CHAPTER 1: INTRODUCTION

The world around us is full of living organisms of hues and shapes that amaze us. The total diversity and variability of living things and of the systems of which they are a part is Biological diversity or Biodiversity. According to the Convention on Biological Diversity "Biological diversity or Biodiversity means the variability among living organisms from all sources, including *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecologic complexes of which they are a part; this includes diversity within species, between species and of ecosystems" (Heywood *et al*, 1995). It is now customary to consider biodiversity in ecological, organismal (taxonomic) and genetic terms and at a variety of levels for each of these. The key units in the ecological hierarchy are populations rather than the individuals they are composed of. Ecosystems are composed of all individuals of all the species in a given area and their physical environment. The addition or deletion of a species can have a profound effect on the capacity of an ecosystem to provide ecosystem services. Based on the latest evidences, the capacity of ecosystems to resist changing environmental conditions and to rebound from unusual climatic or biotic events is related positively to species numbers (Hawksworth & Kalin-Arroyo, 1995). Plants are not evenly distributed, they occur in an intricate mosaic, classified on a world-scale into biogeographic zones, biomes, ecoregions and oceanic realms and a variety of smaller scales within landscapes into ecosystems, communities and assemblages. This distribution of plants is highly dependent on the ecological conditions that occur in an area. The flowering plants with some 2,70,000 species are by far the largest number of species for any plant group. They are the most successful plants on earth, adapted to almost every habitat except Antarctica. The diversity of angiosperms is especially remarkable since they are the most recently evolved plant groups (Pilo, 1996).

Remote sensing systems typically produce imagery that averages information over tens or even hundreds of square meters – far coarse to detect most organisms. However advances in the spatial and spectral resolution of sensors now available to ecologists are making the direct remote sensing of biodiversity increasing feasible, e.g. distinguishing species assemblages or even identifying species of individual trees (Turner *et. al.*, 2003). Also scientifically sound environmental management requires frequent and spatially detailed assessments of species numbers and distributions. Such information can be prohibitively expensive to collect directly. On a global to local scale the only feasible way to monitor the earth's surface to prioritize and assess the success of conservation efforts is through remote sensing (Murthy *et. al.*, 2003).

Among the large ecosystems of the world are the ocean ecosystem (occupying about 71 % of the surface of the globe) and the terrestrial ecosystem. A major ecosystem that lies on the fringe of the terrestrial and ocean ecosystem is the coastal ecosystem. The coastal zone, the area of interaction between the sea and land, includes both marine as well as terrestrial resources, which may either be renewable or non-renewable. This ecosystem is unique in that it is influenced by both terrestrial factors as well as marine factors. It is this interaction of factors that makes this ecosystem very dynamic as well as important. As the increasing human population depletes the large pool of terrestrial resources it will have to look to the ocean for the vast resources that it holds. This will need a more detailed understanding of the interface of the two biomes, the coast. The importance of the coastline can be gauged from the fact that more than one third of the total human population lives on or near the coast (Cohen *et al.* 1997).

The highly productive coastal ecosystems of the tropics play a crucial role in the economic and social development of the region. (Nayak & Bahuguna, 2001). The vegetation found on the tropical coastal region is very unique. The major vegetation types include seagrasses, macro and micro algae, vegetation on sand patches and the highly productive mangroves. Mangroves dominate approximately 75% of the world's coastline between 25° N and 25° S latitudes (Wong and Tam 1995). The importance of the mangrove vegetation can be realized from the fact that more than 70 percent of the marine fishes spend a part of their life in the mangrove environment. Also among the major ecosystems of the world the mangrove ecosystems along with the coral reefs are parallel to the tropical rain forests in productivity. Ecologically mangroves are important in maintaining and building the soil, as a reservoir in the tertiary assimilation of waste, and in the global cycle of carbon dioxide, nitrogen, and sulfur. The protection against cyclones is a “free” benefit. Yet hidden benefits from mangroves, especially in marginal areas, may even be more important than the obvious ones. They play a significant role in coastal stabilization and promoting land accretion, fixation of mud banks, dissipation of winds, wave and tidal energy. 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 (Bandaranayake, 1998).

Mangroves occur in all coastal states and union territories of India to a larger or smaller extent. The mangroves in West Bengal represent the Indian part of the mangroves of the Sundarbans, which are the largest single block of mangroves in the world. With a mangrove cover of 911 sq km, Gujarat stands second only to West Bengal (Nayal *et al.*, 1992).

The mangroves of the Gujarat are distributed in three major regions, viz., the Indus delta, the Gulf of Kachchh and the Gulf of Khambhat. Among these regions mangroves of the Indus delta cover the largest area while due to heavy industrial activity and human pressure the mangroves of the Gulf of Khambhat are remnants of a vast mangrove cover. The Gulf of Kachchh has the highest diversity of mangroves among all the three regions. The region also has a marine national park and a marine sanctuary. However, the diversity and extent of these mangroves has declined. The mangroves had a very extensive and dense distribution with the trees reaching a height of over 14 m. They extended in thick patches along the Okha-Salaya, Vadinar-Sarmat-Sachan-Sui and the Mundra-Mandvi-Jakhau stretches. On account of its rich mangroves, the Island of Pirotan was famous for its pearl oyster fishing during the erstwhile Jamnagar state (Chavan, 1985). The mangroves of the Gulf of Kachchh have been under constant pressure since long. Being an arid zone, it is devoid of any extensive vegetation that can be used as firewood or fodder for livestock and so all the pressure comes on the mangroves. However with the establishment of the Marine National Park in the 1980s these mangroves were provided with necessary protection and there was a substantial rise in the mangrove cover in these areas. This was also helped by the fact that there is very little reclamation of mangrove area for agriculture in this region as the scanty rainfall in this region will make leaching of salt from the soil almost impossible (Untawale & Wafar, 1988).

A spate of high industrial activity in the region after 1995 and the present Port policy of the Government have once again put the mangroves of this region under high stress. The largest Oil refinery in India has been set up near Jamnagar. Along with this another mammoth refinery is planned to come up in this region in the near future. The region has also faced two big cyclones in June 1998 and May 1999, which have had a large impact on the mangroves. In addition to these several ecological factors such as almost no fresh water influx (due to damming of rivers), heavy sand and sediment movement are having a profound influence on the mangroves of this region. All these have posed new problems for the management of the mangroves of this region.

An environmentally sound management of the coastal zone requires information on extent and condition of coastal habitats, coastal processes, quality of coastal waters, human activities and socio-economic conditions. The information required for the effective management of the Indian mangroves can be broadly grouped under the following categories: mangrove inventory, assessment of condition and causes of changes in the mangrove ecosystems. The present level of information on the Indian mangroves cannot be considered to be exhaustive and therefore a need arises to gather accurate information about the community structure, zonation, ecology and the processes working on it. Over and above this the recent trend towards conversion of mangrove areas into aquaculture ponds, saltpans and ports need a periodic reassessment of their extents and structure in order to make sure their effective management.

Satellite remote sensing has proved to be extremely useful in generating information on many components of the coastal environment (Nayak *et al.*, 1992, Navalgund & Bahuguna, 1999). 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 (Green *et al.*, 2000; Nagendra, 2001). Coastal management in developing countries, in particular, is beset with additional problems of unreliable or incomplete baseline information, limited financial resources, a shortage of technical and professional capacity, and a general lack of enforcement of environmental regulations (Knight *et al.* 1997). Remote sensing data has been very useful in mapping the mangroves density-wise (Nayak *et al.*, 1992) Attempts were made to map dominant communities of mangrove using medium resolution IRS LISS III data (Nayak *et al.*, 1996, Bahuguna & Nayak, 1996, Nayak & Bahuguna, 2001).

The present study focuses primarily on developing methodology to identify and delineate the diversity at the community level within the mangrove formations on the islands of Jindra-Chhad, Pirotan, Dide ka Munde Ka bet and the fringing mainland south of Hadde Creek situated on the central southern part of the Gulf of Kachchh using medium and high resolution remote sensing data. The objectives of the present study are,

- To develop methodology to identify and delineate the mangrove diversity at the community level .
- To prepare a mangrove diversity map at the community level for the region.
- To map major floristic habitats in the region.
- Monitoring mangrove habitats from 1998 to 2001.
- To detect changes in the mangrove habitat during 1966-2001.
- To evaluate the various ecological factors influencing the mangrove vegetation of the region.

Importance of the study:

Biodiversity monitoring of a large area is not only difficult but also costly when carried using ground based surveys. The use of remote sensing for the inventory and monitoring of diversity at the community level for large areas is not only cost effective but also the most feasible (Nagendra, 2001). The present study on the mangrove formations of the Gulf of Kachchh has used remote sensing to assess and monitor the diversity at the habitat/community level. The importance of this work can be gauged by the following points.

- The methodology developed in the present study will help to assess the diversity of other major mangrove formations in India at the community level as well as facilitate their regular monitoring.
- The study will reveal the present status of the different communities within the mangrove ecosystem of the study area.
- The study presents an updated enumeration of the present floristic diversity in the area and gives information on a few phytosiociological parameters for which no precise information presently exists.
- The trend of change in the mangrove formations of the area have been monitored from 1966 and the various factors responsible for that change have been evaluated. This will not only help in the efficient management of the mangrove vegetation of the area but will also help in predicting the future of this ecosystem in the area if present conditions prevail.

Layout of the Thesis

With an aim describe the work carried out during the present study clearly and precisely the thesis has been divided into 11 chapters with each chapter decicated to a specific aspect of the study. Chapter 2 introduces the study area while Chapter 3 introduces remote sensing with specific reference to vegetation remote sensing. The mangrove ecosystem has been described in chapter 4 and chapter 5 reviews the literature on remote sensing of mangroves. Chapter 6 elaborately details the materials and methods used in the present study. The spectral responses of the diverse mangrove communities in the area have been described in Chapter 7. Chapter 8 details the mangrove habitat and community zonation while chapter 9 details the floristic diversity in the area and its phytosociology that has been collected during the ground-based surveys. Chapter 10 deals with the change in the mangrove habitat and discusses the various ecological parameters that influence the mangroves of the area. Chapter 11 notes the major conclusions of the present study.