

# RS AND GIS IN CONSERVATION AND MANAGEMENT PLANNING

## Mangrove Mapping and Monitoring

The mangroves of the Sunderban area in India are one of the most productive and diverse ecosystems in the world, and yet they are a threatened habitat. To formulate a conservation and management plan periodic mapping and monitoring of mangroves is a prime requisite. The authors demonstrate that remote sensing and GIS techniques, including visual interpretation, are effective and efficient techniques for this purpose.

The objectives of this study are threefold: mangrove mapping and monitoring, database creation and conservation prioritisation. Essential parameters in monitoring mangrove areas are disturbance index and fragmentation level. The disturbance index provides a measure for the change over time from mangrove to other types of land cover. Fragmentation level provides a measure for the division of mangrove areas: high levels of human activity and natural processes such as erosion cause mangrove areas to become divided into small patches embedded within areas of other types of land cover. Conservation priority can be determined from disturbance indices and fragmentation level, together with other landscape parameters including soil type, drainage density, land use/land cover and geomorphology.

### Geography of Sunderban

Sunderban, an area of 9630km<sup>2</sup>, is located in West Bengal, along the coast of India. Of its 108 islands, 54 are inhabited with a population of around 3.2 million people. Six principal estuarine rivers: Bartala, Saptamukhi, Thakuran, Malta, Gosaba and Herob-hanga drain via Sunderban into the Bay of Bengal. Table 1 shows average climate conditions. The threats to mangrove ecosystems are many and result from human exploitation of biological resources and natural hazards such as land erosion and accretion. Threats to the Sunderban area include habitat alteration, over-exploitation, water pollution, climate change and an abysmal increase in human and cattle population.

### Integrating Data

Landsat-TM and IRS-1D/1C, LISS-III data from 1987, 1998, 2000 and 2002 were used. Survey of India (SOI) 1:50,000 topographic maps were used for geo-referencing and extracting topographic details such as village location, roads, ferry network and drainage information. From a four-day field survey vegetation types were inventoried and linked to tonal variations in the satellite images. Major vegetation types, together with locality details, were recorded. Estuaries and creeks were visited using a jetti. The satellite data was corrected for geometric and radiometric distortions: for the last, the technique of dark-pixel subtraction was used. To extract information from imagery, different band combinations were used; in general, the Landsat-TM bands 5, 6, 1 and LISS-III band 3, 4, and 1 were good for delineation of mangroves dominated by *Phoenix paludosa* and *Avicennia* sp. Thirteen land use/land cover classes were distinguished and mapped. The largest area is occupied by agriculture, followed by water bodies, each nearly one-third of the area; dense mixed mangrove covers over 20% of the area.

The agricultural area has remained fairly constant over the last fifteen years; fish pond/water logged area is, after an increase, now decreasing; dense mangrove has continued to decrease. Sand areas are increasing, which means that accretion is taking place. A change matrix was created for the four periods 1987-1998, 1998-2000, 2000-2002 and 1987-2002.

### Classifying Change

On-screen visual interpretation allowed mapping of mangroves and other land-cover categories. Tone, texture, pattern, size, shape and shadow coupled with site/location and associated features were evaluated for delineating land-cover features. The classification scheme was kept open-ended to enable future workers to augment the scheme. Disturbance index was determined by applying a complex linear model to the various landscape indices. Fragmentation assessment requires that the area be subdivided into spatial units (masks) of decided extent. For this purpose a measure is assigned to each mask representing the level of fragmentation. Tests were conducted to determine optimal mask size, starting from mask size 75mx75m and going up to mask size 350mx350m, with intervals of 25m. Sigmoid stability was obtained with mask size 250mx250m, and this was used in the computation. Three levels of fragmentation were distinguished: low, medium and high. The western part of Sunderban (Ajmalhari and Dulbhashani) shows a high level of fragmentation. These areas are close to settlements, roads and ferry points. The areas with medium-level fragmentation lie mainly on the fringes of creeks and channels. In all other places this can be attributed to protection provided by West Bengal State Forest Department.

### Conservation Area

The conservation area was determined by raster-based analysis of the forest/non-forest map. Fragmentation weights were used to find (possibly) disturbed areas. Weights were assigned to various landscape indices for deriving conservation index: change map 4, soil 0.25, drainage density 1, disturbance index 2, land use/land cover 0.5, geomorphology 0.25. The high values require more attention for

conservation strategies. Critical conservation areas were obtained by change analysis. Time-series analysis was carried out over three periods: 1987-1998, 1998-2000, and 2000-2002; highly dynamic pixels are considered to be a feature of critical areas. The areas dominated by mangrove were stratified in three levels: high medium, medium and low. Ground knowledge and socio-economic drivers were used to validate the results. Conservation priority was determined on the basis of information regarding forest cover, change, soil, drainage density, disturbance regime and geomorphology.

Areas which need immediate attention are Lothian, Dia, Jameson, Prentice, Thakuran, Burge, Ajmalmari, the central area of Herobhanga, the eastern part of Sajanakhali WLS, Jhilla, the northern side of Baghmara, the central region of Gosaba and the eastern side of Mayadwip; 3.6% of the area falls under a high-priority zone. Medium and low together contribute 24% to the total area. The medium-level conservation priority area is spread all over the Tiger Reserve that is too confined to creeks and channels. Most low-priority conservation areas lie in the Tiger Reserve region, except Dulbhasani and Chulkati areas. Areas near habitation and where loss of mangrove forest has occurred due to natural ebb erosion are to be considered for conservation on a priority basis. These areas are present in Jambudwip, Sagar Island, Lothian Island and Ajmalmari. There is an above 70% probability that Sunderban will have an area of around 900km<sup>2</sup> under dense forest by the year 2020; the figure for 2050 is 104km<sup>2</sup>.

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