A study of erosion-deposition processes around Majuli Island, Assam

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Abstract

Majuli, the largest inhabited river island bounded by the river Subansiri to the north and mighty Brahmaputra River to the south, is one of the subdivisions of the Jorhat district, Assam. Erosion of the island is a continuous process since historical times and poses a significant concern. The present approach have been made to study the erosion-deposition processes with the help of data resource generated from the Survey of India (SOI) toposheets and Indian Remote Sensing (IRS) satellite imagery spanning the period from 1966-1975 to 2008 in a Geographical Information System (GIS) environment. The observation has revealed a dramatic change in reduction of land area of the Majuli Island. The land area as evidenced till 1966-1975, 1998 and 2008 were 706.14, 578.38 and 484.34 km² respectively. The total average annual rate of erosion and deposition covering the entire period were 8.76 km²/yr and 1.87 km²/yr. It can clearly be attributed that the island mass suffered significant rate of erosion than the depositional processes.

Key Words: River island, Erosion-deposition process, Majuli island, Brahmaputra river, Subansiri river, Assam

Introduction

The geographical extent of the study area (Fig.1) is 26°45′ N- 27°12′ N latitude and 93°39′E- 94°35′E longitude with mean height of 84.5 m above MSL. Majuli, bounded by the river Subansiri on the northwest, the Kherkatia Suti (a spill channel of the river Brahmaputra) in the northeast and the main Brahmaputra river on the south and the south west is regarded as the largest fresh water inhabited island of the world. Water yield of the Subansiri is 0.076 cumec/km² (Goswami, 1998). The Brahmaputra is a classic example of a braided river consisting of a network of interlacing channels with unstable bars and islands (locally known as chars). As the flow begins to rise with the onset of the monsoon, most of the islands are submerged and the river then flows in more or less single channel. The most striking feature is the continuous shift of the thalweg (deep channel) from one location to another within the bankline, its movement being high in the rising stage (May to August), most erratic during the falling stage (September to October) and minimal in the low flow stages (Goswami, 1998). The mechanism of braiding may be attributed as the affect of excessive sediment load, large and variable flow, erosion-prone banks and the rapid aggradation of the channel (Goswami, 1991, Leopold et.al, 1964).
Majuli is seriously affected by erosion of the Brahmaputra and the Subansiri rivers (Fig. 2, 3 and 4). The extreme braided nature of the Brahmaputra coupled with silt and sand strata of the banks is the main cause of erosion. Erosion in this area was not much before the 1950 earthquake of magnitude 8.6 Richter scale but became active thereafter and attained serious dimension after the 1954 flood. In 1987, Majuli suffered the most severe flood having lost 50,000 cattle and crop (Centre for Natural Disaster Management, Assam Administrative Staff College, Jawaharnagar, Khanapara). Porcupines are being used to control erosion only at a few places, but it has not been found to be effective (Fig.5). The area of the island has been reduced from 706.14 km² in 1966-1975 to 578.38 km² in 1998 and to 484.34 km² in 2008. Space Application Centre (SAC) and Brahmaputra Board (1996) jointly studied the river erosion problem of Majuli Island and identified the areas of the island which have undergone changes along the bankline due to erratic behavior of the river. Brahmaputra Board (1997) prepared a report where the area of the island was mentioned to be 925 km² in 1971. The erosion is a serious problem which threatens the existence of Majuli—one of the oldest cultural heritage site of Assam. Mani et.al (2003) studied the erosion affect around Kaniajan village in south Majuli using satellite data of 1991, 1997 and 1998 and reported a loss of 1900 ha during 1991 to 1997 and 845 ha during 1997 to 1998. Sarma and Phukan (2004) gave a comprehensive account on the origin and geomorphological changes including erosion and deposition in Majuli Island. Kotoky et.al (2005) studied the erosion and deposition of the island from 1914 to 1998 and revealed that the extent of erosion and deposition was not same for the period 1914–75 and 1975–98. The aim of this present study is to evaluate the migration of the rivers Brahmaputra and Subansiri, the locations of erosion and deposition and the rate of erosion and deposition in the island starting from 1966-1975 to 2008.
Fig. 2: Bank erosion by river Brahmaputra (at Bengena Ati).

Fig. 3: River bank under process of active erosion.

Fig. 4: Bamboo trees remained in the river after the bank has been shifted due to erosion.

Fig. 5: Existing Porcupines used to check the bank erosion.

Methodology

The present approach employs Survey of India (SOI) toposheets (1966-1975) and Indian Remote Sensing (IRS) satellite imagery (1998 and 2008) to investigate spatial changes over available period of time. Such information is considered valuable in providing information for a period of more than 33 years, which is often beyond the scope of empirical observation. The Survey of India toposheet nos.83F/5,6,9,13; I/4,8; I/1, 5 of 1966-1975 (scale 1:50,000) covering the study area were scanned, georeferenced and mosaiced and used to prepare the base map. The IRS 1B LISS II satellite imagery of 1998 and IRS P6 LISS III digital image of 2008 are registered to the base map using a set of Ground Control Points (GCPs) in ERDAS IMAGINE 9.1 software. Thematic maps of different periods were prepared on 1:50.000 scale and were integrated using ArcView GIS. The bank lines for different periods i.e. 1966-1975, 1998 and 2008 of the Brahmaputra and Subansiri Rivers,
which limits the south and north banks of the Majuli Island, were digitized and integrated with the help of Arc View GIS. The migration as well as the erosion and deposition caused by the rivers were studied by dividing the whole stretch of the island into 5 km long blocks. Then for each block the extents of migration as well as the amount of erosion and deposition are determined. Ground truth observations were made to prepare the interpretation key and Garmin Global Positioning System (GPS) was used to locate the latitude, longitude and altitude of the study sites. Geomorphic attributes of the flood plain, morphology of the channel and banks, and erosion/deposition activities have been evaluated from the toposheets, imageries and after proper field checking were used for interpretative use of the present study.

Results and Discussions

Bank-line Migration:

The sequential analyses of geomorphological maps (Fig.6) for the period from 1966-1975 to 2008 have been utilized to study the bank line migration for the stretch under study. The channel configuration of 1966-1975 was considered as the base line for evaluation of bank line migration during the period under study.

Migration of the Subansiri:

a)1966-1975 to 1998: The maximum migration was observed near Bohumari and Nunibari for a distance of about 3.12km towards south. The Subansiri migrated towards north for 0.64 km at the western end of Majuli causing deposition. Within 20 to 40 km towards east of the island, the river recedes away towards north for 2.02 km at Majar Chapor and for 2.86 km at Kumaligaon causing deposition. For the rest of the distance from 35 to 80 km the river migrated towards south with a maximum of 1.25 km at Chaporigaon and 1.21 km at Jengraimukh causing erosion (Fig. 7a).
**Fig. 7a:** Bankline Migration of Subansiri River during 1966-1975 to 1998.

**b) 1998-2008:** The major change that had occurred during this period was that the Subansiri river had shifted its course towards east and met Brahmaputra about 15 km ahead from its earlier confluence. Thereafter, the river migrated towards north about 1.58 km at Majar ChaporI which shows deposition of sediments to the island. In the block within 25 km to 35 km the river migrated towards south with a maximum of 2.71 at Aunati Jangal and with 0.8 km at Kumali gaon resulting in heavy erosion of the land area of Majuli Island. Next from 40 km to 80 km the river migrates towards north with a maximum of 0.55 at Khengmiligaon.

Fig. 7a clearly shows that the river Subansiri has migrated for a distance of more than 3 kms towards south at Bohumari and Nunibari. These two places also evidenced highest rate of migration during the period (Fig.7b) of total observation.

**Fig. 7b:** Bankline Migration of Subansiri River during 1998 to 2008.
Migration of Brahmaputra:

a) 1966-1975 to 1998: During the period of 1966-1975 to 1998, a significant change was observed in the migration of bank line of river Brahmaputra. The migration of bank lines during this period is presented in Fig.7c. Heavy erosion of the island was caused by Brahmaputra river during this period as the river migrates towards north at most of the places. The river channel had migrated for a distance of about 6.49 km near Mayadebi, 5.24 km near Manikmukh kuamargaon, 1.73 km at Bengena Ati and 4.24 kms near Khorapargaon (Fig. 7c).

![Bankline Migration of Brahmaputra River during 1966-1975 to 1998.](image)

b) 1998-2008: During the period of 1998 to 2008 it was evidenced that the Subansiri River had shifted its course and joined the Brahmaputra 15 km ahead of its earlier point of debouch in the western part of the Majuli Island. This results in erosion of Majuli Island and thereby decreasing the total area. The next stretch of 65 km mainly showed migration towards the north. The river migrated towards north about 1.53 km near Khorapargaon, 1.14 km near Bengena Ati, 1.53 km near Rajgurubari and 2.5 km near Ujani Gejargaon. In between, the river had migrated towards south at Khoraholgaon and Kapahchali for about a distance of 1.25 kms and 1.8 kms respectively with reference to the 1998 position of the river bank line.

Analysis on total observation covering the period from 1966-1975 to 2008, it was clearly visible that the river Brahmaputra has migrated for a maximum distance of about 6 km towards north near Mayadebi and Khorapargaon areas. However, near Bengena Ati and Ujani Gejargaon the bank line was migrated towards north of a distance of about 2.87km and 5.1 km respectively. From the present investigation it can clearly be attributed that there have been a continuous shift in the bank line of the Brahmaputra River channel indicating significant erosion affect at many places of the Majuli Island (Fig. 7d).
Erosion/Deposition activities around Majuli Island at different periods:

The activity of erosion deposition processes around Majuli Island with reference to the Subansiri (North) and Brahmaputra (South) Rivers have been evaluated for two successive periods i.e. from 1966-1975 to 1998 and 1998 to 2008. In the light of generated information an interpretative discussion have been attempted in the preceding sections.

Activities related to Subansiri River on the north:

a) During the period from 1966-1975 to 1998: The stretch up to 20km from the western end of Majuli Island suffered erosion with maximum at Bohumari and Nunibari of about 8.83 km$^2$ and 10.77 km$^2$ respectively. Thereafter, there was deposition of about 6.07 km$^2$ at Major Chapori and 12.26 km$^2$ at Kumolia gaon. The remaining stretch under study have shown normal processes of erosion and deposition. The total average annual rate of erosion and deposition during this period were 1.23 km$^2$/yr and 1.17 km$^2$/yr (Fig.8a)
b) During the period from 1998 to 2008: The erosion/deposition process in the later period of observation i.e. 1998 to 2008 have shown a dissimilar behaviour than the earlier period of observation. The island mass faces an extreme rate of erosion during the period than the depositional processes. The area near Nunibari has faced high intensity of erosion measuring about 17.82 km². At Auniati Jangal, the erosion was about 5.74 km² and a maximum intensity of erosion was observed near Michhamara measuring about 24.1 km². Deposition was not very prominent with only 3 km² at Majar Chapor and a maximum of 3.05 km² at Kheng mili gaon. It is clear from the observation that the bank on north of the Majuli Island was eroded away by the Subansiri River. The average annual rate of erosion and deposition were 5.05 km²/yr and 1.22 km²/yr respectively (Fig.8b).

![Erosion/deposition activities on North bank of Majuli Island during 1998-2008.](image)

**Fig.8b:** Erosion/deposition activities on North bank of Majuli Island during 1998-2008.

Activities related to Brahmaputra River on the south:

a) During the period from 1966-1975 to 1998 : The stretch under study on the south bank of the Majuli Island underwent extensive erosion. The areas around Mayadebi and Baghgaon have evidenced maximum intensity of erosion up to 25.44 km² and 18.94 km² respectively. However, the stretch from 45 to 50 km from western side of Majuli near Bengena Ati the bank also faced an intensity of erosion about 5.45 km². The areas around Manimukh-Kumargaon and Ujani-Gejargaon towards the eastern end of the island faces an erosion activity up to a maximum of 10.64 km² and 9.52 km² respectively. The western end of the island and at Chelekha gaon have evidenced depositional activities measuring 9.08 km² and 2.45 km² respectively. The average annual rate of erosion and deposition during this period on the souther bank of the Majuli Island were 4.73 km²/yr was 0.42 km²/yr respectively (Fig.8c).

d) During the period from 1998 to 2008 : The period represent increasing intensity of erosion due to the shifting of bankline of the Brahmaputra river towards the north. The initial stretch of 20 km from the western side suffered erosion with maximum of 16.58 km² near Kerkegaon. Shalmari has evidenced erosion of 10.52 km² whereas at Baghgaon the river washed away an area of 7.49 km². In the eastern end of the island Namani Gejegaon and Ujani Gejera gaon measured erosions of 9.07 km² and 8.15 km² respectively. Near the Bengena Ati Satra an erosion of 3.65 km² has been observed. Deposition occurred in the stretch from 30 to 60 kms with a maximum of 4.04 km² at Manimukh Kumaragaon and 2.03 km² at Khorahol gaon. The annual erosion was 6.51 km²/yr and the annual deposition was 0.94 km²/yr (Fig.8d).
**Fig. 8c:** Erosion/ deposition activities on the South bank of Majuli Island during 1966-1975 to 1998.

**Fig. 8d:** Erosion/ deposition activities on South bank of Majuli Island during 1998-2008.

The area of the Majuli Island and area added (deposition) or washed away (erosion) as evidenced from the study during different periods (1966-1975, 1998 and 2008) are as follows:

- **Area in 1966-1975** = 706.14
- **Erosion (66-75 to 98)** = 171.91
- **Deposition (66-75 to 98)** = 44.15
- **Area in 1998** = (706.14 - 171.91) + 44.15 = 578.38 km²

- **Area in 1998** = 578.38 km²
- **Erosion (98-08)** = 115.58
- **Deposition (98-08)** = 21.54
- **Area in 2008** = (578.38 - 115.58) + 21.54 = 484.34 km²
**Rate of average annual erosion and deposition:**

The average annual erosion and deposition are given by the total area of erosion and deposition divided by the period of years. It gives the amount of erosion or deposition in each year. The rate of average annual erosion and deposition per unit length is given by average annual erosion or deposition divided by the stretch in kilometers. Spanning the period over 1966-1975 to 2008 the study attributed that the total average annual erosion and deposition covering the entire period were 8.76 km²/yr and 1.87 km²/yr respectively. Comparatively higher erosion potential was confined to the south bank of Majuli Island than the north bank. The south bank of Majuli Island showed a higher rate of average annual erosion per unit length of 0.08 km²/km by the Brahmaputra River than 0.046 km²/km of the north bank of the island by Subansiri (Table-1).

Also the annual rate of erosion from 1998-2008 was much higher than that of the period 1966-1975 to 1998. 1966-1975 to 1998 showed an annual rate of erosion per unit length of 0.074 km²/km and 1998-2008 showed a much higher erosion rate of 0.178 km²/km. Thus, the present erosion rate was much more than that of the previous years. Thus heavy erosion threatens the existence of Majuli.

**Table-1:** Erosion and deposition along the stretch of Majuli at different time periods.

<table>
<thead>
<tr>
<th>Period</th>
<th>River</th>
<th>Average Annual Erosion (km²/yr)</th>
<th>Average Annual Deposition (km²/yr)</th>
<th>Rate of Average Annual Erosion per unit length (km²/km)</th>
<th>Rate of Average Annual Deposition per unit length (km²/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966-1975 to 1998</td>
<td>Subansiri</td>
<td>1.225</td>
<td>1.166</td>
<td>0.015</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>Brahmaputra</td>
<td>4.73</td>
<td>0.422</td>
<td>0.059</td>
<td>0.0052</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>5.955</td>
<td>1.588</td>
<td>0.074</td>
<td>0.0202</td>
</tr>
<tr>
<td>1998-2008</td>
<td>Subansiri</td>
<td>5.05</td>
<td>1.22</td>
<td>0.078</td>
<td>0.0188</td>
</tr>
<tr>
<td></td>
<td>Brahmaputra</td>
<td>6.51</td>
<td>0.94</td>
<td>0.100</td>
<td>0.0145</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>11.56</td>
<td>2.16</td>
<td>0.178</td>
<td>0.0333</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td></td>
<td>8.76</td>
<td>1.87</td>
<td>0.126</td>
<td>0.0267</td>
</tr>
</tbody>
</table>

**Conclusion**

The fresh water river island Majuli have suffered a significant rate of erosion since historical time. Observation on the bank line migration spanning the period from 1966-1975 to 2008 an extensive rate of migration was observed. The bank line of the Brahmaputra Rivers has migrated for a distance of about 6 km towards north at Khorapargaon and 5.1 kms near Ujani Gejeragoan. The bank line of the Subansiri River has shown its migration up to a distance of more than 3km towards south specifically around Bohumari and Nunibari areas.

The study has clearly attributed that the total average annual rate of erosion and deposition covering the entire period were 8.76 km²/yr and 1.87 km²/yr respectively. The south bank of the Majuli Island shows higher rate of annual erosion per unit length of 0.08 km²/km by the Brahmaputra River than the Subansiri River on the north amounting of
0.047 km²/km. The areas around Majar Chapor, Mayadebi, Baghgaon and Bengena Ati have suffered extensive intensity of erosion.

The average annual rate of erosion per unit length from 1998-2008 was much higher than that of the period 1966-1975 to 1998. An average annual rate of erosion per unit length of 0.074 km²/km was observed during the period 1966-1975 to 1998 where as higher average rate of erosion rate of 0.178 km²/km was observed during the period 1998-2008. The present erosion rate was more than double that of the previous years. Thus, the erosion of the world's largest inhabited river island Majuli should be considered as a national problem and should be addressed in time to stabilize ecological balance.

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