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2. REMOTE SENSING AND AERIAL PHOTOGRAPHY FOR DELINEATION AND MANAGEMENT OF COASTAL ECOSYSTEMS

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INTRODUCTION

Coastal ecosystems such as seaweed, seagrass, mangrove and coral reef, form the dominant and highly productive environments in the tropics and subtropics. These areas, particularly in India, are very poorly understood and needs to be investigated. The management and research aspects of marine environment depends, primarily on survey and mapping of coastal features. Present conventional methods require exhaustive field sampling, manpower and cost. It is very necessary to have a low cost, precise and a rapid tool for the survey of natural marine resources. Very recently (Untawale et al; 1982; Murlikrishna, 1984; Nayak, et al; 1986; Rao et al; 1987) remote sensing techniques have been applied for the mapping of coastal features. The increased and continuous availability of remote sensing data, may provide necessary information to the planners and researchers, interested in the

coastal ecosystems. Mismanagement or lack of management of coastal zones may result in the loss of marine ecosystems, influencing erosion and the sea level rise. In the following paper, remote sensing techniques and their applications for the studies of coastal ecosystems, have been discussed.

DATA SOURCE

Remote sensing processes consists of data collection, interpretation, analysis and generation of resource information in the form of maps and tables.

Aerial photographs could be procured from Survey of India on request. If recent or fresh aerial photographs of desired area and scale are required, agencies like Indian Air Force, M/s Air Survey Company of India Pvt. Ltd., Calcutta and NRSA, Secunderabad undertake aerial photography on demand. Sensitive or restricted areas would normally be covered by Indian Air Force. When aerial photographs have to be taken for the collection of ground truth data and for the study of coastal environment, for optimum photography, guidelines suggested by Orth and Moore (1983) may be worth considering.

The satellite data (MSS, TM and CZCS) in the form of diapositives, Diazo Colour Composites (DCC), False Colour Composites (FCC) and Computer Computable Tapes (CCT), could be obtained from NRSA.

DATA ANALYSIS

Remote sensing analysis mainly concerns with the measurement of electromagnetic energy, reflected, scattered

or emitted from objects receiving and then returning energy from the sun. Various objects return different kinds and amounts of energy, which is captured by photographic film or various sensors in the visible (0.4 - 0.7 μm) and near visible (0.3 - 1.2 μm) spectrums, in the form of spectral signatures.

Identification of the features on the aerial photographs or satellite imageries, is done by detecting spectral signatures (Table 2-4). During analysis of remote sensing data, certain elements and activities (Table 1) must be taken into consideration.

INTERPRETATION OF AERIAL PHOTOGRAPHS

A loose mosaic of the photographs of the desired area is initially prepared and studied. A mirror stereoscope is then used for identification and delineation of the features by training their aerial extent on to a Kodatrace. The tracings are then transferred to tracing paper for the preparation of final maps. Before final maps are produced, the photo-interpreted results are confirmed with the ground truth data.

Area measurements can be done with the help of dot grid, transparent graph sheet and digital planimeter. The percent cover of communities could be done by crown density scale or microdensitometer (Orth et al., 1979; Adams et al., 1977).

INTERPRETATION OF SATELLITE DATA

Satellite data could be analysed with visual interpreta-

tion and with computer aided image analysis, applied to digital data (Numerical analysis). Visual analysis limited to small scale analysis is very simple and cheap, and can be performed with diapositives, DCC and FCC. Band 5 and 7 have been observed to be most suitable for analysing coastal features.

Digital image analysis is divided into three sections.

- (i) Image correction is done to fit remote sensing data to a cartographic base and clean up artifacts in the original data.
- (ii) Image enhancement (Linear stretching, Histogram equilized stretching, principal component analysis and band rationing) is necessary to aid image interpretation.
- (iii) Image classification is done to get quantitative output i.e. mapping and automated area survey.

Digital analysis is done for large scale analysis which is high speed processing, timely and effective over large area.

DIGITAL CLASSIFICATION EXERCISE

Select a coastal area of interest, approximately 512 x 512 pixels of band 4, 5 and 7 from CCT. Make radiometric corrections (Destriping in band 4 and 5, Mean filtering in band 4, 5 and 7, Median filtering in band 4, 5 and 7) and compare the results. Select the training area and generate statistics (Mean and Covariance, Histogram and Scatterogram). Identify the major classes by using unsupervised and then

supervised classifications (Curren, 1985, Lillesand and Kiefer, 1979).

The final results are prepared with the help of ground truth data either collected from large scale aerial photographs or by field sampling.

DISCUSSION

Remote sensing techniques have been utilized by various countries, for the studies of coastal environment. Aerial photographs have been observed to be most suitable for monitoring mangrove, seagrass, coral ecosystems and sand-dunes; due to greater spatial and spectral resolution. Seaweeds from the intertidal and subtidal regions, cannot be recognized on black and white aerial photographs, as they get merged with coarse and black texture of rocks and due to heavy surf and turbidity along the Indian coast. Infra-red aerial photographs are quite suitable for studying of various coastal vegetation including seaweed and coral environments. However, the small coverage, cost, manpower and time factors limit the use of aerial photographs compared to satellite data.

Satellite data has number of advantages over aerial photographs. It provides synoptic view over large area, therefore, large areas can be monitored instantaneously and reliable information could be sought in very short time, at very low cost. Poor spatial (80 m) and spectral resolution restricts the use of satellite data to macroanalysis. However,

TM, SPOT and IRS data has greater spatial resolution (20-30 m) which may replace use of aerial photographs. CZCS and TM data could best be used for studying productivity (chlorophyll), benthic algal and seagrass production (Jobson, et al., 1980, Murlikrishna, 1984).

MONITORING COASTAL ECOSYSTEMS

The following information could be obtained from aerial photographs and satellite data, which is of great help in understanding management of the coastal environments.

- (i) Productivity in coastal waters by estimating chlorophyll concentration.
- (ii) Identification and quantification of mangroves, seagrasses, seaweeds, sand-dunes and coral reefs.
- (iii) Zonation, extent and profile.
- (iv) Progression and erosion, offshore sedimentation, organic export and current system.
- (v) Water characteristics (salinity and turbidity).
- (vi) Land use pattern in the mangrove ecosystem.
- (vii) Location of sites for aquaculture and seaweed cultivation.
- (viii) Continuous changes in the ecosystem.

It has been observed (Sriplang, 1982) that the best results can be produced by combining, 40% output of digital

analysis, 20% visual analysis, 10% physical and biophysical data, 10% ground truth data and 20% data from aerial photographs, topographic maps and other resources.

The effective management and research of coastal zones, require information on coastal landforms, wetlands, shoreline changes, sediment and current pattern, which can easily be obtained from the satellite data.

Coastal vegetation and corals, beside their socio-economic importance, play major role as land builders, provide natural protection against storms, cyclones and floods. The role of mangroves, seagrasses and sand-dunes, in the sediment binding and trapping and stabilization of the coast is very well documented. Similarly, corals and calcareous algae form the great source of lagoon sediments (Mallik, 1979). Thus, these coastal ecosystems have great ability to keep pace with slow rate of sea level rise. As sea level rise, new mangrove vegetation may always form inland.

The loss of mangrove environments occurs due to natural phenomenon, however, human activities cause great damage to the coastal ecosystems. During past, mangrove ecosystems along the Indian coast have been degraded to a large extent (Untawale, 1987). Various activities such as embankments, channelization, draining and filling of land and modification of drainage pattern have resulted into severe loss of mangroves. Similarly, coral environments have been damaged (Jagtap, 1987) due to removal of corals

and sand for commercial purposes, dynamite fishing and impact of pollutants.

It is estimated that the global sea level rise may range from 1-1.5 mm per year (Gormitz et al., 1982; Bannett, 1984) and by the year 2075, it will be 91-137 cms (Hoffman, et al., 1983). Wetland, seagrass and coral ecosystems should be considered more important as regards sea level rise. The loss of these ecosystem may greatly influence erosion, destabilization of the shore, increased flooding and intrusion of saltwater into rivers and aquifers, which may accelerate the process of sea level rise. So far, global warming has not affected coastal ecosystems. However, taking into consideration the importance of the marine ecosystems and sea level rise in the next coming years, comprehensive long term plans of actions are urgently required, to protect these valuable ecosystems. Satellite data, especially SPOT, TM and IRS will provide very valuable information needed for the management of coastal environment.

CONCLUSION

Coastal vegetation and corals have great ability to maintain pace with subsidence and sea level rise through sedimentation and other processes. Remote sensing forms rapid, precise and economic tool, for monitoring of the coastal environments. The effective management of the marine ecosystem could be achieved with the help of satellite data in conjunction with aerial photographs.

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Table 1 Elements and activities used for interpretation of remote sensing data.

<u>Major elements</u>	<u>Activities</u>
i. Size	i. Detection
ii. Shape	ii. Recognition
iii. Shadow	iii. Delineation
iv. Tone	iv. Measurements
v. Texture	v. Deductions and Comparison
vi. Association	vi. Identification
vii. Location	vii. Idealization
viii. Aquitance	viii. Codification

Table 2

Identification of coastal features from black and white aerial photographs.

Class	Subclass	Identifying features
Coastal vegetation	Dense/mature mangroves	Dark grey, coarse
	<u>Rhizophora</u> spp.	Dark grey, coarse
	<u>Sonneratia</u> spp.	Dark grey, coarse
	<u>Avicennia</u> spp.	Very light grey, wooly
	Sparse mangroves	Light grey, coarse
	Young mangroves	Light grey, smooth
	Seaweeds	not possible
	Sand-dunes	Light grey, wooly
Non-vegetated	Rocks	Black, coarse
	Dry sand	White, smooth
	Wet sand	Light grey, smooth
	Newly formed island in	Light grey, smooth
	Sandy beaches	White strips, smooth
Water bodies	Estuary	Dark grey, smooth
	Estuarine shallow water	Light grey, smooth
	Turbid water	Dark grey, patchy smooth
	Rivulets	Light grey, smooth
	Mudflats barren	Light grey, smooth
Lagoon	Reef	White
	Fore reef	Light grey, coarse
	Reef-slope	Light grey, smooth
	Sandy bottom	White, smooth
	Rocks in the lagoon	Black, coarse
	Seagrass beds and seaweeds in the lagoon	Very light grey, smooth
	Sandy beaches	White strips

Table 3

Identification of coastal features
from Infra red aerial photographs

Class	Sub-class	Identifying features
Coastal vegetation	Dense mangroves	Bright red, coarse
	Sparse mangroves	Light red, coarse
	Young mangrove vegetation	Light red, smooth
	Sand dunes	Pinkish, wooly
Water bodies	Clear water	Light blue, smooth
	Turbid water	Dark blue, smooth
	Clear deep waters	Dark blue, smooth
	Fish farms	Light blue, smooth
	Sandy beach	White strip, smooth

Table 4

Identification of coastal features from satellite data
in the form of DCC and FCC

Class	Sub-class	Identifying features
Coastal vegetation	Dense mangroves	Bright red
	Sparse mangroves	Light red
	Seaweeds	Dull brown
	Sand dunes	Linear patchy
	Mudflat	Red and brownish
Water bodies	Creeks	Inlets of seawater
	Water	Blue
Non-vegetated	Mudflats barren	Greenish
	Sand beach	White colour strip
Lagoons	Lagoon	Cyan
	Exposed reef	Greenish, coarse
	Reef slope)	Light blue, smooth
	Fore reef)	
	Seagrass/Seaweed beds in the lagoon	Greenish, smooth
	Rocks	Black, coarse
Others	Submerged islands	Brown/maroon

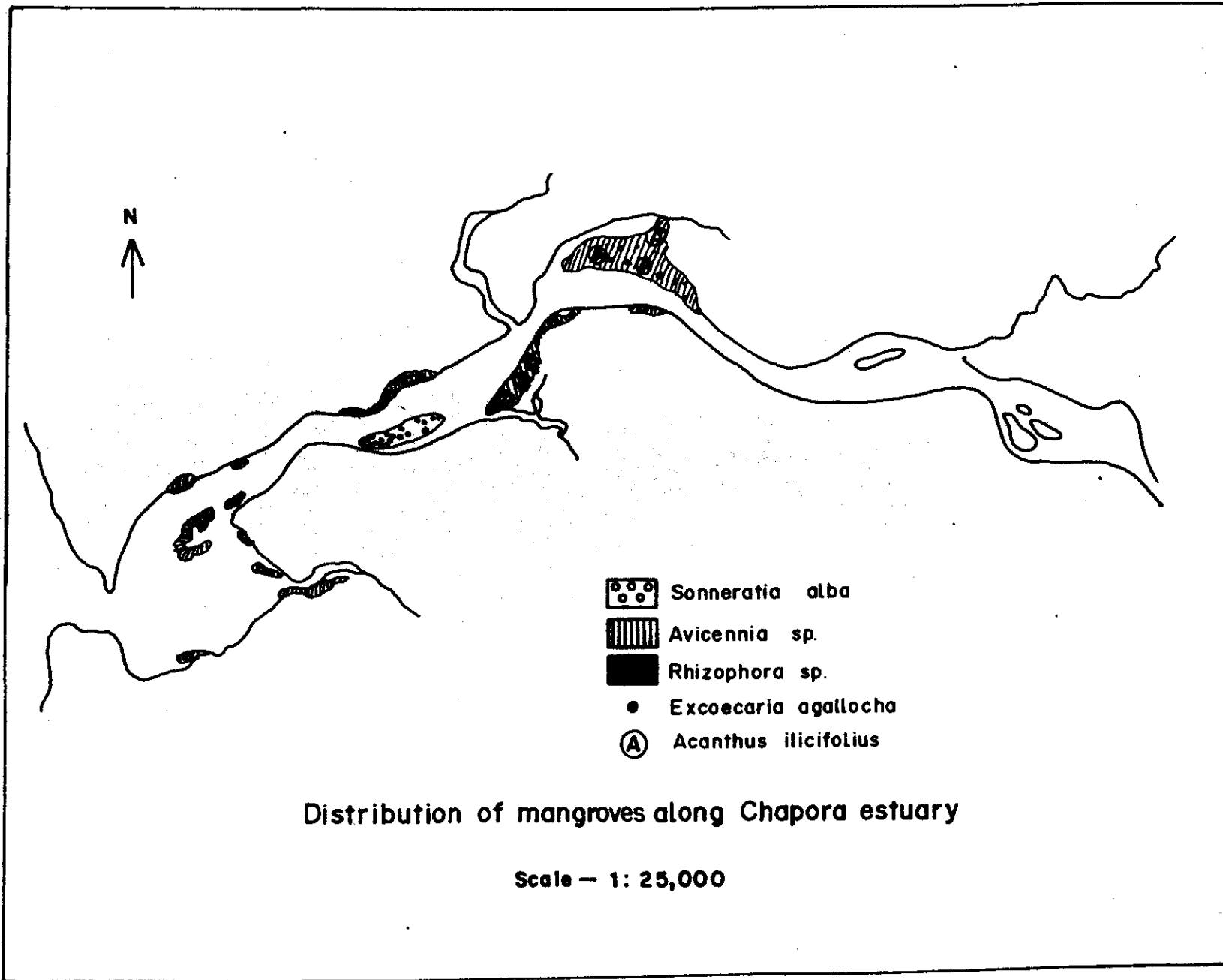


Fig. 1