3.1

COASTAL ENVIRONMENT

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INTRODUCTION

Coastal zone in India assumes importance because of high productivity of its ecosystems, concentration of population, exploitation of renewable and non-renewable natural resources, discharge of waste effluents and municipal sewage, development of various industries and spurt in recreational activities. The principal concern of coastal zone management is to ensure a rational development of the area and judicious use of its resources consistent with the surrounding natural systems and environment. Thus, environmentally effective coastal zone management depends on accurate and comprehensive scientific data on coastal habitats, coastal processes and water quality on which policy decisions are based. The basic problem confronting any coastal management activity/policy in India is the limited availability of baseline data on any of the components of the coastal zone. Realizing the need to have up-to-date information on conditions of the coastal zone (coastal wetlands and shoreline), the present study was conducted on the entire Indian coast.

OBJECTIVES

- Preparing coastal wetland/landform maps of the entire Indian coast using satellite data on 1:250,000 scale showing the spatial distribution of various wetland units with the classification accuracy aimed at 90% confidence level, and
- Preparing shoreline change maps of the Indian coast during the period 1973-1989 using multidate satellite data and Survey of India (SOI) topographical maps on 1:250,000 scale to evaluate areas of erosion and deposition.

STUDY AREA

India's long coastline of about 7,500 km, including that of its island territories and comprised 60 coastal districts.

METHODOLOGY

The classification system evolved earlier was used to classify the wetlands. LANDSAT TM/IRS LISS-II data was used for wetland mapping. As far as possible, low tide data was selected so that upper and lower boundaries could be demarcated. December to March data was used so that algal growth on rocks/reefs, coastal dunes with vegetation, etc. could be mapped, as this type of vegetation growth is seasonal. Wetland classes were identified based on the elements of visual interpretation (tone, texture, location, etc.). Ground verifications were carried out before finalizing the maps as well as for ascertaining the accuracy of the maps.

LANDSAT MSS/TM/IRS LISS-II data for the period 1973-75 and 1984-89 was used for the delineation of shoreline. Multidate satellite data were selected for the same tidal condition as far as possible. Wherever 1973-75 period data was not available, shoreline was taken from the Survey of India (SoI) topographical maps. Shoreline of different dates was compared. Changes in shoreline dipicted either erosion or deposition.

RESULTS/OUTPUTS

Indian mangroves occupy 4,460 sq. km area. At many places, mangroves are in degraded condition due to their use as fuel, fodder and conversion of these areas for agriculture, aquaculture and industrial purposes. There are mainly four coral reef regions on the Indian coast. The Gulf of Kachchh reefs are the most degraded among the Indian reefs. Wetlands along the Andhra Pradesh coast, especially mangroves and mudflats are being reclaimed for agriculture and aquaculture. Reclamation of backwaters for agricultural purposes in Kerala is a serious problem. The conversion of backwaters for agricultural purposes has increased from 535 sq. km in 1988-89 to 865 sq. km in 1991-92. Lagoons have shrunk in Tamil Nadu, South East Indian coast due to their use for agricultural purposes, saltpans and aquaculture ponds.

Eighty coastal wetland/landform maps on 1:250,000 scale showing extent and conditions of wetlands were prepared. Classification accuracy of these maps was estimated to be 83-89% at 90% confidence level. This envisages a reconnaissance level of mapping with various limitations and constraints. This scale is appropriate only in deciphering wetlands in a broader perspective. Smaller patches of < 25 ha cannot be delineated at this scale. Sixty shoreline-change maps were prepared on 1:250,000 scale showing erosional/depositional changes during 1973-75 and 1984-1989. Shifting of river mouths, formation of shoals, narrowing of channel widths and growth of spits were mapped on the Maharashtra coast. On the Kerala coast, out of 575 km length of shoreline, about 275 km area is undergoing severe erosion. Erosion noticed near Ennore and Nagapattinam, may be attributed to construction of artificial barriers. Erosion has also been observed near North Aguada bay and Marmugao in Goa. The Chilka Lake and the Pulicat Lake are being silted up. New mouth bars were observed in the Hooghly estuary. Most of the spits on the east coast of India are growing which is indicative of pronounced depositional activities. Erosion has been observed north of Visakhapatnam and Paradip ports while deposition has

occurred south of these ports. These changes have been attributed to human interference. The plan metric error of shoreline changes maps is 75-250 m at 1:250,000 scale and 0.1 mm at 1:50,000 scale.

3.2

LAND USE MAPPING OF THE COASTAL REGULATION ZONE (CRZ) OF INDIA

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INTRODUCTION

Coastal Zone is the area of interaction between land and sea and both terrestrial as well as marine environments influence this zone. In addition, interactions between coastal zone in India assumes significance because of renewable and non-renewable natural resources discharge of waste effluents and municipal sewage, development of various industries and spurt of recreational activities. Hence, protection of the coastal environment while ensuring continuing production and development is needed. The principal concern of coastal zone management, therefore, has become one of the most significant areas of study to plan a rational development of the area and judicious use of its resources, which is consistent with the surroundings that depends upon accurate and comprehensive scientific data on which policy decisions are to be taken. A basic problem confronting India in this respect is the limited availability of geographic data on coastal zone and it was due to this reason that scientific data on coastal wetlands/landforms/land-uses, water quality on near-shore waters, etc. were studied. Remote sensing data was used because of its repetitive, multi-spectral and synoptic nature supposed to be proved extremely useful in providing information on various components of the coastal environment.

Coastal stretches of bays, estuaries, backwaters, seas, and creeks, etc. are influenced by tidal action up to 500 m from High Tide Line (HTL). The land between the Low Tide Line (LTL) and HTL have been declared as Coastal Regulation Zone (CRZ) by the Govt. of India in which certain activities such as construction, mining, reclamation, etc. have been prohibited as well as certain restrictions have also been imposed on setting up and expansion of industries, operations and processes in CRZ to manage development in coastal areas to offset impact of this growth. In order to regulate various activities in the CRZ, it was felt necessary to have knowledge about the present land-use conditions in the zone 500 m from HTL and wetland conditions between LTL and HTL. Satellite data was considered to be useful to assess present condition in CRZ, particularly wetland conditions between high and low waterlines and

land-use in the 500 m zone from high waterline on 1:25,000 scales for the entire Indian coast.

OBJECTIVES

To delineate wetland features between HTL and LTL and land-use features up to 500 m from HTL on 1:25,000 scale mainly using IRS LISS II and SPOT data. The main emphasis was on vital/critical habitats, tidal wetlands, industrial activities, built-up land reclamation, and sand/rock mining.

STUDY AREA

Entire country's coastline

METHODOLOGY

Wetland/Coastal land-use classification was carried out interpreting IRS LISS II and SPOT False Colour Composites (FCCs). The satellite data of SPOT and IRS for the period 1988-89 was chosen considering the condition of coastal region just before declaring these regions as CRZ. The satellite data of December-February was usually chosen to take care of reproductive cycle of vegetation present in the wetland areas. However, in a few cases, where data for this period was not available, data from other periods was also used. Satellite data were enlarged to 1:25,000 scale using a High Magnification Enlarger (HME)/ PROCOM. The scale adjustments were done using base maps prepared earlier. Coordinates were transferred from base maps to interpreted sheets. HTL was delineated first and then the presences of mangroves, mudflats, beaches, etc. was taken into consideration. The tidal influence in the estuaries and creeks were taken directly from the Survey of India (SOI) topographical sheets. Various wetland categories were delineated between LTL and land-water boundary, while coastal land-use categories were delineated between HTL and land-water boundary and coastal land-use categories in the adjoining strip of 500 m based on the interpretation key. The image interpretation key originally developed for mapping coastal wetlands was slightly modified to take care of additional features. The SOI topographical sheets were used besides ground truthing. Base details such as village, town, district and state boundaries were transferred to interpreted sheets. Edge matching of adjoining sheets was carried out and area calculations were done using dot-grid method, using electronic planimeter.

RESULTS / OUTPUTS

About 1,000 maps on 1:25,000 scales were prepared for the entire country's coastline. Detailed database generated to the coasts pertaind to the state of Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Orissa, West Bengal, Andaman and Nicobar Group of Islands and Lakshadweep Islands. On the Gujarat coast, mangrove and coral reefs, two vital habitats were mainly found in the Gulf of Kachchh. The setting up of the Marine Park and the Sanctuary has helped in the conservation of these habitats. The industrial growth near Surat, Bharuch, Jamnagar and many other places had resulted in damage to land and groundwater and marine ecosystem. It was observed that erosion at Udwada and large tidal inundation

between the Purna and Ambika rivers needed urgent attention. On the Maharashtra coast, only 30 % of mangroves were found in good condition and large mudflat areas were reclaimed for agriculture, industrial, residential and aquaculture purposes, especially in the Bombay and Thane region. Mangroves covered only 8 sq. km in the estuarine region on the Goa coast. The coasts near Vasco and near Betul were of the retrograde type. On the Karnataka coast, few patches of mangroves were present near Kundapur and Ankola. Agricultural activity was pronounced in Dakshna Kannada district. The Kerala coast was found to suffer from the problem of reclamation. Mudflats areas have been converted into wither as filtration ponds or paddy fields. Small, degraded patches of mangroves were present near Kochi and Kanoor areas.

On the Tamil Nadu coast, mangroves of the Pichavaram and Muthupet were important ecosystems and were excellent breeding and nursery grounds for prawn fisheries. Fringing and patch reefs in the Palk Bay and the Gulf of Mannar were found in good condition. Pulicat Lake was a large lagoon and supported a variety of plant and animal life. Reclamation of mudflats for agricultural practices was observed at few places. The Andhra Pradesh houses large mangrove forests in deltaic regions of the Godavari and the Krishna. Mangrove areas were under pressure, mainly due to aquaculture activity. The Orissa coast has Asia's largest lagoon, Chilka Lake and excellent mangrove forest of Bhitarkanika. The large sandy area between Puri and Konark was covered by dense plantations. The West Bengal coast has the famous Sunderbans mangrove forest. At many places, mangroves were under pressure due to agriculture activity. Traditional aquaculture practices were found predominant on the coast. The entire Andaman and Nicobar Group of islands was fringed by coral reefs which were in good condition. Mangroves were found along the estuaries and creeks. The Lakshadweep Islands were coral reef islands of mostly island type most of which were conversed by dense coconut groves.

3.3

MONITORING OF GODAVARI ESTUARINE AND MANGROVE ENVIRONMENT USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

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INTRODUCTION

Mangrove eco-systems are storehouses of various species of flora and fauna showing rich biological diversity, which depend on a number of physico-chemical and ecological factors. The river Godavari, the second largest river in India joins the sea at Kapileswarapuram near Kakinada, East Godavari district of Andhra Pradesh, forming a fertile Gautami-Godavari Estuarine Mangrove Environment, supporting the mangrove vegetation cover over an area of 22,450 ha. Gautami-Godavari Estuarine is a natural positive estuarine eco-system with very high capacity for cycling of nutrients and trace metals for bio-process utilization. It has a good assimilating capacity for various chemical constituents and efficiently converts in addition to solar energy, wind and tidal energy for high bio-productivity, resulting in high economic returns.

The Godavari coastal estuarine is one of the important class of wetlands which represent out-fall regions of the river and mark transitions between fluvial and marine environment, where tidal actions cause intermingling of freshwater and salt-water regime. Mangroves together with mudflats and sea grass meadows are the starting point of the estuarine food chain. They provide the feeding ground for a wide range of fishes, birds, etc. In fact, estuarine fishes, and prawns have worth of crores of rupees. Combined with ignorance, greed and lack of concern, have adversely affected the steady state of the Godavari estuarine coastal environment. To evaluate the present ecological status, a detailed and systematic study was required on the physiographical, physico-chemical and biological features of this ecosystem with the latest tools like remote sensing and *in situ* field studies with advanced field equipment.

OBJECTIVES

- To map the mangroves and identify the parameters that have affected the mangrove and its related eco-system on a 1:50,000 scale using orbital remote sensing data,

- To apply digital pre-image processing techniques in order to improve discernability of features related to mangrove forest on the imagery, and to develop methodology for digital image processing (DIP),
- To map the actual extent of the mangroves and delineate changes with reference to the past data and estimate the environmental damage to Coringa Wildlife Sanctuary, located in the northern part of the study area, and
- To develop a GIS model by assigning different weightages to different parameters.

STUDY AREA

The study area was in the East Godavari district of Andhra Pradesh at 16°23′ N and 82° 20′ E covering a total area of 61,495 ha with 15.282 ha under mangrove vegetation.

METHODOLOGY

Visual interpretation of satellite data was carried out by observing the different interpretation elements/keys like tone, texture, shape, association, etc. Limited ground truth was also carried out after the preliminary interpretation. Maps were corrected and finalized after returning from the field work.

The digital classification was done on a workstation by way of giving training sets to different tones using ERDAS Imaging software. Other reference information consulted during interpretation (both visually and digitally) of the IRS data were Forest Resource Map: Pre-investment survey of forest resources on 1: 250,000 scale; Forest Vegetation Map: Forest Survey of India, (third edition), based on interpretation of imagery data between 1987 and 1990 on 1: 250,000 scale; Plantation Index Map showing approximate location of plantation areas on 1: 250,000 scale; Land-use/Land-cover Map generated from the data of 1995 field inventory; Topographical Maps of Survey of India (SoI); various existing thematic maps and meteorological data. Various parameters obtained from remote sensing and other collateral data were integrated to develop an optimum land-use plan using GIS. Various thematic maps like soils geomorphology, slope and land-use/land-cover were overlaid on one another digitally by assigning appropriate weightage to arrive at an optimum land-use plan.

RESULTS/OUTPUTS

The major physiognomic types such as forests, grasslands and mixed vegetation were distinguished using remote sensing data of IRS, which readily records spectral characteristics of such vegetation cover. Within the physiognomic classes, the variations which affect the amount of chlorophyll were also detectable as variations in the spectral data, as long as these areas were larger than IRS pixel. Thus, variations in density owing to disturbed or degraded forests; small clearing and different degrees of crown closure in mixed tree and grass formations were evaluated.

Using *in situ* field studies, the community structure of mangrove environment, the spatial distribution of nutrients and trace metals in the typical regions of the Gautami-Godavari ecosystem were systematically investigated. The contribution of the mangroves vegetation to the cycling of nutrients and trace metals and its contribution to the total bio-productivity of the eco-system was also evaluated. Cycling of detritus, carbon and nitrogen through the decomposition of mangrove litter and resultant contribution to the

phytoplankton and zooplankton production were estimated. The assimilating capacity of the estuarine ecosystem for nutrients, trace metals and pollutants like pesticides and heavy metals in this sensitive ecosystem were evaluated. As the functional integrity of the estuary depends on both fresh water inflows from upstream and tidal influx, the data generated in this program was found highly useful to form a basis for formulation of suitable developmental plans, without disturbing the complex functions of this highly productive fragile ecosystem.

3.4

TERRAIN ANALYSIS OF COASTAL KARNATAKA

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INTRODUCTION

Because of the increasing population pressure over the terrain of coastal Karnataka, the demand for water resources may also increase in future. The quantification of the Net Annual Groundwater Availability for the contemporary conditions of groundwater resources of the terrain of coastal Karnataka is must to plan future requirements scientifically. The augmentation of the groundwater resources could be done by adopting various suitable methods like rainwater harvesting. The appropriate sites for the construction of rainwater harvesting structures and sites need to be identified which could be considered by the planners in future to tackle such anticipated problems. The terrain analysis was, therefore thought appropriate for such an exercise.

OBJECTIVES

- To generate thematic maps of drainage, stream density, stream frequency, relief, slope, lineament distribution and geology and also isolate the land-use and land-cover characteristics,
- To select suitable sites for rainwater harvesting structures and groundwater recharge and prepare the erosion-proneness map, and
- To record the level and intensity of anthropogenic activities in the Coastal Regulation Zone (CRZ) and to assess the level of implementation of CRZ in Karnataka.

STUDY AREA

Coastal Karnataka stretch lying between 13^0 and 16^0 latitudes and $73^058´$ and $74^058´$ longitudes, at the western fringe of Karnataka state.

METHODOLOGY

The work was carried out in distinct phases, including field and laboratory investigations. The methodology adopted in this study was the one developed by National Remote Sensing Agency (NRSA), Hyderabad. Interpretation of satellite data products was carried out by visual and digital image processing techniques with Survey of India (SOI) toposheets as the base. Interpretation of the aerial photographs was also done though in the present study use of aerial photographs was limited because of non-availability of recent photographs of the restricted coastal terrain. Extensive field work was done to appreciate the land-use/land-cover characters of the terrain upgradation of already prepared maps by field observations. The main remote sensing

data used in the study included IRS IC/ID-LISS 3 data products of three Standard Scenes. The details of the data products used in this study were: IRS-ID LISS-3 Path 96 Row 63 - 7January, 1998; IRS-ID LISS-3 Path 97 Row 64 - January 4, 1998 and IRS-ID LISS-3 Path 97 Row 63 - 29January, 1998.

RESULTS/OUTPUTS

The study dealt with the enumeration of physical and non-physical attributes of the terrain of coastal Karnataka. The data generated formd the baseline data for the terrain resource management plans, which may be executed in future. The spatial distribution of slope, relief and drainage parameters, stream density and stream frequency of the terrain of coastal Karnataka were deciphered. Currently, when compared to northern coastal Karnataka, large proportion of the land in southern coastal Karnataka was being used for agriculture and developmental activities. Thus, if any developmental activities take place in future, the baseline information from the present study may prove quite useful. A good number of sites for the construction of rainwater harvesting structures were identified. The annual groundwater recharge potential and net annual groundwater availability were found high along northeast and southeast parts of the terrain, and low along northwest and southwest parts. Suitable sites for the rainwater harvesting along northwest and southwest regions of the terrain were also identified. Due to industrialization and increasing population along the northwest and southwest regions of the terrain in future, the demand for groundwater would increase. In that case, the locations identified during this study could be considered by the planners for the construction of rainwater harvesting structures to augment groundwater resources. The spatial distribution pattern of erosion-proneness over the terrain exhibited varied nature of erosion intensities. Severe erosions along the eastern part of the terrain where the Western Ghats Scarps exist, were observed. Such increased erosions warranted a proper soil conservation method.

The demarcation of Coastal Regulation Zone (CRZ) and its categories over the terrain envisaged most part of the study area to come under CRZ Category III. The existence of CRZ Category II was more pronounced along the southern coastal Karnataka, south of Udupi. It was recommended that care needed to be taken by the concerned authorities to prevent the destruction of the fragile mangrove environment that existed along most of the estuaries. The results of the study provided the baseline information about the physical and non-physical components that constituted the terrain of coastal Karnataka. Based on the findings, it can be suggested that the terrain could withstand the stress produced by the contemporary human activities.

The number of industries along coastal Karnataka is likely to increase because of the existing infrastructure such as sea-ports, airport, Konkan railway, NH-17, petroleum refineries (MRPL), etc. The expansion in the number of industries would increase the population of the terrain, which would increase stress on the terrain. The demand for built-up land and the agricultural land would increase the requirement of water resources. The clearing of the forests and land encroachment would also trigger large-scale anthropogenic effects on the terrain. In such an exigency, planners and decision-makers for the management of terrain resources should invoke a proper management plan to cope up with the increased anthropogenic activities. Thus, during that planning process, the information provided from the study could be extensively used as baseline information. The planners and decision-makers could extensively use the spatial distribution maps generated during the study.

3.5

PREPARATION OF MANGROVE ATLAS

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INTRODUCTION

India harbours some of the best mangrove swamps in the world, located in the deltas of rivers such as the Ganga, Mahanadi, Godavari and Krishna, as well as the Andaman and Nicobar group of islands and the Gulf of Kachchh. The total area covered by mangroves in India is estimated at about 4,460 sq. km with the largest stretch being Sunderbans in the West (2100 sq. km). Deltaic areas of Orissa and Andhra Pradesh as well as the Kori creek and the Gulf of Kachchh house large tracts of land under mangroves. Small patches are also found in the state of Maharashtra, Karnataka, Kerala and Tamil Nadu.

Monitoring the extent and condition of the mangroves is essential in view of the important role they play in the coastal eco-system and the biological diversity they support. Remote sensing technology, due to its synoptic nature and repetitive characteristics has proved to be immensely useful for mapping the mangrove areas periodically.

OBJECTIVES

To prepare and compile mangrove maps into an atlas so that information about its spatial extent and conditions is readily available to various planners and decision-makers at one place

STUDY AREA

The deltas of rivers such as the Ganga, Mahanadi, Godavari and Krishna, as well as the Andaman and Nicobar group of islands and the Gulf of Kachchh

METHODOLOGY

Mangroves of the country were mapped using IRS and LANDSAT data on 1:250,000 scale for the entire Indian coast and compiled in the form of an atlas.

RESULTS/OUTPUTS

State-wise distribution of mangroves as observed in the study along the Indian coast in nine states is described below:

Gujarat: In Gujarat, mangroves were mainly found in the Gulf of Kachchh, the Kori creek and as sporadic occurrences at few places. In the Kori creek, mangrove and salt marsh vegetation grew on intertidal slopes and high-tidal flat made up of dark coloured, clayey mud. *Avicennia marina* and *A. officinalis* were present along the Kori Creek in the form of narrow patches. They were bushy and mutilated with multiple vegetative shoots attaining a height of about 2m. *Rhizophora* species were rare in occurrence. Marsh vegetation consisted of dwarf under shrubs like *Sueda fruticosa* (quite common), certain members of the Graminae and the Cyperaceae family, e.g. *Aleuropus lagopoides, Cenchrus* spp*, Sporobolus marginatus,* etc.

Mangroves of the Gulf of Kachchh were of scrubby type with stunted growth, forming narrow, discontinuous patches on soft clayey mud. *Avicennia officinalis* was commonly found on this coast. *Rhizophora mucronata* grew more on the seaward side. Condition of mangroves in this area had degraded due to continuous grazing by camel, and their use as fodder and fuel. A large area had *Avicennia* with only exposed pneumatophores. Patches of degraded mangroves (*Avicennia* spp.) were observed near Okha, Poshitra, Pindhara, Dhani, Narara, Sikka, Jindra, Pirotan and near Jakhau port. *Sueda fruticosa, Tamarix dioca,* etc. were the common salt marsh species in the Gulf. A rich gregarious grew, e.g. the mat like growth of *Ulva* sp. and *Sargassum* sp. were found on the edges of the reefs and reef flats of Bural Chank, Ajad, Paga, Munde, Narara, Pirotan and other coral pinnacles.

Maharashtra-Goa: In the Maharashtra-Goa stretch, Mangroves mostly occurred along the intertidal region of estuaries and creeks. Large patches were noticed along the Mandovi estuary, the Vasisthi estuary, the Savithri estuary, the Kundalika estuary, the Dharamtar creek, the Panvel creek, the Vasai creek and the Vaitrana creek. Small and discontinuous patches were detected along other estuaries and creeks, but were not mapped.

Karnataka: In Karnataka, mangroves were sparsely distributed in the estuarine areas. The substrate was made of fine-grained clay particles and was rich in nutrients. The condition of mangroves was good along the Mulki and Sita-Swarna rivers; and in the Chakra-Haldi-Kolluru riverine complex, Sharavati estuarine complex, Tadri creek, Aganashani riverine complex and Kalinadi estuarine complex. *Rhizophora* sp, *Avicennia* sp, *Sonneratia alba* and *Acanthus ilicifolius* were commonly found.

Kerala: The Kerala coast was devoid of extensive or wide mudflats. The mangrove vegetation in the coastal zone of Kerala was very sparse and thin, ruling out any possibility of mapping it using a satellite data, especially on 1:250,000 scale. Increase in the population density and developmental activities in the estuarine shores were the main reasons for the decline in mangroves.

Tamil Nadu: In Tamil Nadu, there were well-developed mangrove forests at Pichavaram, Vedaranyam, and Point Calimere. Commonly occurring species were: *Excocaria agallocha*, *Avicennia alba*, *A. marina, A. maxima, Rhizophora conjugata, R. apiculata, Ceriops tagel*, *Bruigera conjugata, Sesuvium portulascstrum,* etc. *Avicennia* sp dominated where soil was sandy mud and *Excoecaria, Rhizophora*, etc. dominated where soil was clayey mud. Salt-tolerant species grew in between mangroves or on the

supratidal mudflats. Dominating species on the Tamil Nadu coast were *Suaeda monoica, S. maritima, Salicornia brachiata*, etc.

Andhra Pradesh: In Andhra Pradesh, mangrove swamps occurred in profusion in the intertidal mudflats on both sides of the creeks in the Godavari-Krishna deltaic regions. Thick vegetation consisted of tall, dense, halophytic trees along with other plants species. Mangrove vegetation was dense towards the coast. They were also present on the ancient tidal delta at Machilipatnam and were more widespread on tidal flats on the western side of the Krishna delta-lobe. Dense mangroves were also seen over recent spits in the Nizampatnam Bay. Degraded mangroves were found on the landward side of the high and intertidal mudflats and also in intertidal mudflats on the eastern side of the Krishna delta. Scattered mangroves were seen occupying high-tide mudflats on the eastern side of the Krishna delta. Scattered mangroves were seen occupying high-tide mudflats.

On the north Andhra coast, no classical mangrove vegetation was found. Few small pockets of degraded mangroves were found on intertidal flats at the mouth of the Sarada River, south of Uppada. Small patches of marsh occupied the high-tide flat at Bavanapadu. Marsh vegetation was also present on the islands and pale mudflats just beyond the high-tide mudflats.

Orissa: In Orissa, mangroves of the Mahanadi delta occurred along creeks, which were parallel to the coast. The mangrove vegetation included tree, scrub and palm species. Important species in this locality included *Avicennia* sp, *Acrosticum* sp. and *Phoenix* sp. The area was also endowed with rich wild life. The mangroves of Bhitarkanika, which was the second largest, mangle formations in the Indian sub-continent, harbour high concentration of typical mangrove species and a wide spectrum of genetic diversity. Important mangrove species included: *Avicennia alba, A. officinalis, Excoccaria agallocha, Heritiera minor, Sonneratia apetala, Rhizophora mucronata, R. candlena, Ceriops roxburghiana, Xylocarpus parvifolius, Phoenix paludosa, Aegiceras majus, Sueda maritima, Oryza coarctata*, etc. The mangrove forests harbour various life forms. Mangroves of the Balasore coast were quite different due to the absence of fresh water inflow, except at the Dhamra river mouth. The salinity levels remained very high except during rainy season. The emerging island near the mouth colonised a good growth of *Avicenia alba*. The species in other areas included *A. alba, A. marina, Ceriops* sp*, Aegialities rotudifolia, Suaeda maritima*.

West Bengal: The mangroves in the West Bengal coast mainly colonized in the Sundarbans area, which was the largest single block of tidal halophytic mangrove of the world. The rivers mostly carried the freshwater from the upper reaches. The mangrove along riverbanks and the swampy forests were typical halophytic mangrove types. The major species of the dense mangrove forest included *Heritiera fomes, Rhizophora apiculata, R. Mucronata, Bruguiera gymnorhiza, B. parviflora, Ceriops decandra, Sonneratia apetala* and *S. caseolaris. Avicennia* sp. and *Nypa fruticans* were the major species found along the creeks. *Phoenix paludosa* almost covered all the tidal zones of the Sundarbans. However, extensive exploitation of this species prevented its rapid growth and deteriorated its denseness from the major parts of the Sundarbans. The dense mangrove forest was famous for the dangerous man-eating Royal Bengal Tiger

and the most ferocious crocodiles. Other marshy vegetation included *Aeluropus lagopoides*, *Suaeda nudiflora*, S. *maritime* and *Tamarix* sp.

Andaman and Nicobar Islands: In the Andaman and Nicobar group of Islands, the mangroves and terrestrial evergreen forests were gregarious and there were many small tidal estuaries, neritic inlets and the lagoons which supported dense and diverse mangrove flora. The tidal creeks often formed outlets to the rain-fed stream that flew from the interior and carried silt to the shore to form muddy plants, facilitating the spread and regeneration of mangroves.

The islands alone accounted for about 18% of the country`s total mangrove area. The mangrove flora of the Andaman group of islands comprised 27 species and that of the Nicobar group of islands comprised 10 species only. The dominant mangroves species were: *Rhizophora mucronata* and *R. stylosa* and the co-dominant was *Bruguiera gymnorrhiza. Nypa fruticans* occured in the upstream regions of estuaries and neritic inlets.

3.6

EVALUATION OF THE PALK BAY BIORESOURCES THROUGH CONJUNCTIVE USE OF CONVENTIONAL GROUND SURVEYS AND SATELLITE REMOTE SENSING

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INTRODUCTION

In India, the Palk Bay has the landmarks between the Point Calimere and Rameshwaram Island as northern and southern borders, respectively. The eastern part of the bay is connected with Sri Lanka, whereas the western part of the bay forms the border of the Indian subcontinent. The flora and fauna of the Palk Bay are unique, rich and diverse in species content having mangroves, dense and widespread beds of seaweed and sea grass, coral reefs , etc., which support diversified marine life from microbes to mammals. These include phytoplanktons, zooplanktons, seaweeds, sea grasses, shell fishes, fin fishes and a plethora of other organisms. Though all these coastal marine bio-resources are plenty in the Palk Bay region, no detailed study has been conducted till date, except Muthupettai mangroves, to document these resources and the environmental parameters, which influence them for their sustainable utilization. Munaikkadu is one of the fishing villages with frequent landings and it is located in the coastal area of Ramnad district of Tamil Nadu state. The reefs developed around this area are distributed discontinuously. Different types of reef formations, viz. fringing reef, patch reef and coral pinnacles have been observed in this region. The coast is characterized by stretches of corals and rich vegetation of seaweeds and sea grasses and is devoid of mangroves. Active fishing is taking place at this station with the operation of considerable number of mechanized boats. Devipattinum is another coastal village situated in the Palk Bay, 30km southwest of the Ramnad district. The sea bottom at this coast is dominated by sandy to muddy soil. These types of shallow coasts usually support luxuriant growth of sea grasses but not seaweeds and corals. There is rich mangrove vegetation in the southern side of this station. Kattumavadi is a coastal village in the Palk Bay region of the Pudukottai district of Tamil Nadu. There are no major river discharges, expect that of a small river. This coast is dominated by luxuriant growth of sea grasses and seaweeds and is devoid of rocks, corals or any other substrates.

OBJECTIVES

- Documentation of the species diversity, distribution and abundance of sea grasses and seaweeds in the Palk Bay,
- To study the ground truths on physical, chemical and biological parameters of the near-shore waters of the islands, thereby estimating the water quality,
- Real time sampling during the overpass of the satellite IRS IC/ID and interpretation of these data with satellite imageries,
- To study the spectral reflectance properties of the Palk Bay (coral, mangrove and sea grass / seaweed environment),
- Evaluation and delineation of different land-cover classes and the areal extent of corals sea grasses and seaweeds in the Palk Bay through visual interpretation and digital analysis techniques,
- Preparation of coastal resource maps of the Palk Bay and creation of coastal resource database using GIS, and
- Evaluation of the current status of the Palk Bay bio-resources to suggest conservation and management measures for sustainable utilization.

STUDY AREA

Devipattinum, Munaikadu and Kattumavadi in the Palk Bay, Bay of Bengal along the southeast coast of India, covering an area of about 600 sq. km.

METHODOLOGY

The multispectral satellite data was procured from the National Remote Sensing Agency (NRSA), Hyderabad. The IRS ID LISS-III data for the years 2000 and 2002 and of IRS P6 LISS-III for the year 2004 pertained to the Path 102, Row 67 in electronic format (DAT files). Seasonal collections viz. post-monsoon, summer, pre-monsoon and monsoon seasons were done for physico-chemical and biological parameters during April 2003 to March 2004 at two selected stations, viz. Munaikkadu and Devipattinumn in the Palk Bay to collect surface water samples for the estimation of various physical, chemical and biological parameters and spectral reflectance properties of various resources.

RESULTS/OUTPUTS

Various coastal resources, viz. coral reef, reef vegetation, sand over reef, dense and sparse sea grass beds, dense and spare mangrove vegetation and other coastal land feature classes like sandy beach, mudflats and salt pan/ aquaculture ponds were classified using IRS LISS-III satellite imageries. The multidate satellite data of 2000, 2002 and 2004 showed that various resources and land features had been subjected to temporal changes.

The areal extent of mangroves was recorded in the Devipattinumn and Mullimunai regions of the Palk Bay. The Kottakkartaiar was one of the seasonal riverlets of Vaigai River, which formed dense mangrove pockets near its confluence with the Bay of Bengal at Mullimunai. Besides, there were sparse mangrove pockets also all along the coast line. All these mangrove pockets were composed mainly of *Avicenna marina* towards the land ward-side and of thick populations of *Suaeda monoica* and

S. maritima towards the landward-side. *Sesuvium portrulacastrum* was also found to occur as limited patches.

It was difficult to delineate and map the sea grass resources in the coral reef environs, as the coral reef vegetation consists mainly of seaweeds and sea grasses which were differing only in a narrow range of spectral variation. The misclassification problem of sea grass fell under two major categories: (i) distinguishing the sea grasses from spectrally similar substrates and features such as mussel beds, algal blooms and detritus, deep water and coral reefs, and (ii) low density of sea grass beds which were difficult to be distinguished from bare seafloor.

From the satellite remote sensing studies, it was found that the sea grass beds of Munaikkadu region of the Palk Bay were comparatively well protected. In Devipattinumn, several anthropogenic pressures were exerted only on the sea grass resources which had led to the reduction of over 646.08 ha (22.11%) of sparse sea grass beds between 2000 and 2004 due to various anthropogenic pressures. In the field surveys also, only low sea grass biomass was observed. It has been reported that 30-40% of sea grass loss in Indonesia was due to sedimentation and coral mining while 32-50% loss in Philippines was due to industrial developments, ports and recreational activities and 20-30% loss in Thailand was due to aquaculture drainages and waste disposal from domestic sources. The observed sea grass loss warned that the sea grass resources of Devipattinumn coastal area faced a gradual reduction, i.e. transformation from the dense extensive bed stage to sparse patchy beds, mudflats or bare seafloor. If such reduction continues in future, the bio-diversity, including fisheries potential would decline. Hence, it was suggested to take up suitable sea grass transplantation programmes in this region.

The distribution of coral reefs along the southern side of the Palk Bay, starting from Vedhalai, parallel to the coast up to a distance of 6 km and ending near Thonithurai was identified. The reefs started again near Pamban and ran up to Agnitheerthan of Rameswaram Island. The Pamban Pass, connecting the Palk Bay with the Gulf of Manner, was interrupting the coral reefs and had made two separate stretches. The distribution of coral reefs from Munaikkadu to Thonithurai was observed with increasing width.