is a natural process and only affects the toe zone, thereby leading to the broadening of the valley. However, in the years of floods, the advancing riverbank cut through the bank zone and caused erosion in this area too [18]. Overbank zone, on the other hand, is only rarely subjected to the erosional work of the river and is therefore an ideal place for settlements and agriculture.

Most riverbank erosion cases are caused by a process known as mass failure, which occurs when the river's erosional work regularly reaches the bank zone and overbank zone [7,19,15]. But in this paper, we contend that the River Brahmaputra's fluvial geometry and not in Bangladesh and India, erosion and related disasters are primarily caused by mass failure.

Bank erosion in the southern part of Majuli

Riverbank erosion has had a significant impact on Majuli's southern region, which includes places like Salmora, Sukhunamukh, Upper-Sonowal, Korotipar, Malowal Kalita, and Ukhalchuk. The erosive force of the Brahmaputra River causes ongoing issues in these areas. In particular, the after the 1950 earthquake, the southern bank of Majuli saw severe erosion, prompting the construction of protective structures close to Kokilamukh, making the northern bank more susceptible.

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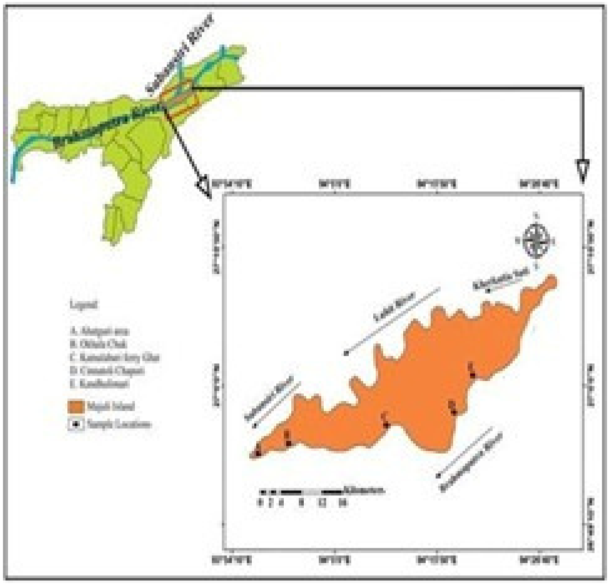

Figure 2. Areas severely affected by riverbank erosion.

Major erosion hotspots

Ahatguri area, Part of the Ahatguri mouza in South Majuli. This entire administrative block has witnessed large-scale land loss and almost complete submergence over recent decades. Okhala Chuk, located along the southern fringe, has been identified as highly vulnerable to riverbank retreat. Kamalabari ferry ghat & Kamalabari region, Erosion here has been continuous. A study by CWPRS (April 2025) reports significant land loss on the southern bank and subsequent deposition nearby [25]. Localities like Podumoni Gaon and Bhakat Sapori (also Bhakat Chapori) are in immediate danger. Cinnatoli Chapori, a small char/island region adjacent to the main southern bank, is often subject to rapid channel shifting and erosion. Kandhulimari, another chapori, is facing a gradual retreat due to increasing sinuosity and bankline migration.

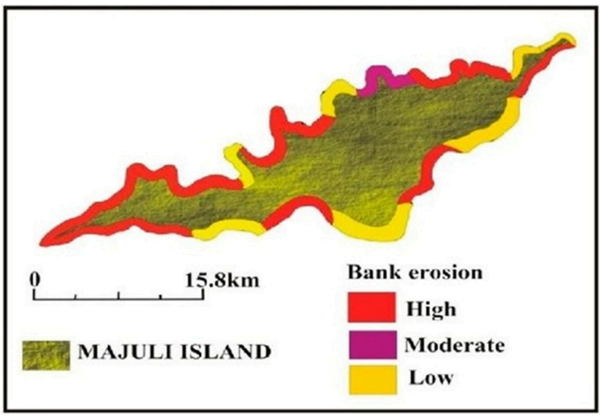

Figure 3. Major erosion hotspots.

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The erosion in these areas is not a new phenomenon. It has been ongoing for many years, exacerbated by events like the 1950 earthquake and subsequent floods. The loss of land has led to the displacement of people and loss of livelihoods.

Table 1. Number of families affected by erosion (2000-2012).

Year	Number of familiesaffected by erosion
2000	567
2001	63
2002	204
2003	100
2004	401
2005	471
2006	150
2007	564
2008	185
2009	52
2010	329
2011	132
2012	321
Total:	3539

The table illustrates the wildly varying yearly effects of river erosion from 2000 to 2012, which impacted 3,539 families overall. Significant increases in the number of impacted families occurred in 2000 (567) and 2007 (564), with additional peaks in 2004 (401), 2005 (471), and 2010 (329), most likely due to large-scale channel shifts or severe monsoon rivers overflowing their banks. On the other hand, troughs in 2001 (63), 2003 (100), 2009 (52), and 2011 (132) imply brief respites, most likely brought on by less precipitation.

Conclusion

Bank erosion along the southern margins of Majuli, driven by the dynamic and sediment-laden Brahmaputra River, remains a critical geomorphological and socio-cultural challenge. The recurring erosion is influenced by natural hydrological variability, upstream interventions, altered sediment regimes, and intensified monsoon patterns linked to climate change. Consequently, Majuli's landmass is shrinking, threatening settlements, satras (Vaishnavite monasteries), and agriculture. Addressing this issue requires an integrated river basin management approach rather than isolated structural measures. While embankments, revetments, and river training structures provide short-term stability, their success depends on appropriate design and alignment with river dynamics. Bioengineering methods, such as vet-based stabilization and riparian buffer restoration, offer sustainable and eco-friendly alternatives. Geospatial tools like remote sensing and GIS are crucial for monitoring erosion-prone zones and enabling data-driven planning. Equally important is community participation, where local knowledge and early warning systems enhance resilience. Long-term success depends on coordinated governance, inter-agency collaboration, and sustained funding. A balanced strategy combining engineering, ecological restoration, scientific monitoring, and community engagement is essential to protect Majuli's fragile riverine landscape.

Disclosure Statement

The Authors declare that there is no conflict of interest.

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