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Geospatial assessment on the occurrences of erosion and pattern of channel migration of river Brahmaputra along the Majuli Island of Assam

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Abstract: Majuli Island of Assam has been suffering heavy erosion through ages, whether it is bankline or surface soil erosion. The Brahmaputra and Subansiri rivers are the main cause of the depletion of this island since they change their course after every flood event since the plains of the Assam suffer from heavy rains during monsoon. The river also erodes the surface picking up a lot of sediment from the area. So, the process of erosion and deposition continues every year. Geospatial technology combined with unmanned aerial vehicle (UAV) remote Sensing (UAV-RS) has been effectively used to assess the changing scenario and channel migration pattern of Brahmaputra along the island over a span of 40 years from 1976 to 2017. A part of Majuli breached by the river during flood was mapped and studied. Deposition is prominent at the right bank from the right side, but gradual erosion hinders the middle part. Therefore, the river was found widening at the middle part. This has in turn reduced the land surface of the island due to which Majuli has been shrinking and sinking over the years and it has been estimated that it will disappear in 10-15 years if such circumstances continue to prevail and no preventive measures are taken.

Keywords: Erosion, Geospatial technology, UAV, Brahmaputra

1. Introduction

Majuli is the largest river island in the world in the Brahmaputra river, Assam, India and also the first Island district of the country. The island had a total area of 1,250 sq km at the beginning of the 20th century (Sharma and Acharjee, 2012), but having lost significantly to erosion, an area of only 352 sq km in 2014 has been estimated (Lahiri and Sinha, 2014). Majuli has shrunk as the river surrounding it has grown (http://majulilandscape.gov.in/geography.php). The island (Figure 1) was formed by the Brahmaputra river in the South and the Kherkutia Xuti, a branch of the Brahmaputra, joined by the Subansiri river in the North (http://en.wikipedia.org/wiki/Majuli). It was simply a landform formed out of continuous depositions of sand due to the changing course of rivers viz. The Brahmaputra flows to the north of Majuli and one of its tributaries- the Dihing, flowing south of Majuli which received the Dikhow, Jhanji, Bhogdoi, Dhansiri rivers and some other small tributaries to meet the Brahmaputra at Lakhu. Physiographically, Majuli has an undulating land form. The river Brahmaputra and its tributaries were shifting southward, eastward and westward as part of the change of course in the river. As the main course of river Brahmaputra (Lohit) was much wider than the course of river Dihing, the northwestern part of Majuli was majorly affected by annual flooding. This resulted in the constant deposition of sand and the introduction of new plant species on the land. Majuli has been suffering huge erosion problems, whether it is bankline erosion or surface soil erosion, caused mainly due to the annual floods during the monsoon season when the Brahmaputra river swells up. Brahmaputra Board in 1997 prepared a report where the area of the island is mentioned to be 925 km^2 in 1971 (http://www.brahmaputraboard.gov.in/NER/Archive/Archive.html).

1.1 Geospatial technologies for soil erosion study

Geospatial technology has proven to be a significant tool for erosion studies on a large scale since field studies for prediction and assessment of soil erosion are expensive, time-consuming and need to be collected over many years. Though providing a detailed understanding of the erosion processes, field studies have limitations because of complexity of interactions and the difficulty of generalizing from the results (Saha et al., 1992). 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 behaviour of the river (Gogoi and Borpujari, 2014). Mani et al., 2003 studied the erosion affect around Kaniajan village in south Majuli using temporal satellite data to estimate land lost due to erosion. Temporal data from satellite imageries also play as an important tool to identify the channel migration pattern of river banklines over the years. Sarma and Phukan (2004) gave a comprehensive account of the origin and geomorphological changes, including erosion and deposition in Majuli Island (Sarma and Phukan, 2004). Kotoky et al., 2004 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 (Kotoky et al., 2004).

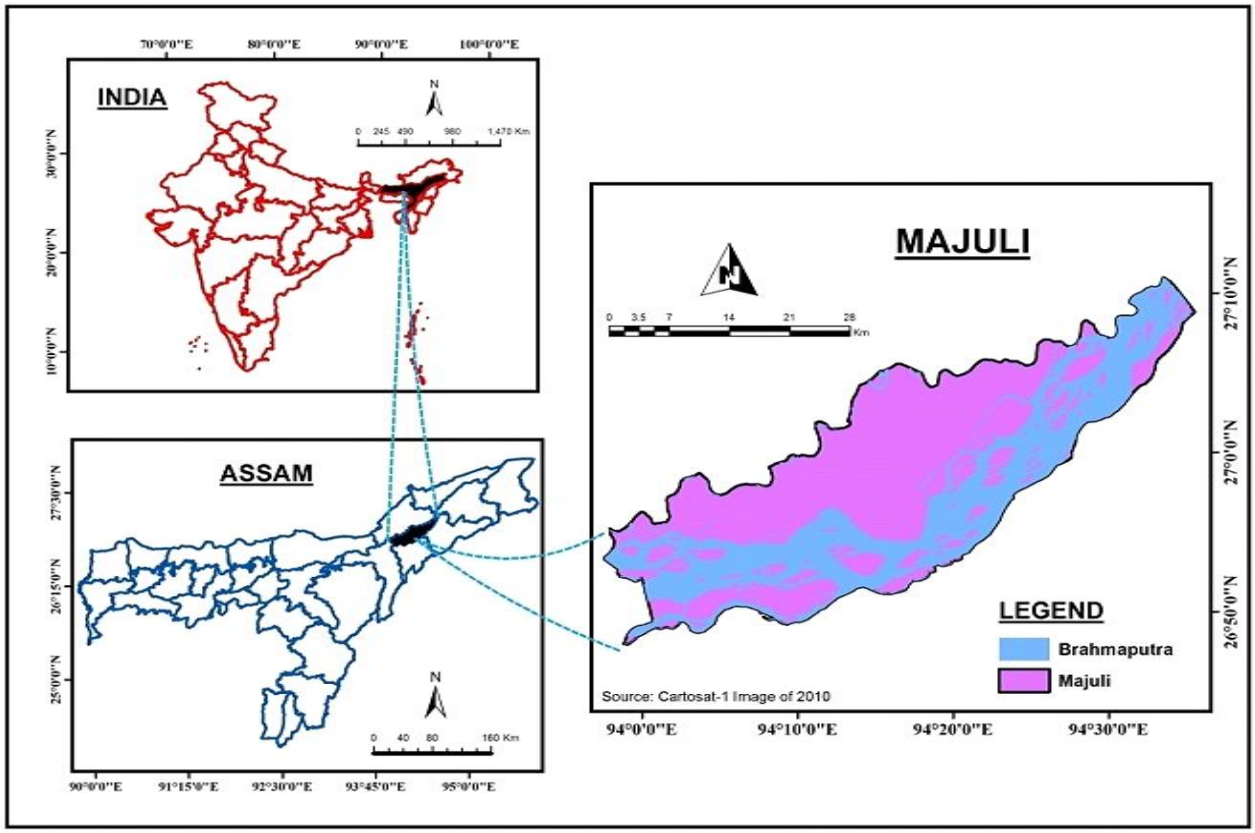

Figure 1: Geographical location of Majuli Island of river Brahmaputra

1.2 Scope and objective

Water erosion is the most widespread form of land degradation and occurs widely in all agro-climatic zones. The displacement of soil material by water can result in either loss of topsoil or terrain deformation or both. This category includes processes such as splash erosion, sheet erosion, rill or gully erosion. The result is more loss of fertile topsoil and plant nutrients. In some cases where subsoil has kankars, lime nodules, etc will get exposed on the top thereby altering the pH regime of the surface soil and subsequent nutrient holding capacity and their availability to plants. Majuli has been suffering huge erosion problems.

The main objective of this work is to assess the occurrences of erosion and pattern of channel migration of river Brahmaputra along the Island over a span of 40 years from 1976 to 2017.

2. Geospatial data and methodology

Satellite images of last 40 years from 1976 to 2017 (1976, 1989, 1999, 2009 and 2017) of Landsat Multispectral Scanner (MSS) of Landsat-1, Landsat-2, Landsat-4 and Landsat-5 with 60 m spatial resolution, 0.5-1.1 µm spectral range, Landsat Thematic Mapper (TM) of Landsat 4 and Landsat 5 with 30 m spatial resolution with 0.45-0.90 µm spectral range and Operational Land Imager (OLI) of Landsat 8 with 30 m spatial resolution with 0.45-0.90 µm spectral range have been utilized to study the fluvial geomorphology of the Brahmaputra river around Majuli Island. Geospatial technology supported by the sophisticated UAV for acquiring high resolution satellite imagery was effectively used for estimation damage caused by the floods on a real time basis. The ground pixel resolution of the UAV image was 5 cm which was flown at a 100 m height from msl in a breaching location in Majuli Island, Assam.

Bankline digitization is done for each year and then these banklines are overlaid approximately at 10 years of interval i.e. 1976-1989, 1989-1999, 1999-2009 and 2009-2017 and then an overall from 1976 to 2017 to analyze the changes. Bankline migration was measured taking 17 cross-sections using the recent channel pattern for each interval to observe the areas being continuously eroded. Bankline migration of the river along with location of 17 cross-sections during time frame 1976 to 1989, 1989 to 1999, 1999 to 2009 and 2009 to 2017 are shown in figure 2, figure 3, figure 4 and figure 5 respectively. The rate of erosion and fill were calculated for the part of Brahmaputra River, which falls within the study area.

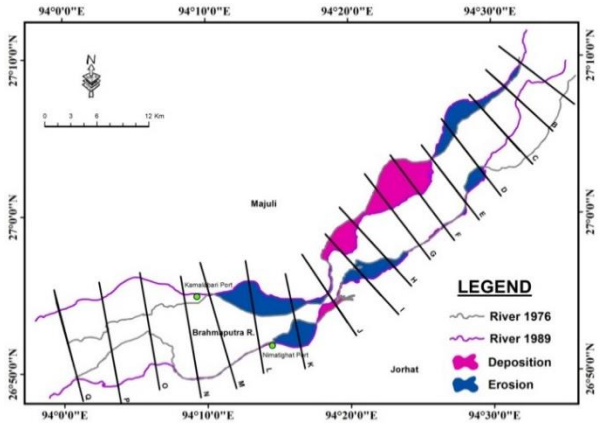

Figure 2: Bankline migration from 1976 to 1989

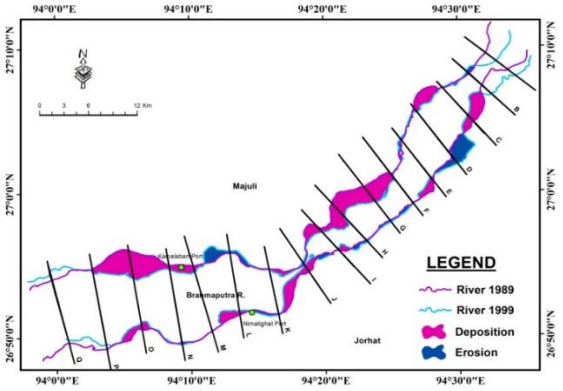

Figure 3: Bankline migration from 1989 to 1999

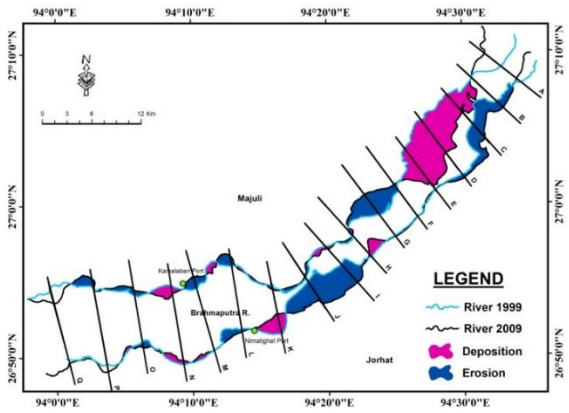

Figure 4: Bankline migration from 1999 to 2009

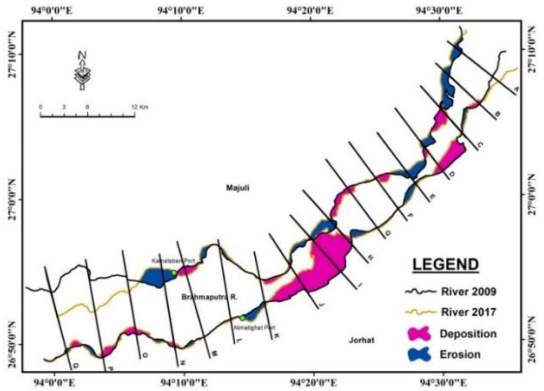

Figure 5: Bankline migration from 2009 to 2017

3. Results and discussion

The river Brahmaputra is flowing from north to south from the high Himalayas of Tibet through Arunachal Pradesh to the plains of Assam, the shifting of the river means shifting the bankline towards the eastern or western side. It was observed that Brahmaputra River below Majuli has been changing patterns continuously over the years.

Except the sections A and B, deposition is more dominant along the both banks of the river which indicates shifting of the channel towards eastern side and narrowing of the river except the sections K to O where the river is widening over the time (Figure 5). Since 1976, the river at the right bank has been continuously eroding the land at the cross sections J (1089.87 m) and L (5572.87 m). Along the left bank (Figure 7), the land being eroded continuously since 1976 is at the section G (423.01 m). The braided channel of the river strikes the bank directly and undermines the silty bank causing overhanging blocks to be carried away easily by the river current. Minus sign (-) in the figure 6 and 7 indicates shifting of the river due to erosion and plus sign (+) indicates shifting due to deposition. Approximately 85.23 sq. km area has been eroded and 135.38 sq. km area deposited since 1976 on both the banks.

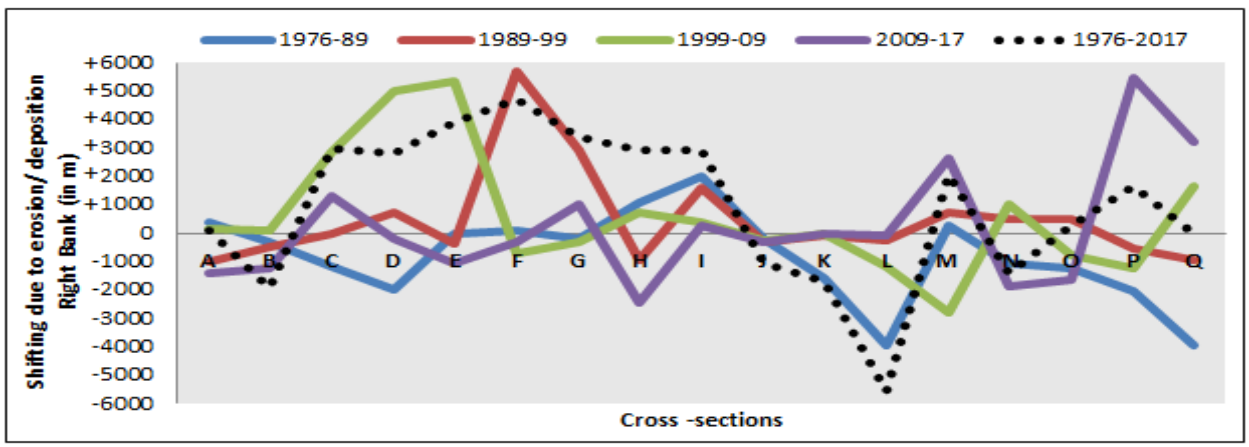

Figure 6: Shifting of the right bank of the Brahmaputra river from 1976-2017 due to Erosion and Deposition

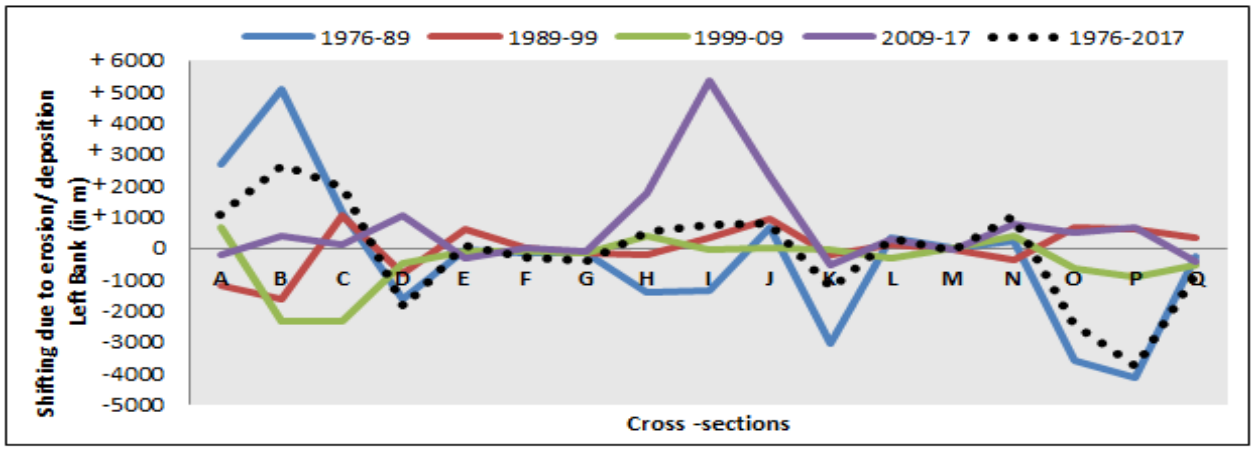

Figure 7: Shifting of the left bank of Brahmaputra river from 1976-2017 due to Erosion and Deposition

Erosion mostly affected the agricultural area and grazing land. The study also helps in understanding the probable erosion affected villages in Majuli. Approximately around 19 villages have been affected to a large extent due to erosion problem and they are under the threat of being completely eroded in coming years (Table 1). A number of important Satras (Satras are treasure troves of cultural artifacts) like AuniatiSatra and Kamalabari etc. are severely affected (Nath, 2012). The main river ports, i.e. Nimatighat and Kamalabari ports were seen shifting from their original location over the years. Nimatighat port has shifted about 0.56 km South and Kamalabari port about 0.65 km North. An example of the image captured by UAV from 100m height is depicted in the figure 8.

Table 1. Erosion Affected Villages

Feature	Village	Feature	Village
0	Bhogpur Satra	10	Borboka Pathar
1	Sekuli Pathar	11	Atoi Chuk
2	Kamjan Alengi	12	Katoni Gaon Na-Satra
3	Lahalial	13	Dakhinpat Satra
4	Potia Gaon	14	Bessa Mara
5	Bhogpur Pathar	15	Sumoi Mari
6	Pohardia	16	Auniati Lekhraj
7	Kamalabari Satra	17	Goroi Mari
8	Radha Chapari	18	Burha Kalita
9	Phutuka Pathar		

Figure 8: UAV image captured from 100m height

The image was acquired with a ground pixel resolution of 5 cm taken in a breaching location in Majuli Island, Assam. The scene shows that the embankment which was breached due to the flood during August 2016. This was also the major road in the villages in and around Samaria. A new path was constructed for the villagers. It was reported that water levels are now receding; however, significant challenges remain to be overcome. The late floods destroyed all agricultural crops and they have also hindered the planting season. Large scale classified image of the UAV data showing breaching location is shown in the figure 9. Geospatial technology supported by the sophisticated UAV for acquiring high resolution satellite imagery can be effectively used for estimation damage caused by the floods on a real time basis.

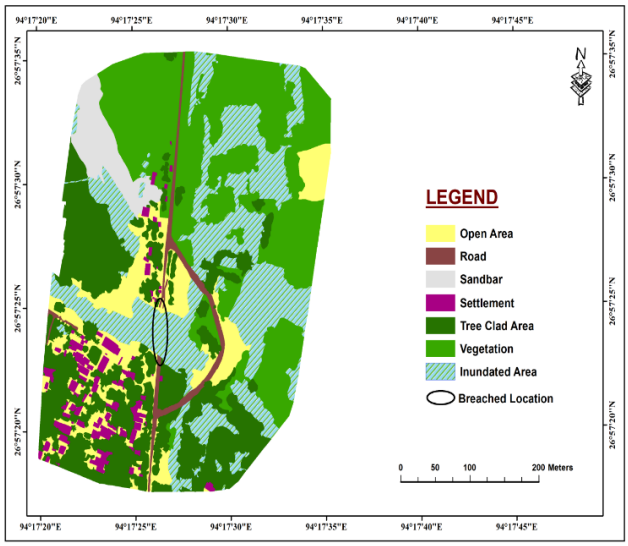

Figure 9: Large scale classified map showing breaching location

4. Conclusion

Majuli is getting eroded continuously due to the erosive nature of the surrounding rivers i.e. Brahmaputra and Subansiri rivers. Among them Brahmaputra is highly destructive, creating a lot of commotion around Majuli. In this paper, bankline migration of the Brahmaputra and its effects around Majuli has been examined. From 1976 to 2017, the bankline of the river changed significantly. Deposition is prominent at the right bank from the right side, but gradual erosion hinders the middle part. Therefore, the river is found to be widening at the middle part. This has in turn reduced the land surface of the island due to which Majuli has been shrinking and sinking over the years and it has been anticipated that a major part of Majuli will disappear within 5-10 years if this process continues to prevail for long without taking up preventive measures in a planned and scientific manner.

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