

Geomorphological Changes in Sagar Island - A Remote Sensing Study

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Sagar Island, located in Sunderbans deltoid complex (West Bengal), was subjected to a study on geomorphological, land use, land cover and coastal vegetation changes, using IRS IC LISS III satellite data pertaining to 1996, 1998 and 1999. The study has shown that considerable changes has taken place in the geomorphology of Sagar Island. The landmass of the island has eroded by 17 km² and accreted by 0.48 km² from 1996 to 1999. The erosion rate was 6.82 km² per year during 1996-98, which reduced to 3.26 km² per year in 1998-99. This may be due to construction of brick walls at erosion zones and increment in area of coastal vegetation. The area of coastal vegetation was 7.4 km² in 1996 and 8.5 km² in 1999. The health of coastal vegetation as indicated by Normalized Difference Vegetation Index (NDVI) was also found to be better in 1999 (0.4-0.56) when compared to that in 1996 (0.2-0.4). The agricultural lands reduced by 16 km² during the same period due to increased human settlement.

Key words : Geomorphological changes, land cover, land use, shore line changes, geoinformatics, remote sensing, Sagar Island.

Coastal zone management is concerned with understanding and proper maintenance of coastal environments, resources and precautionary measures against coastal hazards especially coastal erosion. With current population trends and issues related to bio-diversity, there are bound to be unprecedented demands and problems in supply and management of food, water, land and other natural resources. Geoinformatics have been proposed for an area where there is enormous population growth and the accompanying

threats due to coastal pollution, erosion, and degradation of mangrove forests and overexploitation of living resources. In order to generate an integrated database of an area, it is necessary to develop information system for constant monitoring of the area with reference to its shoreline changes, land use patterns, land cover and changes in coastal vegetation.

Sagar, the largest island of the Sunderbans deltoid complex (West Bengal) was selected for the present study. The island is situated in the estuarine

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environment of river Hooghli and Bay of Bengal. The river Hooghli in the west, the river Muri Ganga in the east and Bay of Bengal in the south (Fig. 1), surrounds the island. The landmass of this island extends from 21°37' 21" to 21°52' 28" N lat and 88° 2' 17" to 88°10' 25" E long (Fig. 1). It is spread over an area of about 202 km² with a length of 30 km in the north-south direction and a maximum width of 12 km. The altitude of the island from the mean sea level is 6.5 m (Mukherjee, 1983). The island is a victim of several tropical cyclones and storms. Sagar island is included in the Sundarbans biosphere reserve. The global as well as the regional changes in climate may induce substantial changes in its physical, chemical and social environment. Hence, this island was selected to create an integrated database on a priority basis, which in turn can be of immense use for coastal zone management of this region.

Materials and Methods

In order to generate an integrated database of Sagar island, satellite images of IRS-1C LISS III and topomap of Survey of India (Table 1) were used. Ground truths were collected, all along the coastal zone of Sagar island and data retrieved from these ground truths are listed in Table 2. The position and extent of area of ground truths were recorded by using Global Positioning System (GPS) and survey techniques. Field observations were processed in the laboratory using ERDAS IMAGINE GIS software Version 8.3. The landmass was classified into five groups, viz., mangrove forests, casuarina

plantations, agricultural fields, terrestrial plantations and sandy beaches (Fig. 2). The type, intensity and condition of coastal vegetation were noted on the basis of field observations and the information gathered from the islanders. To demarcate the erosion and accretion during 1996-99 the satellite images were classified into surrounding water and landmass; then respective images were subtracted one from the other (Fig. 3). The same procedure was adopted to know the changes in coastal vegetation i.e., mangrove and casuarina (Fig. 4). The area was calculated by multiplying the spatial resolution with the number of pixels in the corresponding classes. Normalized Difference Vegetation Index (NDVI) is a computation of ratio of images using data in infrared (IR) and red (R) bands of the electromagnetic spectrum. It was calculated using the formula, $NDVI = (IR-R)/(IR+R)$.

Results and Discussion

The geomorphology of the Sagar Island is changing rapidly due to sharp action of water flow of Hooghli and Muri Ganga rivers. The landmass of the island was found to be 223.4 km² in 1996 which subsequently reduced to 207.9 km² in 1998 and 202.6 km² in 1999 (Table 3). The continuous erosion has submerged about one fourth of its boundary area (70.8 km²) during last 140 years (Bandhyopahyay, 2000). The erosion and accretion during 1996-1999 was 17 km² and 0.48 km², which resulted in an overall erosion of 16.52 km² (Table 4). The erosion rate during 1996-98 was



Fig 1: False colour composite of Sagar Island (IRS LISS III; October 1999)



Fig 3: Shoreline changes of Sagar Island (IRS LISS III; December 1996 & October 1999)

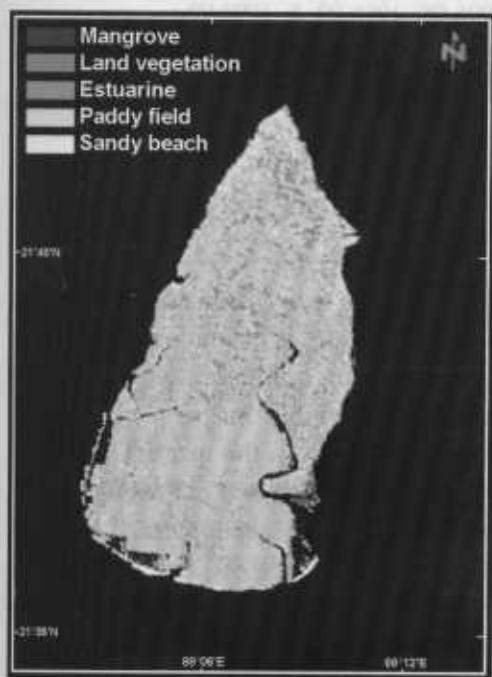


Fig 2: Vegetation classes of Sagar Island (IRS LISS III; October 1999)



Fig 4: Changes in coastal vegetation of Sagar Island (IRS LISS III; December)

Table 1: Data sources

Data	Data Details	Description
Map data (Survey of India Topomap1967)	SOI 79C/1 and 79C/2	Position and contour
Satellite data (IRS LISS III)	Path & Row : 108/57 Date : 11.10.1999	Spatial resolution: 23.5 m Spectral resolution :
	Path & Row : 108/57 Date : 3.12.1998	Green : 0.52-0.59 μm Red: 0.62-0.68 μm
	Path & Row : 108/57 Date : 13.12.1996	NIR : 0.77-0.86 μm SWIR: 1.55-1.70 μm

Table 2: List of parameters retrieved from sampling stations

Field data	Parameters retrieved
<ul style="list-style-type: none"> • Land use and land cover • Shoreline changes • Changes in coastal vegetation • Health of vegetation 	<ul style="list-style-type: none"> • Supervised Classes : Sandy beaches, Paddy field, Land vegetation, Casuarina, Mangrove. • Erosion and accretion during 1996-98, 1996-99 & 1998-99 • Changes in Mangrove and Casuarina during 1996-98, 1996-99 & 1998-99. • NDVI of vegetation during 1996-98, 1996-99 & 1998-99.

6.82 km².yr⁻¹, which has been subsequently and 3.26 km².yr⁻¹ in 1998-99. This may be because of the construction of brick walls at erosion zones and better health of coastal vegetation. Paul & Bandyopadhyay (1987) noticed deterioration of the deltoid environment due to human settlement, reclamation of lowland, indiscriminate resource utilization and mangrove deforestation.

The rapid increase in the population of the Island from 48,000 in 1951 to 1,85,000 in 2000, has led the way for overexploitation of natural resources. The rate of deforestation was 3.15 km².yr⁻¹ in 1996-98, which has reduced to almost nil

in 1998-99. The afforestation was 8.4 km² in 1996-98 and 1.9 km² in 1998-99 (Table 5).

Normalized Difference Vegetation Index (NDVI) is commonly used by scientists to correlate photosynthetic activity and vigour in green biomass by taking advantage of the spectral behaviour of vegetation in IR and red regions of the electromagnetic spectrum. Healthy vegetation reflects 40 to 50% of the incident normalized IR (0.7-1.1 μm) energy and chlorophyll absorption is 80 to 90% of the incident energy in the visible band (0.4-0.7 μm). The artificial afforestation of mangrove and casuarina

Table 3 : Changes in land use and land cover in Sagar Island, during 1996-1999.

Classes	Area, km ²		
	1996	1998	1999
Casuarina	6.5	7.4	7.2
Mangrove	0.9	2.1	1.3
Sandy beach	2.3	1.2	1.2
Land vegetation	79.4	66.8	75.9
Agriculture fields	134.3	130.4	118.6
Total	223.4	207.9	202.6

Table 4. Shoreline changes of Sagar Island

	1967-1999	1996-98	1996-99	1998-99
Erosion, km ²	12.80	13.64	17.00	3.26
Accretion, km ²	6.03	0.48	0.48	0.08

Table 5. Changes in coastal vegetation of Sagar Island

	1996-98	1996-99	1998-99
Deforestation, km ²	6.3	7.8	-
Afforestation, km ²	8.4	6.4	1.9

resulted increasing trend in NDVI from 0.2-0.4 in 1996 and 1998 to 0.4-0.56 in 1999, which indicated the good health of coastal vegetation.

It could be concluded that the island is densely populated which has reduced the per capita availability of natural resources. The encroachment of Coastal

Regulation Zone (CRZ), excessive use of resources and destruction of the coastal vegetation have resulted in the high rate of erosion.

The fisheries sector, inland as well as marine, are in crisis with a wide range of problems like environmental degradation, pollution, over-exploitation and habitat destruction consequently depleting the fish stocks alarmingly. Scientific management requires integrated and authentic database based on which decision could be made for the betterment and management of fisheries sector. There is a limitation in the processing and correlation of the integrated database manually. Geoinformatics is a semi-automatic system, which not only can handle the large database but also helps in the creation of Decision Support System (DSS) with a high degree of authenticity and has many potential applications in fisheries and related areas.

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