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SUMMARY OF THE THESIS

"FLORAL DIVERSITY AND ECOLOGY OF FEW SELECT AREAS OF GUJARAT: A STUDY USING REMOTE SENSING"

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SUMMARY

The highly productive coastal ecosystems of the tropics play a crucial role in the economic and social development of the region. They are characterised by assemblages of diverse faunal and floral species. With unimpeded growth in the population and resultant indiscriminate developmental activities, coastal ecosystems including mangroves are facing the threat of destruction throughout the world. Management measures in mangrove regions are often hindered due to lack of comprehensive information and hence detailed knowledge of various aspects of community composition, their specific locations and extents are required for their proper management planning. Despite its tremendous economic and ecological value, understanding of this unique ecosystem is very little, which may be attributed to its remote locations, hostile terrain characteristics, and lack of funds and skilled personnel. Traditionally, people have used mangroves for the benefit of the local community, but increasing populations have led to an increasing non-sustainable abuse of the resources.

Mangroves have been usually studied applying various conventional methods but their systematic ground sampling is not easy because of their distribution and inaccessible locales. Mapping of mangrove and study of the regional and global scale processes require a tool to visualise the mangroves synoptically.

Habitat maps derived using remote sensing techniques are widely and increasingly being used to assess the status of coastal natural resources and serve as a basis for coastal planning and for the conservation, management, monitoring and valuation of these resources. The main difference between mapping mangroves and other coastal habitats such as reefs and sea grass is that mangrove foliage is terrestrial. No compensation has to be made for variation in water depth and colour. In addition, infrared portion of the electromagnetic spectrum can be used. Mangrove areas, especially, the interior of mangrove stands, are often difficult to access and remote sensing allows information to be gathered from such areas that are otherwise very difficult to survey. To date the remote sensing technique remains the only viable means of gathering information and generating consistent and comprehensive mangrove habitat maps despite constraints like cloud cover.

Mangroves of the Gulf of Kachchh, occurring in the arid region of Gujarat are under high environmental stress and are amongst the most threatened Indian mangroves by both natural and anthropogenic factors. They have not been a focus of much interest to biologists and ecologists across the country perhaps because of its unfriendly geo-environmental characteristics and its said mono-species diversity. In the past, baseline inventory of these mangroves have been created using remote sensing data. However, there is a need to acquire detailed knowledge of the different community zonation and the ecological factors responsible for it, which will form a major input towards their efficient management.

The present investigation has focused on the floristic diversity and ecology of the mangrove forests on the east-west coastal strip on the Southern part of Gulf of Kachchh, that includes the Islands of Pirotan, Jindra-Chhad, Dide Ka Bet, Munde ka Bet, Bhains bid and the mainland areas south of Hadde Creek through remote sensing technique. The study has mainly intended to develop a methodology for discrimination of mangrove community zones using remote sensing data, prepare a floristic inventory of the mangrove and associated flora, to detect changes in the mangrove cover over the past 40 years and to evaluate the ecological factors affecting the study area with particular reference to their impact on mangroves.

Mangrove habitat mapping and community zonation has been carried out with the help of remote sensing data provided by the multispectral LISS III sensor onboard IRS-1C/1D sunsyncronous satellites. Extensive *in situ* data has been collected to i) develop a classification system, ii) prepare a floristic inventory of the area iii) provide input for image interpretation in terms of training sites, and iv) validate the maps generated by image interpretation.

The study demonstrates the importance of the SWIR band in mangrove community zonation using remotely sensed data. Several image enhancement techniques including vegetation indices, principle component analysis and band ratios were evaluated to obtain mangrove community zonation maps at the required detail and accuracy. They were then subjected to rigorous accuracy assessment. Using thematic data available from a variety of sources change in the mangrove habitat of the study area since 1966 has been analysed using the

post classification change detection method. These changes have then been discussed in the light of relevant literature on the various ecological aspects of the area.

Conclusions of the present study, their implications and recommendations are listed below:

1. The multispectral LISS III satellite data has been found to be useful in mapping the different mangrove communities in the study area with high accuracy.
2. The classification system for mangrove community zonation has been evolved in the study. This classification system takes care of tidal inundation, salinity, geomorphological setting and density of the mangroves. This system has also been used to zone the mangroves of few regions of India with area specific modifications.
3. Methodology has been developed which will help in zoning the dominant communities of mangroves, using medium resolution satellite data with the inclusion of SWIR band. Essentially the methodology involves the image analysis technique of band ratioing after carrying out necessary image corrections. The band ratioed image along with the radiance converted images when subjected to supervised classification help in zoning the communities. This study has been verified on the ground with sufficient sampling.
4. The best accuracies for mangrove habitat as well as mangrove community zonation have been obtained by using band ratios followed by supervised classification. The overall classification accuracy obtained was ~89% at 85% confidence level for the mangrove community zonation map. The highest users accuracy of 100% was obtained for the dense mangrove communities (except mixed) while lower accuracies were obtained for the degraded mangrove (~ 75%) and standing dead mangroves (~71%).
5. The spectral reflectance signatures of the different communities in the area have been established for the four band widths in the LISS III sensor.

The importance of the SWIR band in community zonation has been proved. The total reflectance from the *Ceriops-Rhizophora* community is less than that of the *Avicennia* community.

6. Some genera (e.g. *Ceriops* and *Rhizophora*) that have similar spectral behaviour in the LISS III sensor bands could not be spectrally separated. Improved spatial as well as spectral resolution may help in separating the *Ceriops-Rhizophora* community into distinct patches.

7. The mangrove forests in the study area are composed of 7 species of true mangroves. The most dominant mangrove genus in the area is *Avicennia*, followed by *Ceriops* and *Rhizophora*. *Aegiceras* is found in very small numbers. Bhains bid, Pathe Pir ka bela and Chiriya Tapu were the islands with maximum mangrove diversity in the study area. The highest density of mangrove plants was found on Dide ka bet while the lowest density was observed on the fringing mainland.

8. The presence of an extensive salt marsh community is being reported for the first time. It was earlier reported as a component of mud vegetation. The salt marsh community is composed by three species of *Sueda, Salicornia brachiata, Sesuvium portulacastrum* and *Aleuropus lagopoides.* The salt marsh community has steadily increased in extend from 405 ha to 490 ha over 1998 to 2001. In addition to these 57 more angiosperm species have been reported from the study area. *Urochondra setulosa*, an endemic to Gujarat has been located on Pirotan Island as well as on the fringing mainland.

9. The extent of the mangrove community has been steadily decreasing in the past few years. The area under mangrove cover has reduced from 6231 ha in 1998 to 5404 ha in January 2001. The sparse pure *Avicennia* community is the largest in the study area occupying 46 % of the mangrove vegetation of the area. More than 83 % of the mangrove cover in the area has *Avicennia* as one of its components. The pure *Ceriops-Rhizophora* community covers a mere 5.9 % of the total mangrove area.

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10. Mangrove areas fringing the mainland and large islands like Jindra-Chhad and Dide-ka Munde-Ka bet are subject to high anthropogenic pressure and hence the observed density and diversity on them is comparatively less than that of the smaller islands. The smaller islands are more diverse and are more suitable for preservation of the diversity of the mangroves in the Marine National Park.

11. Mangroves of the Gulf of Kachchh are under various natural and anthropogenic pressures. This has resulted in the species diversity of the mangroves to be reduced to just 7 species. The introduction of new species is hampered by the negligible inflow of freshwater into the area due to the damming of most of the rivers flowing into it. This is probably the reason that the introduction of *Kandelia* and *Sonneratia* within the area has not met with success.

12. The study has broad scientific applications to our understanding of the mangrove vegetation of the Gulf and will also be useful towards their management planning.

Recommendations:

1. The islands of Bhains bid, Pathe pir ka Bela, Chiriya tapu and the other smaller islands should be included in the preservation zone in the management of the Marine National Park, while the larger islands can be included in the conservation zone.
2. *Rhizophora apiculata*, which grows on the seaward margin of several mangrove species and can tolerate high salinity to a certain extent can be introduced in the region.
3. The *Rhizophora* plantation should be carried out on the margins of creeks, which have daily tidal inundation while *Ceriops* plantations can be carried out on slightly higher mudflats.

Dharma
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