1.1. Background

The fascinating earth, with its enormity and mystery, has ever been part of human life and consciousness. Oceans are the prime source for human life. Broadly speaking, the human life on earth arose from the ocean. Coastal areas are very important for human being since the beginning of time. Most of the major cities in the world are situated along the coastal areas. Two third of human population are living in and around the coastal areas. Due to abundant natural resources, the urbanization and population increases rapidly on the coastal areas. They put high pressure on the coastal areas and finally they are under severe threat and hazard.

Coastal processes are the action of natural forces on coastal areas, which modify the shorelines and coastal landforms. Both natural and anthropogenic activities leads to coastal degradation and various hazards like global warming, climate change, sea level rise, sea water intrusion, coastal erosion, floods, Tsunami etc. Understanding coastal processes is crucial for sustainable development, coastal management and rehabilitation. The interplay between ocean, land, and atmosphere has not still fully understood even with the latest technology. Even though significant progresses have been made on the coastal processes by means of physical experiments and computational simulations (De Vriend et al. 1993; Ding et al. 2000; Reniers et al. 2004), the extreme complexities of coastal morphological processes, the mechanisms of sediment transport and coastal erosion have neither been fully understood nor described. Advanced numerical simulation and modeling of coastal processes with adequate physical principles and mathematical formulations are very essential to assist the policy makers, coastal planers, engineers and researchers for initiating the developmental activities and to assess the environmental impacts of projects along the coastal area through out the entire world.
Modeling of coastal processes can significantly facilitate the planning of coastal engineering projects and designing of coastal structures for shoreline erosion protection, navigation channel maintenance, coastal environmental assessment, and so on. Even though, we can’t completely eliminate the factors affecting our coastal environment, we have the ability to reduce their impacts. Quantitative analysis of coastal landform dynamics and the development of conceptual modeling tools will eventually solve various coastal problems and helps to understand the complex and diverse nature of our coastal environment. The collective effort will provide unique opportunity to solve various issues like poverty mitigation, population growth, economic development, sociological reformation and sustainable environment which are emerged as the common goal for mankind in recent times.

1.2. Significance of Coastal Landforms

Any feature on the surface of earth such as plains, delta, plateaus, mountains, hills, valleys is known as landform. It is a natural formation of distinct shape and origin made up of any material on the earth. The interaction of different landforms is complex in nature. Landforms are categorised by the characteristic physical processes and attributes such as elevation, slope, orientation, stratification, rock exposure, and soil type etc. It can be classified in to major types such as aeolian landforms, coastal landforms, mountain and glacial landforms, slope landforms, volcanic landforms, fluvial landforms.

Coastal landforms are the characteristic feature and morphology of the land on the coastal zone. They are subject to processes of erosion and deposition as caused by winds, waves, tides, and river discharge. The interactions of these processes and the coastal environment produce a wide variety of landforms like beach, barrier islands, deltas, estuaries, tidal inlets, tidal flats, flood plain, coastal plain and salt marshes etc. The coastal landforms are valuable environmental, aesthetic, and recreational resources for the
human life. They provide enormous resources which leads to rapid economical and sociological developments of the global world. The coastal environment is made up of a wide variety of landforms manifested in a spectrum of sizes and shapes ranging from gently sloping beaches to high cliffs.

Chandrasekar et al. (2000) insists that the study of coastal landform is one of the most interesting areas of geomorphological research. They also states that the study is important as the tides, waves, and currents provide energy, which is working constantly to change the coastal landforms in short intervals. In the past, waves, tides, relative sea level, sediment characteristics, sediment sources and sinks, and landform type controlled the configuration and function of coastal landforms. All coastal hazards are related to the geologic processes and have a profound impact on coastal landforms (Ferraras and Pararas 1988). But now human actions are a significant factor, on par with natural forces in many places, in controlling the shape and function of our shores and coastal landforms. Increased vulnerability to natural disasters of developing countries is a major reason for concern (Kato and EANHMP, 2002).

The potential loss of human lives and property due to natural hazards is very high in the urban areas of many countries (Munich Re., 2000). Nayak (2002) insists that the coastal zone of the world is under increasing stress due to industries, trade and commerce, tourism and human population growth and migration, and deteriorating water quality. He also states that this zone is of very high biological productivity and thus forms an important component of the global life system. So, it is very essential to protect our coastal resources and reduce the natural hazard and losses. This task requires both spatial and non-spatial information on landforms, habitats, coastal processes and natural hazards on a regular basis. Hence the study of coastal landform dynamics is very essential and efficient one to attain a healthy environment.
1.3. Role of Satellite Remote Sensing and GIS Technologies

Satellite remote sensing is the art, science and technology of obtaining information about a distant object, area or a phenomenon through the analysis of data acquired by a device called “sensor” which is not in physical contact with the object or area under investigation (Figure 1.1). The imageries sent by the sensors contain the information about the object and they are subjected to various digital image processing techniques. Finally the required information can be extracted and interpreted. Chandrasekar et al. (2000) reported that the space technology by virtue of its capability to provide information over a large area in a repetitive basis has proved to be very useful in identifying and monitoring various coastal features towards a suitable action plan to achieve the development in any coastal area. Champati (2000) also insists that the information given in digital format is easily accessible to policy makers and coastal engineers for various applications and developmental projects.

Geographic Information System (GIS) is a computer system (Figure 1.2) for collecting, checking, integrating and analyzing the spatial and non-spatial information of the earth (Rhind, 1988). It processes all type of spatial and non-spatial data of the earth. GIS has many definitions due to its comparative recency, rapid rate of development, commercial orientation and diversity. Cowen (1988) states one of the important definitions for GIS. According to him, GIS is a decision support system involving the integration of spatially referenced data in a problem-solving environment. Due to the recent advancements in remote sensing, the GIS undergo a rapid development and they are used in almost all applications pertain the human development. Desai et al. (2000) have reported the advantages of GIS for the integration of various thematic information derived from satellite data with other collateral data such as socioeconomic and cultural data are significant in arriving at integrated coastal zone management practices.
Figure 1.1 Active and Passive Remote Sensing Technology

Figure 1.2 Essential Components and Architecture of GIS
Several studies using satellite data have proved its efficiency in understanding various coastal landforms and associated processes. (Anderson et al., 1973, Nayak and Sakai 1985, Loveson and Rajamanickam 1998). Nayak (2002) states that the modern scientific tools of remote sensing, GIS and GPS are extremely valuable in the development of coastal databases and to analyse them in the integrated manner and derive management action plans. Therefore the remote sensing technology with GIS can be effectively used to classify various coastal landforms and to study their dynamics. Remotely sensed information integrated with the other collateral information through GIS can be effectively used for the conservation of coastal ecosystems.

1.4. Scope and Significance of the Study

The dynamics of coastal landforms by natural and human impacts is a topic today of considerable attention and significant. The present study focuses on the quantitative analysis of coastal landforms between Tuticorin and Kanyakumari of southern coastal Tamil Nadu of India. It primarily analyses the state and dynamics of various landforms features such as shorelines, beaches and sand dunes etc. in the temporal and spatial scales. The coastal landforms are highly incorporated with the human life. Most of the developing countries like India are actively involved in sustainable coastal development. Major economy of many countries depends on their coastal resources. These developing countries face many problems due to the impact of various hazards on their coastal environment. India has a coastline of about 7,500 km (Chandramohan et al., 2001) and nearly 250 million people live within a distance of 50 km from the coast (Areti 2007). The coastal area acts as a buffer-zone between the marine and the terrestrial realms, soaking up a major portion of the impact and energy of waves and storms (Mascarenhas 2004). The coastal zone is endowed with a wide range of ecosystems such as mangroves, coral reefs, sea grasses, salt marshes, sand dunes, and estuaries and each of these
ecosystems are in turn characterised by distinct biotic and abiotic processes. In addition to their ecological value, these ecosystems play a vital role in the nation’s economy by providing livelihoods for a majority of the coastal population. Despite their diversity of terrestrial and aquatic habitats, ecological landscapes along the coast remain rather poorly understood, but nevertheless under intense human pressures (Daniels et al., 2003).

India has been identified as one amongst 27 countries which are most vulnerable to the impacts of global warming related accelerated sea level rise (UNEP, 1989). This high degree of vulnerability of Indian coasts can be mainly attributed to extensive low-lying coastal area, high population density, frequent occurrence of cyclones and storms, high rate of coastal environmental degradation on account of pollution and non-sustainable development. Most of the people residing in coastal zones are directly dependent on natural resource bases of coastal ecosystems. Any global warming-induced climatic change such as increase in sea surface temperature, change in frequency, intensity or tracks of cyclones, sea level rise may aggravate the potential risks to coastal zones. The rise in sea level could result in the loss of cultivable land due to inundation, salt water intrusion into coastal ecosystems and into groundwater systems and loss of terrestrial and marine biodiversity.

Due to this cyclic process based on erosion, transport, and sedimentation, a constant morphological alteration takes place, which can range from a few seconds to centuries and from centimeters to thousands of kilometers on a temporal and spatial scale (McMagnus, 1998). The study area is characterized by many landforms with diverse ecosystem. It is endowed with a variety of coastal habitats like coral reef, mangroves, seaweeds and sea grass bed, salt marshes, sand dunes, ports, fishing harbors and variety of coastal industries. The ever-increasing population combined with other factors offer
great stress on coastal zone and often leads to degradation and erosion of the coastal areas. The impact of natural and human induced changes on these coastal landforms is to be analysed by using remote sensing and GIS technologies. There is an urgent need to protect this coastal environment while ensuring its continued production and development. The need for such a program is most urgent and highly imperative.

1.5. Objectives of the Study

The Prime Objectives of the Study are...

i) To compare and analyse the beach topographical and morphological changes by using beach profile surveys. The field study also focus on the littoral wave processes and the transport of sediments along the coastal stretch.

ii) To extract the shorelines by using multi-date satellite data and to estimate the coastal erosion and accretion. The shoreline change rates have to be estimated and the vulnerable areas should be demarcated.

iii) To map the various coastal landforms by using remotely sensed satellite images and other secondary data. The dynamics of these coastal landforms have to be analysed. The study also focuses on the application of multi-spectral data for potential mineral mapping.

iv) To develop a web-based coastal GIS (Intranet) by integrating all spatial and non-spatial data.

The present study is to collect, analyse and disseminate the information of the coastal landforms and their dynamics with remote sensing and GIS technologies. The study has four major stages. The first stage is to collect the spatial and non-spatial data required for the analysis. The second stage is to process the data with available modern techniques to extract the information of various coastal features. The third stage is a crucial part of this study and is devoted to compare and contrast the extracted information with various coastal processes. The geological and hydrological processes associated with
the dynamics of different coastal features are to be also analysed and interpreted in this stage. The fourth stage is to disseminate all the obtained information for research, planning, developmental projects and decision making purposes.

The interaction between waves and beach profile response in the near shore is a highly complicated phenomenon resulting from many different processes acting at widely varying scales (Larson and Kraus, 1995). The present study is to analyse the dynamics of beaches during the period from Mar.-2006 to Feb.-2008 through volumetric and Empirical Orthogonal Function (EOF) analysis of beach profiles. The geometrical and morphological parameters of beaches have to be estimated and analysed by using the latest software tools and newly developed computer program.

Littoral drift is very important for coastal zone management with regards to coastal protection and maintenance of coastal infrastructures like harbors, waterways and other coastal engineering designs. In recent years, there has been increased focus on the near-shore zone due to rapid development of coastal regions and the need to protect the infrastructure from storms and long-term coastal erosion (Kelley et al., 2004). In this present study, the littoral environmental observation (LEO) has to be carried out for the selected beaches between Kanyakumari and Tuticorin from Mar-2006 to Feb-2008. The longshore sediment transport rates (LSTR) has to be estimated from the collected near shore wave data by using the well known CERC formula. The impact of longshore sediment transport on modifying the shoreline has to be analysed.

Shoreline is the one of the rapidly changing landform in coastal area. Shoreline analysis is a very objective treatment of the variety of ways in which humans have altered the landforms with an emphasis on the importance of retaining the normal functioning
beaches and dunes in a ways that achieve natural values while accommodating development and use. So accurate demarcating and frequent monitoring of shorelines are very essential to understand the dynamics of coastal landforms. The shoreline provides the unique information on the dynamics of coastal landforms and it is very useful to manage our coastal resources and to plan the recreational and developmental projects along the coast. The present study has to analyses both long-term and short-term changes of shorelines. In-order-to eliminate the inherent manual limitations during the physical analysis of shoreline changes, the extracted shorelines are also analysed through the Digital Shoreline Analysis System (DSAS).

Coastal landform mapping is very essential for sustainable and eco-friendly exploitation of natural resources. The study aims to identify and map all the coastal landforms in the study area by using remotely sensed images. Both visual image interpretation and image processing tools has to be used to predict the landforms. The dynamics of coastal landforms with various coastal processes and human interventions has to be dealt. The study should also leads to the development of potential mineral mapping for the exploitation of mineral resources along the coast in a sustainable way.

The scope and objective of any scientific study will be rewarded only on the effective utilization of the obtained results by the users of different categories. In-order-to attain this specific task, the obtained results are delivered through ArcIMS, a web based Geographic Information System (Intranet-GIS). The spatial and non-spatial information including maps and meta-data have been published. ArcIMS also provides to build and customize the appropriate viewer required by the user community. Thus the present study will be very useful to research and developments, policy making purposes, resource management and environmental protection.
1.6. Location of Study Area

The study area is the coast between Tuticorin and Kanyakumari of southern coastal Tamil Nadu of India with different morphological features and diverse ecosystem (Figure 1.3). The Tamil Nadu coast line extends over a distance of 906 km endowed with a variety of coastal habitats like coral reefs, mangroves, seaweeds, salt marshes, sand dunes, sea grass bed etc. According to the Johnson (1919) classification who had given importance to the sea level oscillations, the south Tamil Nadu was considered an emergent coast. According to Sheppard (1963) classification, the Tamil Nadu coast belongs to the nature of coast where marine deposition dominates. Based on the existing characteristic features, Ahmad (1972) classified the Tamil Nadu coast as a depositional plain type. The south coastal Tamil Nadu has also diverse ecosystem.

The exact location for the present research lies between the Kanyakumari coast (From Manakudy Palayar Estuary) and Tuticorin urban coast which extends over a distance of 160 Km and enclosed by the latitudes from 8° to 8.88° N and longitudes from 77.5° to 78.30° E. The major coastal settlements are Tuticorin, Kanyakumari, Tiruchendur, Ovari, Manappad and Kayalpattinam. The study area includes headlands along Manappad and Tiruchendur coast. There is a major port in Tuticorin and a fishing harbor in Muttam near the Kanyakumari coast. The study area is highly dynamic with many cyclic and random processes owing to a variety of resources and habitats. The coastal ecosystem is highly disturbed and threatened by problems like pollution, siltation, erosion, flooding, sea water intrusion, storm surges and ever-expanding human settlements. In-order-to simplify the approach and analysis of this research, the study area has been subdivided in to four coastal zones namely Kanyakumari (KAN), Ovari (OVA), Tiruchendur (TRU) and Tuticorin (TUT) on the basis of coastal geomorphology, drainage pattern and diverse energy conditions which are stated in Table 1.1.
Figure 1.3 Location of Study Area
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Kanyakumari</th>
<th>Ovari</th>
<th>Tiruchendur</th>
<th>Tuticorin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Geology</td>
<td>Crystalline Rocks</td>
<td>Crystalline Rocks</td>
<td>Marine Calcareous, Siliceous sand</td>
<td>Coralline Rocks</td>
</tr>
<tr>
<td>Coastal Geomorphology</td>
<td>Cliff Rocks, Beach Ridges, Marine Terrace</td>
<td>Dune Complex, Wave cut Platform</td>
<td>Headlands and Bays</td>
<td>Spits, Bays, Mud Flats</td>
</tr>
<tr>
<td>Shore Configuration</td>
<td>E-W</td>
<td>NE-SW</td>
<td>NNE-SSW</td>
<td>N-S</td>
</tr>
<tr>
<td>Beach Gradient</td>
<td>3-6 °</td>
<td>2-4 °</td>
<td>3-5 °</td>
<td>1-3 °</td>
</tr>
<tr>
<td>Beach Composition</td>
<td>Moderate Heavy Mineral</td>
<td>Rich Heavy Mineral</td>
<td>Calcareous</td>
<td>Siliceous Calcareous, Muddy</td>
</tr>
<tr>
<td>Breaking Wave Height</td>
<td>0.6-0.8 m</td>
<td>0.5-1.2 m</td>
<td>0.3-0.7 m</td>
<td>0.2-0.5 m</td>
</tr>
<tr>
<td>Wave Energy</td>
<td>High Wave Energy</td>
<td>High Wave Energy</td>
<td>Medium Wave Energy</td>
<td>Low Wave Energy</td>
</tr>
<tr>
<td>Width of Beaches</td>
<td>50-80 m</td>
<td>50-130 m</td>
<td>70-100 m</td>
<td>50-110</td>
</tr>
<tr>
<td>Drainages / Estuaries</td>
<td>Minor/ Manakkudy</td>
<td>Nil</td>
<td>Nil</td>
<td>Major/Thamb raparani</td>
</tr>
<tr>
<td>Net Littoral Sediment Drift</td>
<td>$20\times10^3$ cu/m</td>
<td>$80\times10^3$ cu/m</td>
<td>$50\times10^3$ cu/m</td>
<td>$75\times10^3$ cu/m</td>
</tr>
</tbody>
</table>

Table 1.1 Classification of Study Area in to Four Coastal Zones
1.7. Physiography, Climate, Temperature and Population

India is a tropical country and a land of diverse topography, soils, vegetation and climate. The study area is diverse nature with different coastal features. Sand dunes are present along the coast of Kanyakumari. The southern part of Kanyakumari coast is sandy beaches with heavy minerals. The general relief goes over to 15m above MSL. The south of Tiruchendur coast, consist of sandy beaches with heavy minerals. Sand dunes along the Tiruchendur coast rise up to a height of 67m. The coastal belt between Tuticorin and Tiruchendur has raised beaches with sand bars parallel to the coastline in a trend towards north to south direction. Sand dune and Terri dune complexes are present along the coast between Tiruchendur to Manappad.

Climate is an important factor in the alteration of coastal landforms. The elements of climate include rainfall, temperature, and wind. Coasts that experience prolonged and intense winds experience high wave-energy conditions. Seasonal patterns in both wind direction and intensity can be translated directly into wave conditions. The geographical location of coastal Tamil Nadu is such that the climate condition shows only slight seasonal variations.

Generally the temperature and humidity is relatively high all the year round due to close proximity to the sea. The climate of the study area is tropical with little variation in summer and winter in summer and winter temperatures. April-May is the summer season and the temperature is 22-38° C. Sometimes it may increases above 40° C during the peak summer. During this period the humidity is more and the coastal regions become uncomfortable warm and sweating. But the proximity to the sea in bringing the moisture has laden sea breezes in to the land during the evening and night which brings a welcome relief from oppressive heat of the day.
Despite the rest of the world, the east coast of India experience two monsoons. Oceanography of the Indian east coastal region is mainly controlled by the north-east (NE) and south-east (SW) monsoons. The equator-ward West India Coastal Current (WICC) during summer monsoon, along the southwest coast turns around Sri Lanka to northeast and flows in to the Bay of Bengal as the southwest monsoon current (Vinayachandran et al., 1999). Along the study area, the wind speed during the southwest monsoon ranges from 36-60 Km/hour. During this period, the temperature is around 18-28° C. The rainfall during the south-west monsoon is around 60-70 mm/month. The north-east monsoon starts from October and extends up to December. The wind speed during the north-east monsoon is ranges from 20-40 Km/hour. But, during cyclone the wind speed may increase above 100 Km/hour. Also heavy rainfall (100-200 mm/month) accompanied by thunder and lightning occur during this period. During November to February the climate is somewhat cool. But the temperature does not drop much and it is mostly around 21° C.

The study area includes the part of three coastal districts of Tamil Nadu namely Kanyakumari, Tirunelveli and Tuticorin. The Kanyakumari district has a total population of 167634. Rural population is 582107 and urban population is 1093927. The Tirunelveli district has a total population of 2723988. Rural population is 1415742 and the urban population is 1308246. In Tuticorin district the total population is 1572273. The rural population is 766823 and the urban population is 805450.

1.8. Water Bodies and Drainage Pattern

The study area has many rivers drain into Bay of Bengal and Indian Ocean forming estuaries adjoining coastal lagoons. The Kanyakumari zone has 5 small rives namely Kodayar, Chittar I and Chittar II, Pazhayar, Valliar, Ponniavaikal, Paraliyar.
There are many channels namely Pandiyan-Kal, Thovalai Channel, Anandanar Channel and Puthanar Channel. Water from these channels reaches the Indian Ocean at Manakudy near Kanyakumari. The dams in the districts are ‘Pechiparai’ and ‘Perunchani’. The water from Pechiparai-Dam is taken along the left bank canal to ‘Puthen-dam’ across the river Paraliyar. Puthen-dam is the main head works of the entire system when water of the Pechiparai and Perunchani meet. Thovalai channel extends up to Tirunelveli district by the name of Radhapuram channel.

The Ovari zone of the study area enjoys the benefit of the early showers of south west monsoon and of the later rains of the north-east monsoon. This area is chiefly irrigated by rivers rising in Western ghats. The major river is Tamiraparani and it has large network of tributaries which includes the Karamaniyar, Peyar, Ullar, Karaiyar, Servalar, Pampar, Manimuthar, Varahanathi, Ramanathi, Jambunathi, Gadananathi, Kallar, Karunaiyar, Pachaiyar, Chittar, Gundar, Aintharuviar, Hanumanathi, Karuppanath and Aluthakanni. The Tuticorin zone has no big reservoirs. However Papanasam and Manimuthar Dams which are located in the Tirunelveli district under Tamirabarani river system are the main sources of irrigation in Tuticorin coastal zone.

1.9. Soil, Vegetation, Land Use and Land Cover

The geological formation of the coast is made up of marine and alluvial soils, raised beaches and alluvium, sand stones, clays and lignite. The coastline along Kanyakumari is rocky in several places, while sandy in other areas. There are traces of coral reef on the eastern coast of the though now largely dead and extinct. The soil type along the Kanyakumari coast is mostly marine and alluvial sandy soils with red loam variety. The Perumanal coast has aeolian sand deposits. The coasts along the Tuticorin have dark brown, very deep, fine, calcareous, mildly alkaline soils. The soils are of
medium depth with free drainage, pH ranging from 6.0 to 8.5, contain low amount of organic matter, nitrogen and phosphorus but with adequate amounts of potash and lime. The soil of Tuticorin is clay-loam of laterite origin with an admixture of gravel and sand.

Paddy cultivation is performed along the coast of Kanyakumari. Besides paddy, other important crops grown are pulses, tapioca, banana, coconut, rubber, cashew, mango, arecanut, cloves, cardamom, pepper etc. Groundnut cultivation is mainly undertaken in Ovari and Tiruchendur zones. Palmyrah trees are grown mostly in Tiruchendur, Periathalai and Ovari. Jaggery is produced from palmyrah juice and the production of Jaggery is the main occupation of Tiruchendur coast people next to agriculture. Banana and other vegetables are raised in Tiruchendur coast.

The soil along the Tuticorin coast is Dark brown, very deep, fine, calcareous, mildly alkaline soils. In Tiruchendur coastal dune areas ocacia (Udai) is cultivated followed by millets. In the coastal belt from Tuticorin to Manappad, there are vast stretches of red sterilized and locally known as Teri lands. These lands have been partially reclaimed using heavy doses of tank silt and crops such as Banana, Coconut and vegetables and even rice are grown.

The coastal area around Tuticorin and Tiruchendur are mainly used by the salt industry. Tuticorin district constitutes 70 per cent of the total salt production of Tamil Nadu and 30 per cent of that of India. Tuticorin is the second largest producer of Salt in India next to Gujarat. Tuticorin is traditionally known for its Pearl and Shipbuilding. Tuticorin has been a centre for maritime trade and pearl fishery for more than a century. It is one of the ten major ports in India and the second-largest port in Tamil Nadu and third-largest container terminal in India.
The coastline encompasses of the study area has almost all types of inter-tidal habitats from hyper-saline and brackish-water lagoons, estuaries and coastal marsh and mud flats to sandy and rocky shores with varying degrees of exposure and widely varying profiles. Sub-tidal habitats are equally diverse. Each local habitat reflects prevailing environmental factors and is further characterized by its biota. Thus the marine fauna itself demonstrates gradients of change throughout the coast. Salinity becomes the important regulating factor. Sea grasses occur in the inter-tidal and mid-tidal zones of shallow and sheltered areas of sea, gulf, bays, backwaters and lagoons. They are submerged monocotyledonous plants and are adapted to the marine environment for the completion of their life cycle under water. They form a dense meadow on sandy and coral rubble bottom and sometimes in the crevices under water.

1.10. Anthropogenic Activities and Natural Calamities

Recently various developmental projects like Koodankulam nuclear power plant, Sethu-samuthiram ship canal were started along the study area. The Sethu-samuthiram ship can project is a very important one since it is off shore project. Though India has a peninsular coast running to 3,554 nautical miles, it does not have a continuous navigational sea lane running within its territorial waters. Ships navigating from one side of the country to the other have to circumnavigate Sri Lanka due to the presence sand stone reefs, near the Rameswaram coast.

The Sethu-samuthiram project is an off-shore massive navigational channel of length 152.2 km, width 300 m and a depth of 12 m linking the Gulf of Mannar and Balk bay, which will connect the eastern and western parts of the Indian coast and there by reduces time and fuel cost. About 80 million cubic meters of dredged sediment is dumped at nearby sites. Kudankulam Nuclear Power Plant is a nuclear power station under Indo-
Russian collaboration which is currently under construction in the coast of Kudankulam in the east of Kanyakumari. Another power project is planned by coastal Energen Pvt. Ltd, an arm of the Coal & Oil Group of Dubai (C&O Group) is announced its plans to set up a 2,000 MW plant in Tuticorin district, Tamil Nadu. The plant aims to supply power to both industries and consumers and will bring down power generation cost. Several developmental projects and small scale industries are functioning along the study area.

Indian coastal area has large amount of heavy mineral deposits such as Zircon, Ilmenite, Monazite, Rutile, and Sillimanite which have wide applications in the field of paint industry, nuclear sectors, pharmaceuticals, aviation, communication, electronics, water purification and oil refineries etc. The Indian resources of placer minerals are: 348 Million tons (Mt) of Ilmenite, 107 Mt of garnet, 21 Mt of zircon, 18 Mt of Rutile, 8 Mt of monazite and 130 Mt of sillimanite. Indian resources constitute about 35% of world resources of Ilmenite, 10% of Rutile, 14% of zircon and 71.4% of monazite. India meets about 10% of the world requirement of garnet (Thomas and Baba, 2005). The south Tamil Nadu coast of India particularly from Navaladi to Periathalai coast is rich in placer minerals. On-shore coastal sand mining is actively involved along these coasts. The inland Teri (red colour) sand dunes and beach placers have more amounts of mineral deposits. Currently the beach sands are extracted and processed physically for exporting 100 % without any value addition.

The disaster can be defined as any kind of disruption of human ecology which cannot be absorbed by the adjustment capacity of the affected community with its own resources (Verma, 1987). The disaster can be mainly classified in to two types. One is natural disaster and the other is man-made disaster. Ganguly et al. (1993) insists that a determined human effort can totally or to a great extent prevent man-made disaster, the
same does not hold good in respect to natural disaster which have become a growing concern of mankind all over the world particularly during the last three decades. India being a vast country with a tropical monsoon type climate has all types of natural disaster prone areas except active volcanoes. The coastal area of southern Tamil Nadu is prone to flood, cyclone, earth quakes and sea erosion. Small to medium type cyclones are frequent during the monsoons in the last three decades. Although earthquakes, tsunamis or any other natural disasters are unpreventable, studying their impact on the coastal zone allows us to design and implement better strategies for mitigation activities. INSAT Disaster Warning System (IDWS) have been installed along the coastal Tamil Nadu and proved its worth during the last formed cyclones.

The recent Indian Ocean tsunami (26 December 2004) produced major changes on the Indian coast. The disastrous tsunami occurred in the Indian Ocean due to a devastative earthquake of magnitude Mw = 9.0 at 00:58:49 GMT (07:58 local time) on December 26, 2004 struck at 3.09° N, 94.26° E, near Indonesia (Figure. 2). The tsunami had a great impact on the coastal areas of Indonesia, Srilanka, India and other neighboring countries. More than two hundred thousand people were killed making it the most devastative tsunami in the last forty years. Many beaches were entirely devastated by this tsunami.

Chandrasekar et al. (2005) and Mujabar et al. (2007) reported that the tsunami induced large amount of beach erosion and accretion along the study area. Channels were deepened by tsunami-induced currents, and sometimes made shallow by transported and deposited sediments. The Tsunami has devastated extensive stretches of coastal areas of western side of Kanyakumari. The damage was more in areas, which are low lying and flat devoid of any vegetation.