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Erosion Study of a Part of Majuli River-Island Using Remote Sensing Data

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ABSTRACT

Majuli, the world's largest river island, is situated in mid of river Brahmaputra in Assam. River Brahmaputra flows in highly braided channels most of them are transient in nature, being submerged during high monsoon flows and changing drastically their geometry and location. Majuli island, home of about 1.3 million people is endangered because of the erratic behavior of the river. In this study, an attempt has been made to observe the trends of erosion in a small part of Majuli island, the area near Kaniajan village in south Majuli- a stretch of about 11 km, using satellite data of 1991, 1997 and 1998. Image processing of digital data has been done in ILWIS software. Supervised for delineation of river from land and then change detection analysis has been done to find out changes in river course from 1991 to 1997 and further from 1997 to 1998. Erosion and deposition maps of the area have been prepared and the erosion of island is measured at various sections at 1 km interval. Erosion of 1900 ha has been observed during the period of six years from 1991 to 1997 and 845 ha during the period of one year from 1997 to 1998.

Introduction

Brahmaputra river is characterised by high seasonal variability in flow, sediment transport and channel configuration. In the valley of Assam, it flows in a highly braided channel with the presence of numerous laterals as well as mid channel bars and islands. Most of them are transient in nature, being submerged during high monsoon flows and drastically their geometry and location. The very existence of Majuli, the world's largest river island and home of about 1.3 million people, based on 1991 census, is endangered because of this erratic behavior of the river. The severity of the erosion might be understood from the fact that the area of island, including some sand chars and chaparis (local names for the numerous small and relatively recently formed islands near the main island) has reduced from 1246 km^2 in 1950 to 925 km^2 in 1971.

Remote sensing satellite data having ability to provide comprehensive, synoptic view of fairly large area at regular interval with quick turn around time makes it appropriate and ideal for studying and monitoring river erosion and its bank line shifting. NRSA (1980) has done the river migration study of river Brahmaputra using

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airborne scanner survey. The study was performed with the objective of to map the area adjacent to main stream of Brahmaputra river for studying the river migration status and the effectiveness of the existing flood control works and to suggest improvements. It has been further recommended to carry out repetitive survey to monitor changes in landuse, river channels and banks and associated features to provide a base for estimating the response of the rivers to flood events. Bardhan (1993) studied the channel behavior of the Barak river using satellite imagery and other data to identify the river stretches, if any, which remained reasonably stable during the period 1910-1988. SAC and Brahmaputra Board (1996) jointly took up a study to access the extent of river erosion in Majuli island. The work has led to identify and delineate the areas of the island which have undergone changes along the bankline due to dynamic behaviour of the river. Based on this report and other collateral data, Brahmaputra Board (1997) has prepared a status report on the erosion problem of Majuli Island and reported its area as 925 km^2 based on 1971 survey. Reports mentioned the locations of sever erosion only without any quantitative assessment and recommended some remedial measures of the problems and further monitoring of the island. Mani and Patwary (2000) studied the trend of the erosion in the Majuli island and reported the area of main island as 486 km^2 using IRS 1C LISS III data of January 2, 1997. In this paper, an attempt has been made to observe the trends of erosion in a small portion of Majuli island using multispectral multidate digital data. All image processing and data analysis has been done in ILWIS software.

Study Area

The area near Kaniajan village in south Majuli, severely affected by erosion, has been selected for the study. The geographical extent of the study area (Fig. 1) is 94° 9' E to 94° 17' E longitude and 26° 51' N to 26° 55' N latitude and extending from to Kalitagaon to Gohaingaon. The Brahmaputra river has bifurcated in this region and a comparatively smaller bifurcation flows south of main Majuli island and divides sand chars and chappari from main island. Further a spill channel (Chumoimari-Kaniajan spill Channel) emerges from the north bifurcation and afterwards joins the main river. The major bifurcation flows between south of char and north of Niamati ghat. The sand char is full of tall grasses and remains almost under water during high monsoon flow. Fig. 1 shows the study area.

Methodology

Survey of India toposheets 83 J/1 and 83 J/5 at 1:50,000 scale, (year of survey 1971-72) were scanned, georeferenced and mosaiced. Multi-spectral satellite data of IRS 1A LISS-II (hardcopy FCC) of date March 28, 1991 and IRS 1C LISS-III of date January 2, 1997 and December 28, 1998 have been used in this study. FCC (LISS-II data) is also scanned, registered and resampled to 24 m pixel size to keep the uniformity in data set. Registration of satellite images with SOI topo sheets are done and thereafter study area is extracted. Supervised classification of data has been done to delineate river bank line from land. The thematic maps of the study area showing only "river" and "land" for three dates namely; March 28, 1991, January 2, 1997 and December 28, 1998 are prepared. The river bank line as delineated from satellite data of IRS 1A LISS-II (hardcopy FCC) of date March 28, 1991 is considered as the base map and any changes observed in subsequent images are measured with reference to this base map. Change detection analysis is performed to find out changes from 1991 to 1997 and from 1997 to 1998. Verification of results/interpretation by interaction with local people (officials/students from the area) have been carried out and accordingly results are modified. As the images of IRS 1C LISS-III data are used for the measurement of all the changes and therefore any change measuring more than 3 pixel size i.e. 3×24 m ~ 75 m is observed.

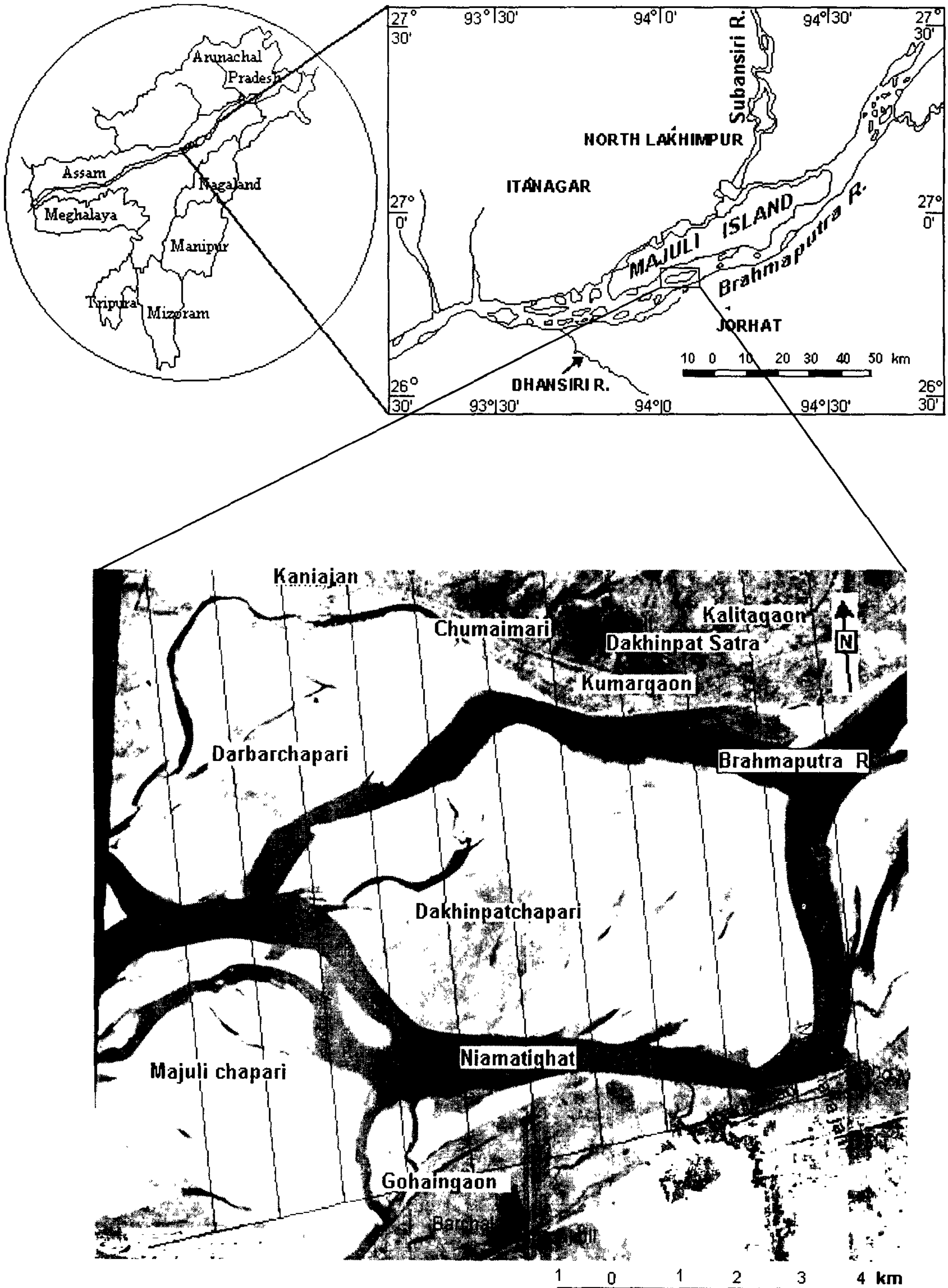

Fig. 1. Study Area

As the river is flowing in east-west direction and eroding/depositing the island either in its north or south bank, sections in the north-south direction has been drawn at 1 km interval and the shift of the river (bank line) is measured along these sections as shown in Figs. 2a, 2b, 3a and 3b.

Results and Discussion

Digital data of the year 1997 and 1998 is only available while hardcopy FCC of the area was available for the year 1991. This hard copy FCC is scanned and thus digital data of the area for 1991 is generated. The error generated from this may be ignored as this data is used for delineation of river bank from land, two classes widely separated spectrally. Thus not much error is expected to propagate in the classified maps (thematic maps). On evaluation of digital signature of various classes (water body, river sand and land mass), large variations are observed. Even water course in river is showing various tones probably, because of their varying depths and sediment concentrations. Similar behaviour is observed in case of river sand and land mass. Therefore, while defining the training set for supervised classification, number of classes are defined for water body, land and river sand separately. After classification of the images using maximum likelihood algorithm, these classes are merged judiciously to finally represent only two classes namely, river and land (Rao, 1999).

Change detection technique is utilized for evaluating the erosion or deposition. It is assumed that any pixel of class "river" in thematic map of previous year showing class "land" in thematic map of subsequent year is because of deposition. Similarly, pixel of class "land" in thematic map of previous year showing class "river" in thematic map of subsequent year is because of erosion. It has been observed that though river erosion is prominent in the study area, at a few locations deposition has also taken places. Some of these locations have been inquired and/or physically verified. The closing of small rivulets in some areas has reduced the erosion and during course of time, these areas have been developed and are now used for agriculture purposes. Figs. 2a and 2b show the erosion map during 1991 to 1997 and during 1997 to 1998 respectively. Black patch shows that in the previous year the particular area was a developed landmass and due to erosion by river it has now become the part of the river. Similarly, Figs. 3a and 3b show the deposition map during 1991 to 1997 and during 1997 to 1998. In these figures the black patches shows that the area was earlier part of the river course but now has fully or partially developed as landmass.

For the detailed estimation of erosion and deposition, measurements are made at different sections at 1 km interval and the magnitude of shift of river is calculated. Erosion of 1900 ha has been observed during the period of six years from 1991 to 1997. Further, erosion of 845 ha has been observed during 1997 to 1998. Thus the average rate has increased from 335 ha/year to 845 ha/year. From the erosion and deposition maps as shown in Figs. 2a, 2b, 3a and 3b, section-wise status of erosion/deposition have been measured as detailed below:

Section-1: During 1991 to 1997, left bank shifted southward by 350 m and right bank has shifted northward by 1700 m. Also a landmass of 290 m width appearing in the imagery of year 1991 has developed to 650 m width. Further another landmass has been eroded from 2050 m to 550 m width. During 1997 to 1998 Left bank has been shifted by about 100 m southward and right bank is shifted northward by about 300 m. Further, both the land mass of about 650 m and 550 m wide are eroded away.

Section-2: During 1991 to 1997 left bank shifted southward by 680 m and right bank has shifted northward by 1600 m. Also a landmass of 850 m width appearing in the imagery of year 1991 has developed to 1350 m width. During 1997 to 1998 Left bank has been shifted by about 350 m southward and right bank is shifted northward by about 600 m.

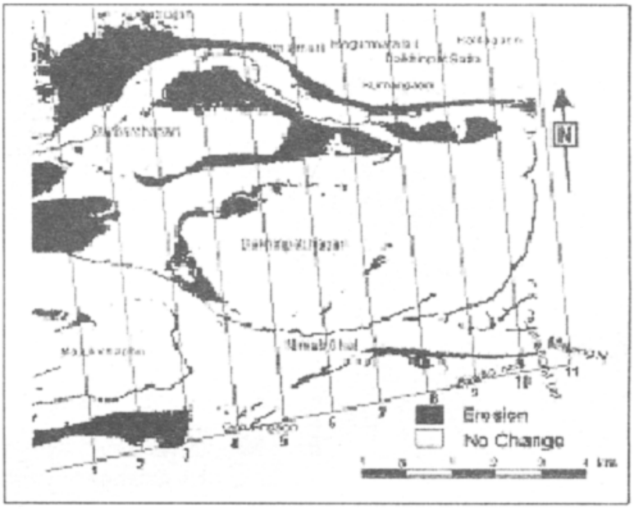

Fig. 2a. Map showing erosion during 1991 to 1997

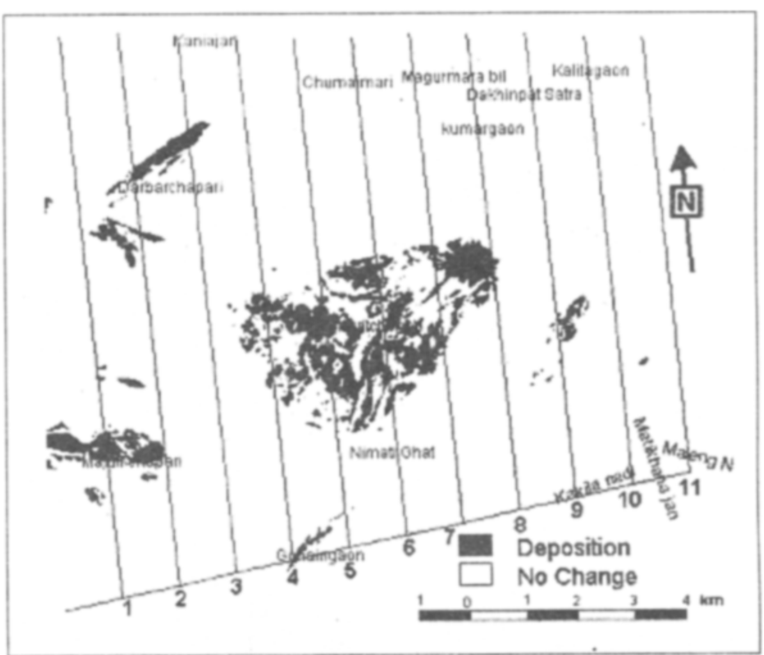

Fig. 2b. Map showing erosion during 1997 to 1998

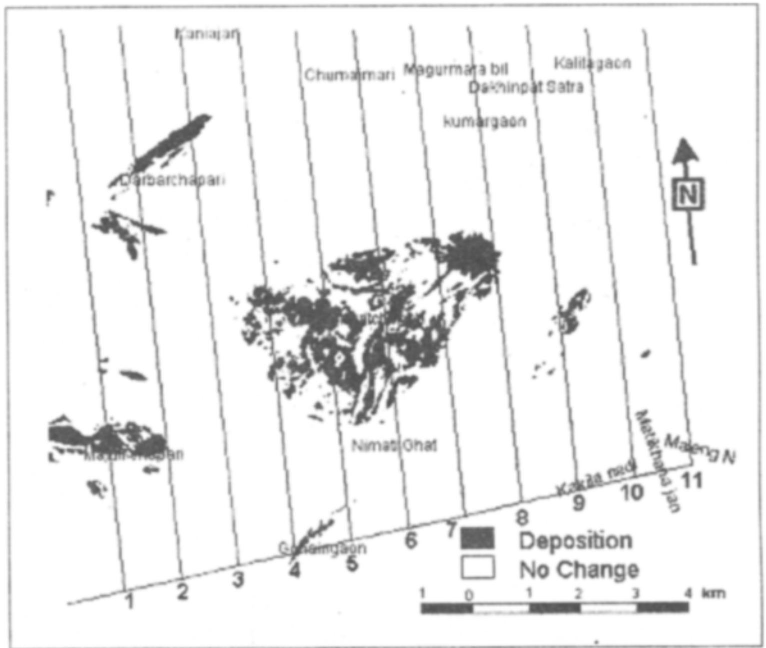

Fig. 3a. Map showing deposition during 1991 to 1997

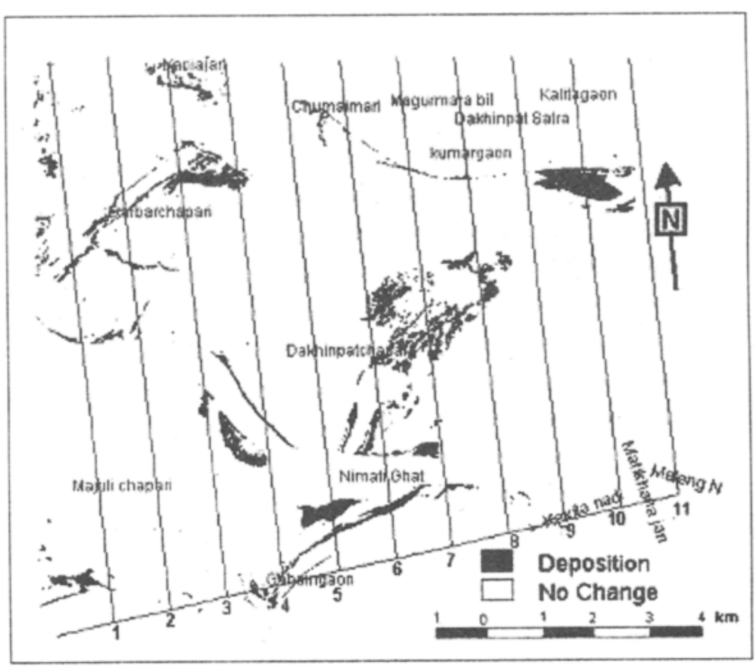

Fig. 3b. Map showing deposition during 1997 to 1998

Section-3: During 1991 to 1997 left bank shifted southward by 1200 m and right bank has shifted northward by 850 m. During 1997 to 1998, no change has observed.

Section-4: During 1991 to 1997 left bank shifted southward by 100 m and right bank has shifted northward by 300 m. Also a landmass of 1400 m width has been eroded. Another land mass of 1500 m width that is under development during 1991 has been developed fully to 1900 m width. During 1997 to 1998 no change has been observed on either left or right bank while the two land masses have been eroded by 350 m and 900 m, respectively.

Section-5: During 1991 to 1997, no change in left bank has been observed while north stream has eroded its right bank by 200 m and left bank by 750 m. A landmass of 1500 m width has been developed while another landmass of 1000 m width has been eroded. During 1997 to 1998 no change has been observed on left bank while right bank has shifted northward by 300 m. landmass of 1000 m width has been eroded while another landmass of 450 m width has been developed near southern stream.

Section-6: During 1991 to 1997, left bank is shifted by 100 m southward while right bank is shifted by 500 m northward. A landmass of 3000 m width has been developed while another landmass of 1000 m width has been eroded by joining of north and south streams. During 1997 to 1998 no change has been observed.

Section-7: During 1991 to 1997, left bank is shifted by 250 m southward while right bank is shifted by 200 m northward. A landmass of 600 m width has been eroded by joining of north and south streams. During 1997 to 1998 no change has been observed.

Section-8: During 1991 to 1997, left bank is shifted by 400 m southward while right bank is shifted by 200 m northward. A landmass of 200 m width is developed. During 1997 to 1998 no change has been observed.

Section-9: During 1991 to 1997, no change in the left bank is observed while right bank is shifted by 150 m northward. A landmass of 450 m width is eroded. During 1997 to 1998 no change has been observed on the right bank while left bank is shifted by 100 m southward.

Section-10: During 1991 to 1997, left bank is shifted by 100 m southward while right bank is shifted by 150 m northward. A landmass of 200 m width is eroded. During 1997 to 1998, right bank has shifted southward by about 550 m while No change on the left bank has been observed.

Conclusions

It is observed that during the period of six years from 1991 to 1997 the Brahmaputra, in general has eroded its both the banks - island side on north (right bank) and Niamatighat side on south (left bank). During March 1991 and January 1997, left bank has been eroded as much as 1200 m at section-3 and about 1700 m on right bank. Also, the small-bifurcated stream of the main Brahmaputra river has shifted towards north direction and thus eroding the Majuli island from its south side. Further, it has been observed that deposition is taking place in the left bank of smaller bifurcated stream (towards sand char side). Total 1900 ha land has been eroded during the period while deposition has taken place over 700 ha of land.

It is also observed that during the period of one year from 1997 to 1998 the erosion on either side of the river is comparatively very less considering the 1998 flood. Except at section 1, 2 and 5 (Chumoimari-Kaniajan spill channel) where river bank has migrated upto 300, 600 and 300 m respectively towards Majuli side; it appears, there is no change in the river bank line. This may be due to bamboo protection of the river bank done by local people and NGOs. Also, no change on the left bank of river may be attributed to the clay nature of soil. However, exact reason for this aspect, could not be ascertained. Further, about 450 ha land has been eroded during the period while deposition has taken place over about 500 ha.

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