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Evolution of the Morphology of the River Brahmaputra Due to Vegetative Cover Changes

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ABSTRACT

The response of fluvial morphology deserves attention because of its large impacts on landscape and riverine habitats. With the help of multi-date digital satellite data, the evolution of the morphology of the river Brahmaputra has been reconstructed. The multi-spectral vegetation index like Normalised Difference Vegetation Index has been tested to provide new information and improved sensitivity to vegetative cover.

The results of this research indicated that the fluvial morphology in the Brahmaputra valley has changed considerably as a result of shifts in vegetative cover. The study vividly portrayed that the loss of vegetative cover in the basin was about 10% and the increase in sediment load at Pancharatna, near the downstream end of the basin was found to be about 12% during the study period 1990 - 2002

KEYWORDS : River Morphology, River Vegetation, Remote Sensing; Brahmaputra River

Introduction

Changes in floodplain sediment dynamics and the shape of the riverbanks have profound effects on riverine habitats and on the biodiversity of the riparian zone. In the past, the fluvial morphology of the river Brahmaputra has changed considerably under the influence of vegetative cover. These morphological changes have attracted considerable scientific attention (Rogersa and Schumm, 1991; Orbock Miller et al., 1993; Kazanca et al., 2004). This profoundly changes water and sediment supply to the rivers, and is likely to cause major fluvial morphology changes. In recent times, the morphology of the river and its tributaries underwent a distinct transformation due to change in sediment load and river discharge.

The River Brahmaputra

The River Brahmaputra flows in India through the states of Arunachal Pradesh for 278 km, mostly across the Himalayas, where it is called Dihang or Siang. The Dihang emerges onto the plains at Pasighat (elevation 155 m). Near Kobo in Assam, 52 km downstream from Pasighat, two large rivers - the Lohit and Dibang joins the Dihang, afterwards the river is known as Brahmaputra. The Brahmaputra flows for about 670 km through the province of Assam within which it receives 103 tributaries - 65 on the right (north) bank and 38 on the left (south) bank (Sarma et al., 2002). The slope of the river decreases suddenly in front of the Himalayas and results in the deposition of sediment and a braided channel pattern. It flows through Assam, (India) along a valley comprising its own recent alluvium. In Assam, the Brahmaputra basin receives 300 cm mean annual rainfall, 66-85% of which occurs in the monsoon period (Sarma et al., 2002). The study shows that the mean annual discharge at Pancharatna for 1990 - 2002 is 13,714 m^3/s. Average monthly discharge is highest in July (19.23%) and lowest in February (1.55%). Most hydrographs exhibit multiple flood peaks occurring at different times from June to September. The mean annual suspended sediment load is 440.8 million tons and average monthly sediment discharge is highest in July (25.36%) and lowest in January (0.35%). The bed load at Pandu (near Guwahati) is found to be 5 -15% of the total load of the river (Goswami, 1985).

The study area comprised of 64 pre-defined cross-sections (during British era), from Kobo (cross-section 65 at chainage 640.07 km) at the upstream side to Dhubri (cross-section 2 at chainage 17.34 km from Indo-Bangladesh border) at the downstream side, spanning over about 622.73 km length in Assam province of India. Considering the river flow, the confluence of river tributaries and gradient, the study area has been divided into 7 reaches (Fig. 1). The reaches are described in Table 1.

Slope of the River

As per the longitudinal profile of the river (Fig. 2) the slope of the river at different reaches are; 1.63 m/km in Tibet, 4.3 m/km to 16.8 m/km across the Himalayas, 0.62 m/ km in plains up to Kobo, 0.27 m/km from Kobo to Dibrugarh, 0.17 m/km from Dibrugarh to Neematighat (near Bessamora), 0.15 m/km from Neematighat to Tezpur, 0.14 m/km from Tezpur to Pandu, 0.11 m/km from Pandu to Jogighopa 0.094 m/km from Jogighopa to Dhubri and 0.079 m/km from Dhubri to the mouth. A sudden decrease in slope in front of the Himalayas near Pasighat results in a large amount of sediment deposition, which chokes up the channel and gives rise to development of prominent braiding pattern.

Fig.1. Seven Reaches of the Study Area

Table 1 Detail of Study Reaches

Reach	Cross-section		Location		Distance
	From	To	From	To	(Km)
R-I	02	10	Fagiraganj (Dhubri)	Goalpara	65.28
R-II	11	20	Goalpara	Pally	89.76
R-III	21	30	Pally	Tongani	79.57
R-IV	31	40	Tongani	Behali	120.88
R-V	41	50	Behali	Jhanjmukh	107.60
R-VI	51	60	Jhanjmukh	Kahaispur, Dibrugarh	98.44
R-VII	61	65	Kahaispur, Dibrugarh	Dighatarang (Kobo)	51.00

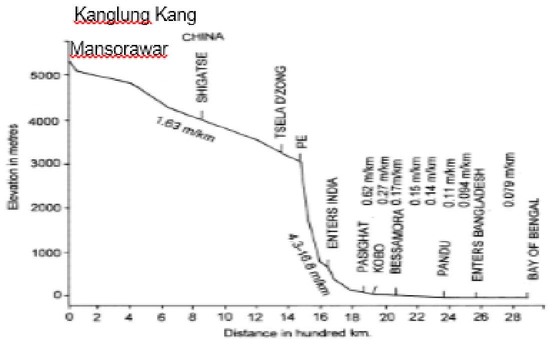

Fig.2 Modified Profile of River Brahmaputra (WAPCOS, 1993)

Remote Sensing Analysis

One set of Survey of India toposheets (1965) and digital satellite images of IRS LISS-I and III sensor, comprising of 32 scenes for the years 1990, 1997, 2000 and 2002 have been used for the present study. In order to assess the fluvial planform, maps and imageries have been registered and geo-referenced with respect to Survey of India (1:50,000 scale) toposheets using second order polynomial. The sensors provide multi-spectral data in 4 bands, two in visible (0.52 -0.59µm and 0.62-0.68µm), one in near infrared (NIR 0.77-0.86µm) and one in shortwave infrared (SWIR 1.55-1.70 µm) regions of the electromagnetic spectrum. The spatial resolution of LISS-I is 72.5m and that of the LISS-III is 23.5 m. The data used in the analysis have been presented in Table 1. ERDAS IMAGINE 8.6 image processing software has been used to perform the image processing works. The digital satellite data of the year 1990 first geo-referenced with the Survey of India toposheets with more than 25 Ground Control Points (GCPs) using 2nd order affine transformation model and a root mean square error less than 0.5 pixel has been obtained using the nearest neighbourhood re-sampling technique. The satellite images of the other years were co-registered using image-to-image registration technique.

As is known, the incident energy in Near Infra-red (NIR) band striking on the water surface is highly absorbed; it appears blackish blue on the satellite imagery. In contrast to water, the land features absorb much less incident energy depending on cover type, roughness, composition etc. This sharp contrast between land and water boundaries in NIR band makes the delineation of the river boundary from the land mass easier. As the study reach is covered by seven image frames, these are merged into a single mosaic each for the years 1990, 1997, 2000 and 2002. The geo-referenced mosaic image frames of all the four years are used to delineate the active river segments, tributaries, islands and bars. The river braid belt is used to delineate the margins of the primary braided channel from each set of imageries and the channel patterns are digitized using ARC/INFO software to assess lateral movement between images for a spatial analysis of channel morphology over the period.

Preparation of Normalized Difference Vegetation Index (NDVI) Layer

The mosaiced image frames for all the years are prepared reach-wise (for seven reaches) and the variation in Normalised Difference Vegetation Indices (NDVI) for the basin are found out reach-wise for different years to infer dominant trends in morphological variability response in the basin due to presence of vegetative cover in the flood-plain.

$$\text{NDVI} = \frac{(CH_2 - CH_1)}{CH_2 + CH_1} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Where, CH_1 and CH_2 are the spectral reflectance at near infrared and red wavelengths respectively. To highlight the vegetation classes, NDVI values were rescaled using equation (2). The output gives the vegetation densities.

Rescaled NDVI = NDVI * 200 + 50 …. (2)

Presence of vegetative cover reduces the erosion and hence the transported silt load is reduced. This is tested to provide new information and improved sensitivity to vegetation. As part of an effort to understand the pattern of the vegetative cover, the response of spectral vegetation indices to such temporal changes as well as their ability to discriminate among the major vegetation types encountered in the basin is studied. An assessment of the functional behaviour of this index with the sediment erosion is also attempted. Such an investigation yields a preliminary insight on the dominant trends over the Brahmaputra basin. Vegetation layers obtained by NDVI were density sliced to have four vegetation classes (Table 2). Figs. 3 to 5 present the trends of vegetation cover.

Inference on Dominant Change in Sediment Load

The salient morphological features of the Brahmaputra are shaped by fluvial processes of the process of erosion, transport and deposition of sediment that are fundamental to the hydraulic geometry of the channel. The rationale behind high yield of sediment in the river could be attributed to the erosion process due to loss of vegetative cover, growth of urbanisation, encroachment of flood plain by the incising river and prevalence of shifting 'Jhum' cultivation in the region. The multi-spectral vegetation index like NDVI has been tested to provide new information and improved sensitivity to vegetative cover. An assessment of the functional behaviour of this index with the sediment erosion is attempted in this investigation, which yields a preliminary insight on the dominant trends over the Brahmaputra basin. The reach-wise study of NDVI vividly portrays that the loss of vegetative cover in the basin is about 10% and the increase in sediment load at Pancharatna (cross-section 9), which is near the downstream end of the basin is about 12%.

Table 2 Classes in NDVI Analysis

Vegetation category	Class
Very high vegetation	1
High vegetation	2
Medium vegetation	3
Less vegetation	4
Water	5
Sand bars/islands	6

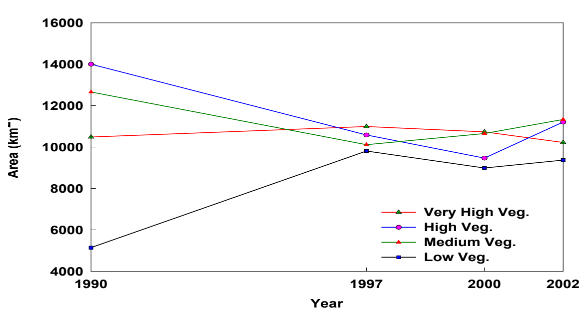

Fig. 3 Trends of vegetation cover

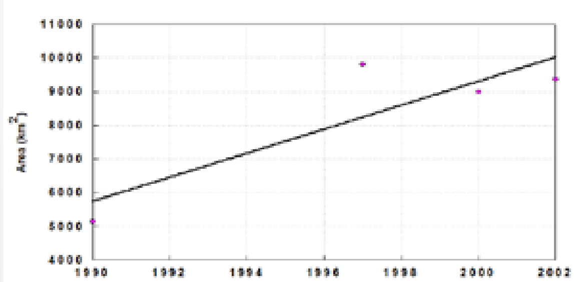

Fig. 4 Trends of low vegetation cover change in the basin

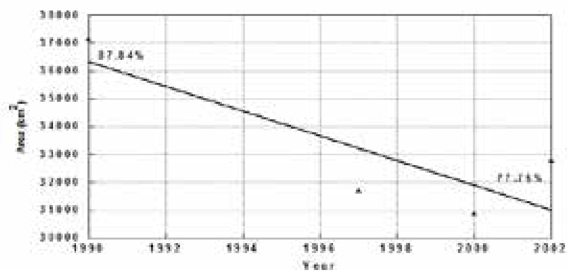

Fig. 5 Trends of high vegetation cover change in the basin

Discussion and conclusions

Adjustment processes that affected fluvial system of the Brahmaputra include channel degradation and aggradation, lateral river migration, widening or narrowing, avulsion, and changes in the quantity and character of the sediment load at spatial and temporal scale. One of the vital finding of the investigation is a pointer to the close relationship between losses of vegetative cover with river sediment load. The multi-spectral vegetation index like the NDVI has been tested to provide new information and improved sensitivity. The analysis shows that loss of 10% vegetation cover contributed to 12% increase in the sediment load at Pancharatna (cross-section 9). The rationale behind high yield of sediment in the river could be attributed to the erosion process due to loss of vegetative cover, growth of urbanisation, encroachment of flood plain by the incising river and prevalence of shifting 'Jhum' cultivation in the region.

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