# *CHAPTER I*

# THE PROBLEM AND PROCEDURE

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## 1.1 INTRODUCTION

The vast resources of the oceans are essential elements for the survival of coastal communities. Ironically, the world's marine environments are also disposal systems for human generated waste. It may be an overgeneralization, but there is some truth in saying, *"Everything comes from the sea and everything returns to the sea."* The implication is that since the oceans have limited resources, there is a need to minimize the impact that the growing size and number of coastal communities have on marine environments.

Although non-coastal communities also have pressing environmental issues, maintaining sustainability in coastal development is particularly important because *"more than half of the world's population lives within 60 km of the shoreline, and this could rise to three quarters by the year 2020"* (UNCED, 1992). At the advent of the 21st century, there are 20 cities in the World with a population of over 10 million, of which sixteen of those cities are along coastlines. Growing populations not only put a greater strain on already depleting resources, but are also responsible for the degradation of marine habitats for those resources. According to the report of the Independent World Commission on the Oceans (1998), over 70 per cent of the world's fish stocks are being exploited at or even beyond sustainable limits. *"Over 80 per cent of all marine pollution originates from land-based sources which are primarily industrial, agricultural and urban"* (UNCED, 1992). The need to rethink development planning in coastal areas is undeniable. Steps towards the sustainable development of coastal communities should be involved by researchers, educators, and planners from a coordinated network of international aid agencies, non-governmental organizations (NGOs), national policy makers, and local communities.

### 1.1.1 The Coastal Zone

The coastal zone is the interface where the land meets the ocean, encompassing shoreline environments as well as adjacent coastal waters. Its components include river deltas, coastal plains, wetlands, beaches and dunes, reefs, mangrove forests, lagoons, and other coastal features. *The limits of the Coastal Zone*

*are often arbitrarily defined widely among nations, and are often based on jurisdictional limits or demarcated by reasons of administrative cases.* For planning purposes, this definition is often quite impractical, however, as huge areas containing whole countries would fall under this definition (World Bank, 1996). For practical planning purposes, the coastal zone is a special area, endowed with special characteristics, whose boundaries are often determined by the specific problems to be tackled.

Coastal areas are highly affected by dynamic processes. Coastal spaces also support unique and especially fragile ecosystems, being areas of great environmental and aesthetic value. These coastal ecosystems also tend to have very high biological productivity. The reproduction and nursery grounds of most fish and shellfish species in the coastal strip are of significant economic value.

## 1.1.2 Coastal Uses

Humanity has always had a close relationship with the coast. Traditional uses of coastal space include trade and conquest, migration and defence and in some cases, a focus for cultural and spiritual identity. Coastal zones are still of crucial importance for coastal states today. They are home to the bulk of the population, and account for a considerable share of the country's economic activities, being highly valued by society for the non-marketable goods and services they provide. A wide range of human activities takes place in the coastal zones like industry, tourism, fishing, aquaculture, etc. When these activities develop together on the narrow coastal strip, problems tend to arise, creating conflicts. Due to its highly dynamic character, even development work with clear local objectives may have adverse effects elsewhere along the coast.

## 1.1.3 Value of Coastal areas

***1.1.3.1 Environmental Value:*** Coastal areas provide a large number of environmental goods and services. Their ecological importance is being widely accepted whether we take a more utilitarian or a more '*environmentalist*' approach. The main characteristic of the coastal ecosystems is its dynamic nature resulting from the transfer of matter, energy and living organisms between land and sea, under the influence of primary driving forces such as: weather and climate, sea level rise and tides. Marine, estuary

and coastal areas often have nutrient-rich water because both flows from the land and also ocean upwelling. The tendency of them is to have high biological productivity (FAO, 1998). Moreover coastal areas often contain critical terrestrial and aquatic habitats like estuarine areas, coral reefs, coastal mangrove forests, coastal wetlands, tidal flats, sea grass beds etc. They comprise unique ecosystems and support a rich biodiversity. It is estimated that 90 per cent of the world's fish production is dependent on the coastal areas. These areas support numerous migratory and non-migratory waterfowl and shorebirds. Maintaining the biodiversity is widely accepted as an imperative of our times. (Ramsar convention, 1971) Physical features of the coastal ecosystems, such as belts of mangrove can mitigate the effect of:

- Natural disasters such as storm-tide surges, shoreline retreat or floods;
- Natural processes such as coastal erosion, land accretion, damage from wave or wind action.

Even when the coastal ecosystems are not unique biological systems, their location at the sea-land interface makes them valuable for the recreational and aesthetic point of view. They support tourism activities and provide attractive sites for residential areas and industrial development.

***1.1.3.2 Economic Value:*** The coasts are areas of convergence of people and human activities. Historically, coastal areas have been a major habitat for humans due to the favorable biophysical and climatic conditions, together with the ease of communication and navigation. Nowadays, although coastal zones occupy less than 15 per cent of the Earth's surface, they accommodate more than 60 per cent of the world's population. If the trend continues, there could be upto 75 per cent of humanity living in coastal areas by 2025 (UNCED, 1992 and EEA, 1999). Harbours, that have always been nuclei for the development in the past, have an ever-growing importance today. Traditional resources based activities, such as coastal fisheries, aquaculture, agriculture and forestry are now being competed by activities such as shipping, industry and tourism. From the social and economic point of view, coastal areas' importance is indubitable as coastal resources support key for economic and subsistence activities. These resources permit the development of agriculture, fisheries, forestry, mining, oil and gas extraction, marine transport, tourism (EEA, 1999) etc. Most productive agricultural lands of the world are located in river deltas and coastal plains. In future the dependence on coastal resources is likely to remain

strong in the conditions of urbanization and economic diversification (*mostly in the developing countries*). Industrial development often entails the processing of agricultural, fishery and forestry products, together with oil refining and textile manufacture. These diversified economic activities are also often dependent on coastal resources and, as economic diversification increases and makes the component sectors more interdependent, conflicts over natural resources and the environment. The conflicts already exist when putting a lot of pressure over the coastal fragile environment and the threats have already become in some areas complicated due to environmental issues.

### 1.1.4 Coastal risks

Recent research shows that climate change could involve a rise in sea level of several millimetres per year, and an increase in the frequency and intensity of coastal storms. Depending on where they occur, the combined effects of these two phenomena will have serious repercussions on this area, such as major floods or erosion. At the same time, the expected growth in tourism in particular will increase human pressure on natural, rural and urban environments.

### 1.1.5 Interactions in the Coastal areas

A global study of the coastal zone and its interactions is a real challenge as coastal processes respond and interact with local as well as with global drivers. The local geomorphology as well as the way coastal societies manage the coasts determines the responses to the environmental pressures. A structural approach in management is suited only if it has a holistic view. The coastal system is interdependent and interrelated and has direct and indirect connections with the external systems of inland and offshore. For example, fish may be dependent on the mangrove swamps as the habitat for juveniles, or the coral reef may be related to the filtering properties of the mangrove, so that only clean water reaches the reef. Conversely, if the silt from soil erosion covers a coral reef it could die. The soil erosion could be, accruing many miles upstream, caused by inappropriate forestry and agriculture practice. Coastal reefs, dunes and mangroves may protect coastal agriculture from soil erosion or storm surge (FAO, 1998). If the economic development is not well managed, it can create serious problems related to water

pollution, degradation of critical habitats, depletion of natural resource stocks etc. The publicized benefits in increased employment and rising incomes will be undermined by the costs of health, productivity and aesthetics. All economic activities consist in changing resources or inputs in products or services. Subsequently, all activities will affect and interact with their environment, whether it is ecological, economic or social. Such interactions can be categorized as synergistic, complementary, competitive and antagonistic.

- The activities are *synergistic* when their interaction results in an increase whether in economic activity or environmental benefits greater than the sum of their individual results. For instance, tree conservation on a land used before for agriculture in a coastal area will provide wood, stabilize the soil, preventing erosion and slides, lead to a more rational and complete use of soil fertility which enhances the relations between species, diversifies economic opportunities.
- Two activities are complementary when they share the same resource(s) or facility without conflict and when one activity provides inputs to the other. For example, forest industry supplies timber for boat building or when agricultural by-products are used in cultured fish feeding.
- A competitive interaction is when the activities have a shared requirement for a limited supply of resources, resulting in conflict. The competitive interactions can be either reciprocal or one-sided. A reciprocal competition is, for instance, when farmers and urban dwellers use the same groundwater supply because of suffering from shortage of water or its increasing salinity. A one-sided interaction is for example, where upstream water is used for irrigation affecting the flow of downstream and consequently damaging fishery habitats.
- An antagonistic interaction exists when the output of one activity degrades the resources or modifies the environment harming of another activity. For instance, pollution from urban activity can affect fisheries by killing fish, destroying fish habitats, infecting them with substances which are harmful for human beings.

A systematic and holistic view of managing the coastal area should aim at maximizing synergistic and complementary interactions and minimizing competitive and antagonistic ones.

### 1.1.6 Environmental problems

There is a big pressure on the coastal environment coming from both natural and anthropogenic driving forces. Coastal areas' dynamic nature results from the exchange of matter and energy between land and sea. The natural processes such as the dynamics of alluvia and natural sedimentation that determines nutrient and energy flows are being modified by human activities. They affect water flows by constructing dams, extracting water or deviating rivers. They also lead to erosion due to deforestation. The reducing or blocking of sediment supply can slow down the vertical accretion – aggravating salt-water intrusion problems. On the other hand it can give rise to the retreat of the coastline through wave erosion (FAO, 1998). This is the case of the Romanian coasts at the Black Sea affected by erosion because of the hydropower plants on the Danube which block sediments from the sea water.

***1.1.6.1 Coastal Pollution:*** A large amount of substances mainly originate in human activities from everyday housekeeping to agriculture, industry, traffic and energy production. They are flowing into the seas which are harmful for the environment. There are two main types of sources:

- Point sources when the pollution is from particular sites (*e.g. discharges of wastewater from sewage treatment plants and industry, oil spills and sea farms*).
- Diffuse sources when the pollution is either leaching from the land (*e.g. nitrates from the cultivated fields*) or consisting of atmospheric fallout (*e.g. substances in chimney smoke are bound to dust and sooner or later precipitate*). Many of these substances are innocuous in the environment being degraded by micro-organisms and other natural processes. However, they can disturb the balance between different animals and plant species. Other substances only degrade with difficulty and can harm coastal life in general.

The most dangerous substances are heavy metals and poorly degradable organic substances such as PCBs (*Poly Chlorinated Biphenyls*), pesticides, softeners for plastics, TBT (*Tri Butyl Tin*) and the PAHs (*Poly Aromatic Hydrocarbons*) that have to be monitored (Miljostyrelsen, 2001).

Heavy metals occur naturally in the environment. Such an occurrence is called background level. The background level is exceeded when the heavy metals

contaminate the sea through atmospheric fall out and discharges from urban and industrial area. After contamination, most of the heavy metals such as Mercury and Cadmium are incorporated into particles of the sediments. A small quantity is dissolved into water and can be spread in coastal food chains. They are very toxic both for humans and other organisms.

PAHs are substances that are formed during the combustion of fossils and fuels (*oil, gas and coal*). The main sources of PAHs in the coastal environment are oil spills from shipping, oil extraction and spillage from industrial activities. Some of the PAHs are very toxic to coastal and marine organisms and others can act as carcinogens causing changes in the genetic material of man and animals. However, most of the organisms metabolise the substance and eliminate them. This limits the accumulation of the substances in the food chain. The environmental issues shown before are related one way or another to human activities. They are dominant in the coastal areas where man's presence is more and more acute. The Coastal Human Pressure Indicator (CHPI), estimating the number of the world inhabitants per km of coastline shows an increase from 6,300 inhabitants per km at the beginning of 1970s to 9000 inhabitants in the early 1990s and to 10,000 inhabitants at the beginning of the 21$^{st}$ century (OECD, 1993). Since these are areas where people want to live and work and where recreational activities have an important place, coastal zones face anthropogenic pressure leads to lack of from development. The rapidly increasing pressure on the coastal zones gives rise to many conflicts among both traditional resource users and the 'newcomers'. The concern is that the ones who enter the scene will diminish the resources. The environmental concern is expressed in terms of protecting stakeholders' interests in resource use and not the environmental protection itself (Rosenthal, 2000). A way of managing the coasts, which encompasses both stakeholders' interests and the integrity of the coastal ecosystems, is needed.

***1.1.6.2 Sea level rise:*** The natural threats for the coastal zones are also tidal surges and sea-level rise (FAO, 1998), which sometimes are interrelated. Sea level rise is a '*natural process*' as greenhouse gases mainly $CO_2$ emissions indeed the consequent climate changes caused by human activities, contributed to the melting of the glaciers and, finally to the sea level rise. The most serious impacts of the sea level rise identified in the meeting of '*Global and regional sea-level change and hydrological*

*changes*' at Lori-Porto San Paolo, Italy during 4th -6th October, 1999 (Sahagian, 1999) are:

- Shoreline erosion- mostly of the beaches – is because the equilibrium profile is maintained in the coastal zone. The coasts will respond to the sea level rise by inland erosion thus extending the region of impact. Nearshore topography is important for the local authorities to be able to predict the impact of the shorelines on local coastal area.
- Exacerbation of storm wave damage, particularly during high tides is related with sea level rise.
- Coastal ecosystems losses are subject to flooding and cannot keep pace with rapidly rising sea level and they are drowned. Humans try to artificially maintain the existing equilibrium profile with defences (seawalls, levees etc.). In some of these cases ecosystems can be completely lost, as they cannot migrate landward.
- Aquifer salinisation is a serious problem because the world population relies on groundwater drawn from coastal aquifers for fresh water supply. The water supplies can be salinizated as the sea level rise and the depth of the freshwater lens in the coastal zone is reduced (Sahagian, 1999).

## 1.2 COASTAL ZONE AND ITS RELATIVE PHENOMENA

### 1.2.1 Coastal zone: An ecological, social and economic system

The shore is the place where sea and land meet. Geographers, Geologists and Biologists unanimously acknowledge the unique properties of coastal zones as the contact zone between the lithosphere and the hydrosphere. This interface is represented on geographic maps as a thin coastline. This line, also known as the shoreline, is a good example of the statistic approach to shore study. Actually, the interface is a dynamic system. The size, boundaries and shape of this system constantly change under the influence of different factors both natural and anthropogenic. In order to take into account coastal dynamics, it is more appropriate to use the term coastal area, or zone rather than "*coastline*".

### 1.2.2 Need for coastal zone management

Protecting against coastal risks and providing adequate usages for these areas are not immediate compatible goals. In fact, the huge concentration of human activities in this narrow strip has led to rapid degradation of these zones' richness and important ecosystems and habitats and, as a result, the entire coastal system faces an uncertain future.

However, the coastal zone is a difficult area to manage due to temporal issues (current, tides and seasons) and the overlapping of physical geography and hydrography (inshore, shoreline and offshore), of jurisdictions, legal mandates and the remits of government agencies and the often competing needs of stakeholders. Typically, many different local, national and regional government agencies are responsible for different aspects of the same physical areas and different uses of the coastal zone, for example, fisheries, environment, agriculture, transport (inland and marine), urban planning and cadastre, etc. These ministries often find themselves undertaking the same or similar tasks and sometimes, proposed planning against each other due to inharmonious and competing objectives of their legal mandates. The frequently encountered government technique of merging some ministries, organisations or agencies and separating others, either physically or based on mandates, usually fails to yield the desired results of increased efficiency in government and reduced duplication of effort and resource expenditure.

### 1.2.3 Evolution of Coastal Zone Management practices

The scientific commission of the UNESCO General Conference at its meeting in 1993 was marked by an important event concerning the joint declaration of the four international Chairmen of the large UNESCO scientific programmes: i) the Intergovernmental Oceanographic Commission (IOC), ii) the Intergovernmental Man and Biosphere Programme (MAB), iii) he Intergovernmental Hydrology Programme (IHP) and iv) the International Geographical Correlation Programme (IGCP). After having requested increased cooperation between the UNESCO scientific programmes, both at the level of the international structures and the national committees, the Chairmen proposed four priority fields of research: Small Islands, Coastal Zones, Biodiversity and the Prevention of Natural Hazards. In application of this declaration, the Chairmen of the French Committees of the IGCP, the IOC, the MAB and the IHP

took the decision to carry out a joint project. The given work had been undertaken by the different teams to the international situation and it was decided that this project should cover the Coastal Zones, sometimes also referred to as “Littoral regions” (UNESCO, 1997).

The large sectoral ad-hoc management strategies of the past have proved inadequate to deal with the highly complex ‘hybrid’ human-environmental interactions characterizing the development of coastal areas. Environmental costs of the traditional model of economic growth and the current challenge imposed by the paradigm of Sustainable Development (UNEP 1992) imply a move towards more rational approaches to coastal development. As a result, Coastal Zone Management (CZM) initiatives are turning to more integrated strategies worldwide, attempting to balance the benefits from the economic development and human uses of the coastal space while sustaining over the long-term, ecological, socio-cultural, and historical values of a particular area.

### 1.2.4 Inputs to CZM evolution

- The UN Conference in the Human Environment (1972) and the rise of the Global Change concept
- The UN Conference on Environment and Development (UNCED, 1992) and the statement of the Integration Principle by Agenda 21, (Chapter 17)

This key statement was enunciated when coastal management had already accomplished almost three decades of evolution and implementation, during which the UN system had strongly contributed.

- Implementation of national policies during the 1990s.
- Issues of global change, globalisation, and increasing attention to a multi-perspective concept of diversity

During the 1970’s, environmental and developmental goals were pursued in a non integrated way; then the need to contextually pursue them arose and expanded during the 1980’s; finally the full integration was enunciated by the adoption of the sustainability concept by Agenda 21 in 1992. An evolution has solidified, during which the emphasis was initially posed on the environment conceived in physical and chemical terms, then the economic and biological components were introduced, and finally the social and ethical components were embraced.

## 1.2.5 Integrated Coastal Zone Management (ICZM) - Definitions

Many definitions of the ICZM amongst inter-governmental organisations and scientists exist. Integrated Coastal Zone Management (ICZM) is a broad concept used for the first time in USA in the 1970's. Nowadays it is being accepted in many of the coastal countries as the right framework towards coastal protection and development. Basically ICZM was seen as the management of the coastal zone taken as a whole in relation to local, regional and international goals with a particular focus on the interactions between various human activities and resource demands both within the coastal zone and between activities from the coastal zone and from other regions. A part of the management was the integration of environmental protection goals into economic and technical decision making process (OECD, 1993).

Recent definitions (European Environmental Agency, 2003; PROCOAST, 2000) emphasis the fact that ICZM is a dynamic, continuous, iterative and multidisciplinary process to promote sustainable management of the coasts. As mentioned earlier, the ICZM is based on the general system theory. This process unites in one complex '*general system*' government and community, science and planning, sectoral and public interests by promoting and implementing an integrated plan for the protection and development of coastal systems and resources. An effective management involves an increasing number of disciplines – geomorphology, marine geology, oceanography, law, economics, geography etc. Altogether building up a multi-disciplinary, integrated view, which is a key point in the development of ICZM. It covers the full cycle of information collection, design of planning, decision making, management and implementation, but it does not stop here as it is dynamic (*because the system involved are usually extremely dynamic*) and iterative.

## 1.2.6 Development of the Concept

What is now widely recognised in the literature as Integrated Coastal Zone Management (ICZM) was conceived in the early 1970's as Coastal Zone Management (CZM). The concept was consolidated in the USA in 1972, when the CZM Act was passed (Millemann, 1995), as an attempt to resolve the increasing anthropogenic pressures on coastal resources. This act set the scene for what is acknowledged as the first national CZM programme, prompting developed countries of the world to take an

interest in the quality and management of their coastal environments. Subsequently, a number of countries worked on coastal management plans independently, without the use of a formal title; examples include Australia and Sweden (WWF, 1994).

In the 1980's, the term integrated was added when it became clear that the effective management of coastal areas requires an inter-sectoral approach. The main difference between ICZM and the earlier CZM, as noted in the Noordwijk Guidelines for Coastal Zone Management (World Bank, 1993), is that the former attempts a more comprehensive approach taking account of all of the sectoral activities that affect the coast and its resources and deals with economic and social issues as well as environmental/ecological concerns (World Bank, 1993).

The inclusion of ICZM as one of the principal recommendations of Agenda 21, at the United Nations Conference on Environment and Development (UNCED) – the Earth Summit - in Rio de Janeiro, 1992 gave the concept both international prominence and political legitimacy.

## 1.2.7 General Principles of ICZM

ICZM is still a relatively new and evolving concept and there is as yet no consensus regarding even issues such as the fundamental nature and structure of the coastal zone, the most appropriate time-scales for the application of CZM policies, or the key criteria for defining sustainability in coastal zone development. Nevertheless, there are some agreed general principles for ICZM:

***1.2.7.1 The integration principle:*** The integration principle was developed in Agenda 21 as a tool to pursue Sustainable Development in coastal zones, which requires "*New approaches to marine and coastal area management and development, at the national, subregional, regional and global levels, approaches that are integrated in content and are precautionary and anticipatory in ambit*" (Agenda 21, 17.1, 1992).

Integration can be seen as one of the tools or methodologies for realizing the goal of Holism. The ideal meaning of Holism is that all aspects of an issue or consequences of a decision are considered (*natural sciences, economic, socio-cultural, legal, institutional questions, etc.*).

There is a need for at least five different dimensions of integration:

1. between sectors

2. between levels of government
3. across the land-water interface
4. between disciplines
5. between nations (especially when nations share an enclosed or semi-enclosed water body)

***1.2.7.2 The Precautionary Principle:*** The Maastricht Treaty adopted the Precautionary Principle as a fundamental element of environmental policy: Article III-233 of the draft Treaty establishing a constitution for Europe.

On the 2nd February, 2000, the European Commission issued a Communication on the precautionary principle, in which it adopted a procedure for the application of this concept, but without giving a detailed definition of it.

## 1.2.8 Aim of the ICZM

ICZM aims to reduce or eliminate problems, assisted with the coastal areas resulting in ethical and economic benefits. Ethical benefits include sustainable development, the promotion of social equity (*through consideration of the viewpoints of all stakeholders*) and protection of traditional uses of coastal resources. Economic benefits accrue from an integrated approach to management, which can have cost benefits when compared to management for separate sectors. Effective planning for the future also provides cost benefits.

## 1.2.9 Benefits of ICZM

Over the long term, ICZM can assure the needed balance among environmental, economic, social, cultural and recreational objectives, all within the limits set by natural dynamics.

- From the economic point of view, ICZM can reduce both conflicts between competing activities; risks to capital investment and can improve the efficiency of public and private investments.
- Administratively, ICZM, by facilitating co-ordination of policies, plans and management strategies at all levels- local, regional, national helps to achieve a consistent development of objectives and activities linking land and sea based management. Having the consistency induced by ICZM, the region/county can

deliver effective responses to international (for example EU) directives and obligations (Procoast, 2000).

- Three major outcomes of an effective ICZM can be underlined (Richter, 2001): development of a robust and well-informed ICZM process; - positive changes in societal behaviour towards economically rational, socially responsible and environmentally sustainable forms of development; - improvements in the quality of ecosystems and social systems.

### 1.2.10 ICZM Approaches

There is not only one single right ICZM approach. While the sustainability is not a set of prescriptive actions (Key & Alder, 1999), ICZM is a process that leads to action (Simonetti, 2001). Seen by many as an environmental management strategy, ICZM '*seeks to synthesise principle and realities, operationalising them into decisions about coastal resource use*'. ICZM prescribes behaviour, which affects a wide range of natural environments and human institutions. *There is no Golden Rule or universal framework for promoting ICZM.* The diversity of cases corresponding to the variety of coastal systems and composing driving forces makes reasonable diversity in approaches to the development and co-ordination of ICZM process.

## 1.3 INTEGRATED COASTAL ZONE MANAGEMENT – GLOBAL LEVEL

Since ICZM was arising in the 1970's, it proliferated many efforts had been made in this respect in many countries of the world. In the year 2002, there were approximately 700 ICZM efforts in existence around the world (Hildebrand, 2002). Current inventories are further developed and reviewed by ICZM practitioners and international assistance agencies. These ICZM efforts take place in all parts of the world, in all types of political regime, at all levels of governance at all levels of national economic development and in all types of environments. At the sub national levels, there are over three times as many ICZM efforts than at the national level. There is an obvious similarity in the specific problems and development opportunities that have motivated the initiation and development of a great majority of ICZM programs. This similarity regarding the motivating issues occurs although there is a considerable variation among coastal countries in terms of socio-economic and

environmental conditions, morphological and climatic factors, laws and institutional systems. Since 1990, there is a considerable increase in the number of developing nations and developing semi-sovereign states involved in the ICMZ process at the national or local level. Most of the developing countries have received substantial support. It is usually non-reimbursable grants from international assistance institutions (*e.g. World Bank, GEF, Inter-American Development Bank, Canadian International Development Agency etc.*) for the initiation and preparation of an ICZM effort. The support for implementation is provided as a loan not as a grant (Hildebrand, 2002).

## 1.4 REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM FOR ICZM

In order to formulate effective CZM plans, it is necessary to develop accurate, up-to-date and comprehensive scientific databases on habitats, protected areas, water quality, environmental indicators and carry out periodic assessment of the health of the system. The modern scientific tools of remote sensing, GIS and GPS are extremely valuable in the development of databases and to analyse them in the integrated manner and derive management action plans. The GIS stores all data relevant for Coastal Zone Management. It handles data on all spatial scales (Entire regional coast vs. a single harbour) and is a powerful analysis tool, allowing the comparison of measurements from different years, as well as overlay analysis of measurements and modelling results. Availability of repetitive, synoptic and multi-spectral data from various satellite platforms, viz. IRS, LANDSAT, and SPOT, have helped to generate information on varied aspects of the coastal and marine environment. Ocean colour images from OCANSAT I OCM, SeaWiFS, MODIS, provide information on biological aspects, which is useful for fisheries and coastal ecosystems.

Orbital Remote Sensing (*particularly in the visible and IR spectral regions*) is being used to monitor the effects of arrangement of impacts such as fluvial discharge, marine processes, weathering and waste disposal on land and at sea (Barale & Floving, 1996).

Remote sensing can monitor both long and short term changes of the coast. For example, historical aerial photographs can be used to measure changes to coastal geomorphology resulting from variation in the long term sediment balance, and

satellite imagery can be used in conjunction with current nautical charts and tide tables to detect gross sediment transport (Culshaw, 1995). More dynamic water based processes can be analysed by studying the evolution of temperature patterns and their relationship to the spatial distribution of plankton or to currents (Barale & Folving 1996 and Baban 1997). The seabed form and the patterns of water movement are interrelated and strongly influence biological diversity in the coastal zone. Remote sensing can be used to monitor the effects of developments by mapping the marine biodiversity (Davies et al., 1997). Estuaries can also be monitored for changes in their sedimentation regime. Both the gross sediment load (Culshaw, 1995) and more subtle indices such as the distribution of suspended solids, turbidity, temperature, salinity, and amounts of chlorophyll and phosphorous (Baban, 1997) can be measured to check the health of an estuary. Some coastal developments have a direct effect on smaller sections of the coast line, but remote sensing is still an invaluable data gathering tool due to the extensive nature of coastal processes.

## 1.5 COASTAL REGULATION ZONE

Coastal regulation zone is the boundary from the high tide line to 500 m in the landward side. However, the zone is between the low tide line and high tide line. In the case of rivers, creeks and backwaters, the distance from the high tide level shall apply to both sides and this distance shall not be less than 100 meters or the width of the creek, river or backwater whichever is less (Ministry of Environment and Forests, Notification, February, 1994). On the basis of which India has brought out the coastal areas under four Coastal Regulation Zones.

### 1.5.1 Coastal Regulation Zones in India – An Overview

In response to growing environmental deterioration in the 1980's and 1990's, prompted by an earlier letter regarding coastal protection from the Prime Minister of India, Mrs. Indira Gandhi, in 1981, The Ministry of Environment and Forests (MoEF), Government of India (GoI), introduced Environmental Guidelines for Beaches in 1983. It followed this with the promulgation of environmental legislations such as the Coastal Regulation Zone (CRZ) Notification (1991). The CRZ Notification applies to the entire Indian coast, including the Lakshadweep and Andaman & Nicobar Island groups. The notification regulates a range of activities along the coastal stretches on the landward side measuring a width of 500 m from the

High Tide Line. The notification applies to coastal stretches of seas, bays, rivers, estuaries and backwaters that are influenced by tidal action. The notification also covers the area between the High Tide Line (HTL) and the Low Tide Line (LTL). The area under the jurisdiction of the notification is called the Coastal Regulation Zone (CRZ). The notification prohibits certain activities within the CRZ, which could have a detrimental effect on the sensitive coastal ecosystem. At the same time, it permits other activities under specific conditions. In essence, the CRZ notification recognised that the coastal area is a sensitive area and only those activities that required the waterfront and foreshore area could be permitted only in selected areas with proper safeguards. The entire Coastal Regulation Zone of the country is further classified into different zones as follows:

**CRZ – I:** (i) areas are those that are ecologically sensitive including marine parks, national parks, sanctuaries, mangroves, wildlife habitats, heritage, historically important, areas likely to be inundated by global warming, etc. (ii) areas refer to the inter-tidal zone lying between the low tide line (LTL) and the high tide line (HTL).

**CRZ –II:** areas are those that are already developed close to or upto the shoreline (this is with reference to the geological features as of 1991). These "*developed areas*" are within municipal limits or in other legally designated urban areas which are already substantially built up and have been provided with drainage, approach roads and other infrastructural facilities, such as water supply and sewerage mains.

**CRZ – III:** areas are those that are relatively undisturbed and do not belong to either Category-I or II. These include the coastal zone in rural areas (developed and undeveloped) and also areas within municipal limits or in other legally designated urban areas, that are not substantially built up. By definition then, all rural areas are classified as CRZ – III and some urban areas could also be included in this category.

**CRZ –IV:** areas are those coastal stretches in the Andaman & Nicobar Islands, the Lakshadweep Islands and small islands, except those designated as CRZ-I, CRZ-II or CRZ-III. While the general prohibitions apply to all the

CRZ categories, the permitted activities can be undertaken only in certain areas of these four CRZ categories.

For each of the CRZ categories, the regulations differ. It was only in the year 1998 that the MoEF (under orders from the Supreme Court of India in 1996) constituted the State Coastal Zone Management Authorities (CZMAs) and a National Coastal Zone Management Authority to ensure the implementation of the notification. The structure introduced by the MoEF after the Supreme Court directives had two tiers (National and State CZMA) but in some states it is supplemented with another tier at the district level such as in Tamil Nadu and in Karnataka. Within one year of the CRZ Notification, each of the coastal states was expected to prepare State Coastal Zone Management Plans (CZMPs). These plans were to be examined by the MoEF in light of the CRZ notification and then approved. However, none of the states have fully approved plans and the MoEF has only granted conditional approval for these plans. The states are expected to revise and resubmit revised plans and maps. Since no state possesses a fully approved CZMP (Coastal Zone Management Plans) *till date, implementation of the CRZ notification has been abysmal*. Without a fully approved and operational CZMP, it is not possible to arrive at a clear or even quick estimation of areas where certain activities are permitted. The present status is that all over the Indian coastline, violations of the CRZ notification abound. Relative to the number of violations, in response, there has been insufficient punitive action from implementing agencies. The CRZ notification is far-reaching in its vision and scope, and is unique in attempting to bring under a single directive, the effective management of the Indian coastline under a sustainable and multiple-use paradigm. Since its introduction, however, the notification has been amended 19 times (upto 24th July, 2003), each amendment permitting more activities within the area declared as CRZ. The MoEF and the state governments constituted several committees to review matters related to its implementation. Negligible efforts were made to involve civil society groups in these reviews or in the finalisation of the various amendments to the notification. Indeed, of the 19 amendments (as of 24th July, 2003) to the notification, only three persons called for objections and suggestions from the public. The content of these committee reports are therefore bereft of critical inputs on issues of ground level implementation and the current problems facing coastal areas. The fact that coastal states responded to the notification with various degrees of prevarication and lack of enthusiasm (*demonstrated by their reluctance to prepare CZMPs until directed to do*

*so by the Supreme Court*), together with the numerous dilutions of the CRZ have led to considerable undermining of the efficacy of this ambitious legislation. It has been pointed out earlier, that the CRZ Notification needs to be strengthened and improved in order to effectively manage our coastal areas. Specifically, earlier recommendations to this order include the following:

- A review of the CRZ Notification should take place in order to strengthen the protective provisions of the notification.
- The MoEF should rescind those amendments to the CRZ notification, which had an overall effect of diluting its protective provisions.
- The State Coastal Zone Management Plans must be finalised by the State CZMA (Coastal Zone Management Authorities) and should be drawn based on principles of participatory planning and adopting a precautionary approach. The MoEF should approve the CZMPs after careful consideration and without causing unnecessary delay.
- This review contains suggestions on procedures and principles useful for drafting the coastal zone management plans.
- The identification of CRZ – I areas should be a priority and must be attended to immediately.
- The HTL and LTL and the other demarcating lines of the CRZ should be identified and demarcated on the ground.
- There are several clauses that require interpretation and clarification from the MoEF, particularly related to land use in the post-tsunami context. These include questions on the permissibility of reconstructing authorised damaged structures in CRZ–I areas and No Development Zones of the CRZ-III areas, the identification of areas for rehabilitation in the absence of a functional CZMP, the verification of the legitimacy of damaged or demolished structures.
- The CZMAs should be assisted in their functioning by district CZMAs and the village panchayats must be involved in ensuring the implementation of the approved CZMPs.
- Besides the above, environmentalists, lawyers and other experts have made specific suggestions for the implementation of CZMPs India.

## 1.6 REVIEW OF LITERATURE

### 1.6.1 International Scenario

A principal coastal concern today is beach erosion. It is estimated that 70 per cent of the world's sandy shorelines are eroding (Bird, 1985). In the United States it may reach 90 per cent (Leatherman, 1988). The worldwide extent of erosion suggests that eustatic sea-level rise is an important underlying factor, although many other processes contribute to the problem. In many low-lying coastal areas, human impacts, such as the maintenance of tidal inlets and subsidence induced by groundwater and hydrocarbon withdrawals, have also made a substantial contribution to the erosion problem (National Research Council, 1990). At the same time, coastal populations are burgeoning, and this trend seems set to continue (Culliton et al., 1990).

About 40 per cent of the human race lives on or near the coast, a proportion that is increasing allometrically (Carter, 1988). Throughout the ages, mankind's relationship with the shore has traditionally been based on some form of management. He subdivides coastal management into three broad areas: policy, planning and practice and he suggests, "*raise conflict between various coastal user and interest groups*". These conflicts may include disputes between jurisdictions over access to key resources; conflicts between sectors of society over the allocation of the resources; conflicts between human use of the coast and the ecological requirements of other components of the coastal system; and conflicts arising through misunderstanding or underestimating the operational requirements of natural coastal processes such as sediment movement, shoreline erosion, etc.

A detailed review of the integrated Coastal Zone Management practices in the countries of East Asia has been carried out by Chua and Yu (1978). Sorensen and Brandani (1987) have provided an overview of the efforts undertaken by the countries of the Latin America. The World Wildlife Fund (WWF) has reviewed the Coastal Zone Management activities of number of countries, especially the ICZM programme since its conception. The development of this programme through time has also been analysed. Westcott (2001) has evaluated the ICZM plan in various states of Australia He discussed the level of adoption and implementation of ICZM and stated that it differs from state to state. Judging the progress of ICZM programme in various states according to the existence of a lead agency, dedicated coastal legislation and statutory

strategic policy (or) plan, he has conducted in the states of New South Wales and Victoria and ahead of the other states.

Clark (1988) and Clark (1992) have framed a comprehensive account of the concepts and practices of a coastal zone management. Cicin-Sain and Knecht (1998) have brought out the concepts and practices involved in the subject of Integrated Coastal and Ocean Management. In their work, they have provided essential information about coastal zone management, benefits of integrated coastal zone management meant primarily for the coastal and ocean mangers. Their work contains information regarding the initiation, implementation, and operation of an integrated Coastal Zone Management programme.

Snedaker and Getter (1985) have formulated the guidelines towards the management of coastal resources and coastal developmental activities. Their work provides description of five major coastal systems along with their management strategies viz., coral reefs, mangrove ecosystems, beach system, estuaries and lagoons and sea grass beds. The coastal development activities have been grouped based on economic categories like agriculture, fisheries, energy, transportation, urbanization and industry and the management strategies and discussed each category in detail.

Scialabbe (1998) has prepared a guideline for Integrated Coastal Area Management (ICAM) to examine issues especially in agriculture, forestry and fisheries sectors, and suggests the processes, information requirements, policy directions, planning tools and possible interventions that are necessary for ICAM.

The proliferation of integrated coastal management programmes has led the UNESCO to prepare a reference guide on the use of indicators for Integrated Coastal Zone Management (UNESCO, 2003).

The European Commission (1997) has devised an integrated coastal zone management programme for managing its coastal resources. It has also prepared a document in the year 1999 which describes in detail, the general principles and policy options relating to the Integrated Coastal Zone Management in Europe. In the same year, the European Commission has prepared a document in which the lessons that have emerged to form the various component of the European Commission Demonstration Programme on Integrated Coastal Zone Management which was launched in 1996. The Demonstration programme has yielded a wealth of technical information about ICZM mechanisms and solutions to specific problems faced in the coastal zone. The document was prepared to compile and to diffuse the principal

policy lessons emerging from the experiences of the Demonstration programme and to stimulate debate and develop consensus on a European ICZM strategy, designed primarily to reverse the trend towards unsustainability that is reported to be pervasive in coastal zones across Europe.

Pernetta et al., (1993) have highlighted the need for integrated approaches to management and planning of coastal zones and also outlined and defined the process of integrated, cross-sectoral coastal area planning besides discussing the past experiences CZM activities on various parts of the world. An integrative framework and methods for coastal area management with special reference to the *Association of South East Asian Nations* (ASEAN) has been presented in detail by Chua et al., (1992).

Hatziolos et al., (1996) and Ngoile (1997) have provided an overview of major issues relating to the state of the marine and costal environment in African Continent and have set out various approaches for its protection, including institutional, managerial, economic and scientific approaches.

Fedra and Feoli (2001) have used the methods and tools of spatial analysis, their integration and application to Coastal Zone Management. A critical analysis of the coastal area management programme which includes the policies and management strategies in a number of Southeast Asian countries have been made by Chua and Pauly (1989). Anderson and Skrizhevskaya (1997) have described an ambitious approach that is also supposed to include socio-economic aspects in an Integrated Coastal Zone Management planning for the Ukrainian Black Sea Region.

Ajjour and Drabih (1997) formulate coastal zone planning and management for the Gaza, Palestine. They have listed out the coastal zone problems of the area which includes destruction of beach landscape and natural coastal habitat, waste water discharges, developing of solid waste and construction waste directly on the beach, beach erosion, unplanned development, conflicting land uses, lack of awareness among the public and the government.

Thomson (1998) has critically analysed the issues relating to coastal management in New Zealand. He has stated the problems of the coastal management programme in the country and has suggested alternatives to improve the efforts towards the management of the country's coast.

The Conservation Foundation (1980) has brought out a guidebook recommending a number of policies which could enable communities towards

conservation to reach for the highest standards of environmental and hazards protection. Their work mainly focuses on seven places of concern: banks and bluffs, dune lands, beaches, coastal water and basins. Olsen et al., (1999) have prepared a manual for assessing the progress of Coastal Zone Management programmes. By reviewing the coastal zone management programmes implemented in various countries. Bower et al., (1994) brought out a framework for planning for ICZM. The experiences of the concepts, policies, and implementation of Integrated Coastal Zone Management programme in Ecuador have been narrated by Robadue (1995).

Thai-Eng (1998) has assessed the performance of eight ICM project in Southeast Asia that were developed through the ASEAN/US Coastal Resource Management Project and the Global Environment Facility (GEF)/UNDP/IMD Regional Programme for the prevention and Management of Marine Pollution in East Asian Seas. He has highlighted the achievements made besides identifying the areas that needs to be addressed.

A detailed account of the activities relating to Integrated Coastal Zone Management in Tanzania and Seychelles has been studied by Linden and Lundia et al., (1996). Norbert, Michele Grace, and Jeffrey (2005) have stated that the geomorphological characteristics and configuration of the islands are products of a suite of natural processes, complemented by human actions that describe the landforms of beaches, dunes, inlets, and barrier island gaps and basic controls on these landforms.

Chua (1997) has synthesised the experiences of Integrated Coastal Zone Management planning that is being adopted in several countries. He has broadly outlined the lessons learned from the study of the outcomes due to the implementation of the Integrated Coastal Zone Management plans in these countries.

Gibson et al., (1996) have provided a comprehensive account of the guidelines for developing Coastal Zone Management plan of Belize in a GIS environment. A comparative analysis between the conventional and remote sensing methods towards the assessment and management of coastal zones and resources has been carried out by Mumby et al., (1999). Edwards (1999) has given a detailed account on the utility of Remote Sensing data both airborne as well as satellite data towards the various applications related to coastal management. The advent of Remote Sensing and the worldwide recognition of its potential to provide vital inputs towards CZM planning

has prompted the UNESCO (2000) to publish a manual which could be treated as a handbook for Coastal Management using Remote Sensing especially for tropical coasts.

Nowadays, in recognition of the many problems that have arisen in the past through inappropriate use and management of the coast, a new and more "*environmentally-oriented*" ethos of coastal management is emerging, based on more holistic, trans-disciplinary and integrative principles, and aiming at sustainable management of coastal resources. This new philosophy depends, however, on a thorough understanding of the entities and relationships at work in the coastal system, and this in turn demands a solid base of data and information to be harnessed in support of decision-making. Thus, for these and many other reasons, coastal scientists and administrators are increasingly looking to the developments in information technology for tools and methodologies that might assist them in their work. Three areas of information technology which have already proven their worth in coastal studies have been the use of computers for simulation modelling of coastal processes such as sediment transport or ocean wave behaviour; the use of satellite imagery and remote sensing techniques and the application of Computer-Aided Design (CAD) packages for designing civil engineering structures for the coastal zone. Against this, however, and somewhat paradoxically, geographical information systems (GIS) have not yet enjoyed the success at the coast that they have undoubtedly had within more terrestrial spheres of investigation. Successful application of Geographical Information System (GIS) tools and concepts to the coastal zone is one of the great challenges for developers and users of the technology.

In 1989, the International Geographical Union's Commission on the Coastal Environment approved the establishment of a Commission Project aimed for investigating and promoting the utility and application of GIS for coastal management purposes. The Commission on the Coastal Environment formally came to an end in August 1992, but a new Commission on Coastal Systems was authorised, and continued to August 1996. Sponsorship of the Project on Coastal GIS was transferred to the new Commission, and work on this research initiative continues. A number of facets to the Project have already been put in motion, including participation in international conferences on the theme, and establishment of an electronic discussion group (COASTGIS), based on a Listserv node on the Internet computer network, to facilitate exchange of information. Further activities are also planned, including a

possible compendium volume of papers on the theme of GIS and the Coast. An important problem, identified early in the work of the Commission Project, is that the literature base relating to coastal applications of GIS is very small, and such references as do exist tend to be scattered across a very great number of journals, proceedings, volumes and other source. Thus, gaining access to the existing literature is a somewhat daunting task, which may itself be an impediment to progress in the field. It was decided early in the Project to compile an annotated bibliography of literature on the subject that is an effort to improve knowledge of, and access to, relevant information about coastal GIS to date, some 150 references have been identified. While it is intended to maintain the bibliography into the foreseeable future through periodic updates and inclusion of new references, it now seems an appropriate juncture at which to publish the first "*hard copy*" results of the search (*provisional "pre-release" versions have been circulated to Project supporters for amendment / comment from time to time over the past two years*).

Law (1991) describes the rationale behind selection and use of GIS to develop and implement shoreline management plans for the Great Lakes shores of Ontario, Canada. The paper outlines briefly, the process for developing Shoreline Management Plans, the limitations of conventional mapping, the potential of GIS and the current provincial perspective in Canada towards using GIS in shoreline management. The traditional spatial unit used in map-based shoreline management in Ontario is the littoral cell, defined as "*a self-contained sediment system that has no movement of sediment across its boundaries*". Each littoral cell is divided into shoreline reaches *("segments of shoreline that have a similar physiography, geologic composition, average annual recession rate and orientation to waves"*). The GIS selection was based on hardware restrictions which required implementation on an AT (286) PC-compatible machine; a perceived need for twin-screen operation because of the need to interact with the public and the need to maintain privacy of certain information; a need for user interface with other existing GIS, image processing systems and databases; and finally, "*the system should be capable of producing a minimum of twelve map layers of information to be overlaid simultaneously in Boolean operations*".

The UNEP (*United Nations Environment Programme, 1995*) in its guidelines for Integrated Planning and Management of Coastal and Marine areas in the Caribbean, has put forth that for solving conflicts and/or finding optimal solutions, the

integration of recent tools such as Geographic Information System (GIS), Image Processing System (IPS), Remote Sensing with Data Management, Data analysis and modeling, as to be promising.

Gilman et al., (1999) have opined that the appreciations of the complex nature of coastal process are vital for an effective coastal zone management planning. But for their understanding, it is required to analyse a large number and a variety of disparate data sets, and in order to model the data, relational analysis allow clear observation. The authors state that GIS is the most effective tool and they have demonstrated with a few case studies. Muir and Shea (2001) have illustrated in their report how integrated coastal zone management and GIS analysis supported by International Conventions and European Union regulations can reduce pollution and lower the chances of oil spills. They have discussed in detail how integrated coastal management, that incorporate GIS analysis, can communicate and minimize the risks and severity of oil pollution in coastal and marine waters.

Connolly and Cummins (2002) have dealt the various aspects of Integrated Coastal Zone Management in Ireland. They have also highlighted the utility of GIS and the European Union's integrated coastal zone management Demonstration programme guidelines in undertaking integrated coastal zone management plans. GIS and CAD packages have been used by the Alaska Coastal Zone Management programme (ACMP) for an array of coastal management activities (Report of the ACMP, 2002). In the study, they have also listed out the standards and guidelines of spatial data used by the ACMP and the GIS protocol.

Aitchison et al., (1968) state that the history of terrain evaluation was developed in the United States of America, England, South Africa and Australia. Terrain evaluation is a technique which integrates land resources, mainly surface materials, soils, water and vegetation on a common platform. Agro-ecological zones project, started by FAO (*Food and Agriculture Organization, United Nations*) in 1976, was an important landmark in the history of land evaluation. The aim of the project was to obtain a first approximation of the production potential of the worlds land resources by an evaluation of agro-ecological zones. Yin et al., (1987) provide a physical land evaluation exercise in Malaysia for tropical tree crops.

With the advent of the mapping and information technology, land information system (LIS) has been developed in various parts of the world, including India. Land Utilisation Types (LUT's) and integrated coastal information system of the ITC, the

Netherlands are the best examples in which automated evaluation of coastal zone management strategies stimulation model (COSMO, 1993) was developed to illustrate the analysis of coastal zone management strategies, as described in the document.

The planning task is to analyse and evaluate CZM strategies under different scenario for the path development. This is done in two round (*the demo version COSMO only allows for round one)*: first, several predefined cases are examined; second, the cases can be modified and analysed/evaluated. The following steps are included in COSMO.

- Provide an overview of Cases' characteristics and problems.
- Shows the analysis conditions (objectives, criteria and scenario)
- Provide an overview of predefined CZM strategies (round 1) and allows the user modify strategies (round 2)
- Facilitates the analysis of a specific case
- Allows the comparison of all cases.

Beek, (1983) describes that the land evaluation means the process of collecting and interpreting basic inventories of soil, vegetation, climate and other aspects of land in order to indentify and make a first comparison of promising land use and alternatives in simple socio-economic terms.

## 1.6.2 National Scenario

Coastal area studies on sea level variations along Tamil Nadu coast is in an infant stage. Stoddart and Pillai (1972) have attempted to date a coral sample from Rameswaram area and have found the age to be around 4000 years before the present (BP) and suggest the lowering of sea level.

Loveson and Rajamanickam (1987,1988a) and Loveson et al., (1990) have discussed the changes in shoreline in this area based on the disposition of landforms like the beach ridge patterns, and the occurrences of backwater zone and pointed out the possible fall in sea level. Further, a few archaeological evidences reveal that, the sea level has been lowering along the Southern Coromandal Coast (Rajamanickam and Loveson, 1988). Loveson et al., (1990) has brought out 3 or 4 minor regression / palaeo-sea strands along the Southern Tamil Nadu Coast using LANDSAT imagery.

Since the last decade (WWF, 1992), remote sensing is the techniques capability which has been amply demonstrated in various parts of the world. It has

also been used in India by Bahuguna and Nayak (1994) and by the Indian Governments Departments of Ocean Development (DOD) and Space Application Centre (SAC) in 1997. Their mapping has revealed the existence of various reef forms such as shore platform, patch, coral pinnacles and atoll. The total area occupied by the reef and its associated features is 94.3 sq km. Reef flat and reef vegetation including algae is found to occupy 64.9 and 13.7 sq km respectively.

Kumaraguru (2000) studied the socioeconomic condtion of Coral Reef Resource users in the Gulf of Mannar Coast, South India by choosing marine fishing villages in the Gulf of Mannar region for assessing the socioeconomic status of the fishermen and coral reef related resource usage by people. The purpose of this study was to generate baseline data on socioeconomic status of the reef related resource utilization in the Gulf of Mannar region. This would, in turn, contribute to the long term planning of socioeconomic monitoring of coral reef resource users in the Gulf of Mannar. Melkani, (2002) studied threats to conservation of biodiversity in Gulf of Mannar and proposed remedial actions under GEF-UNDP (*Global Environmental Fund - United Nations Environment Programme*) initiative. He has extensive experience in forestry and conservation issues in terrestrial and coastal areas in Tamil Nadu.

John Joseph (1991) has studied the coastal forestry resources of Tamil Nadu, concluded that it is continuously subjected to intensive escalation of biotic and industrial pressures which lead to consequent degradation. The Gulf of Mannar Biosphere Reserve was described by Krishnamoorthy (1991) and pointed out the lacunae in the management strategy and emphasised the need for cooperation among various agencies.

The study of coastal process, physiography, ecology, and its conservation of Tamil Nadu and special care gave to the studies in the Gulf of Mannar biosphere reserve areas using different tools were illustrated by Natarajan, Dwivedi and Ramachandran, (1991).

A number of other studies which provide an account on the status of coral reefs of the present study area have been carried out by Shepard and Wells (1988), Allan white and Arjan Rajasuria (1995) and Pillai (1996). All these studies provide a comprehensive picture not only on the status of the coral reefs but also of the government policy towards their conservation and management.

Similar study has been undertaken by Bahuguna and Nayak (1998). Issues relating to coastal zone management with reference to India along with the role of remote sensing have been dealt in detailed by Nayak, (2000).

According to Pillai (1986) about 96 species of corals belonging to 36 genera occur in the study area. Apart from algae the reefs are also found to shrimps, fishes (Krishnamurthy, 1987) besides the extensive sea grass beds on which the green turtles, Olive ridley turtles and dugongs.

The government of India established the islands of Gulf of Mannar as a biosphere reserve in 1989. The Gulf's 3600 species of plants and animals make it biologically one of the richest coastal regions in India. The GoM (Gulf of Mannar) has been reported as a total of 94 species of corals belonging to 37 genera, and the coral reefs are mostly of fringing type. During 1998 to 1999, surveys had been conducted to estimate the recent status of the coral reefs of this region.

Agarwal (1988-b) has studied the geomorphology of Gulf of Mannar of Manapad to Vaippar and reported the northward movement of sediments along the coast and the presence of saltation in Tuticorin harbour and the utility of marine geomorphology in developing the concept of sub-marine terrain evaluation in harbour engineering. Rajamanickam, (1989) has brought out very informative status paper on sea level variations along the Tamil Nadu coast.

Bojan et al., (1991) have identified the potential areas available for development of brackish water prawn farming along the Coromandal coast of Tamil Nadu and also pointed out the non-availability of natural seed resources.

Aruchamy et al., (1991) has brought out the stages in the Manimuttar delta, by tracing the meander belts and coastlines and evolution and morphological changes in the Vaigai delta. These observations are made from IRS – 1A data indicating the dispositioning of different landforms from ancient channels.

Balakrishna (1991) has studied coastal industries along Tamil Nadu and pointed out places for different industries while Prakash, (1991) and Ramachandran et al., (1991) have brought out the coastal pollution along the Tamil Nadu Coast. Further he demarcate the coastal regulation zone of Tamil Nadu with different tidal lines (2004) while studying the sea water salt production in detail and discussed about different issues which affect the salt production.

Legal issues of CZM in Tamil Nadu have been discussed by Balu (1991). Balraj (1991) has studied the major ports and harbours and summarised that the state Government should initiate critical studies on erosion, accretion and its problems. Balaraman, (1991) has studied the coastal population of entire Tamil Nadu and brought out the population density, growth rate and sex ratio. Franklin et al. (1991) brought out the three levels in classification system for coastal mapping using remote sensing.

Deveraj and Santhanam, (1991) have studied the manpower requirement for shrimp culture (*19, 500 in 15, 000 ha*), oyster farming (*7500 in 5000 ha*), mussel (*7500 in 5000ha*), sea weed farming (6500 in 5000 ha), offshore trawling (1500 in 100 trawls) and fisheries products development (*11500 or 70000 tonnes/annum*).

Sivasubramanian et. al., (1991) have written about the coastal soils of entire Tamil Nadu, based on the electrical conductivity, pH and sodium absorption of soils taken from 30 cm to 1 m depth during field traverse.

Balakrishnan (2006) is the well expert in the conservation and stabilization of sand dunes in Nagapattinam coastal tract area experiencing from South Poigainallur, Tamil Nadu. The sand dunes have protected from coastal area natural disasters such as cyclones and high tides. The dunes have in fact been largely responsible for minimising the number of deaths in the village during the tsunami.

The UNDP has been assisting the Government of India in its efforts to establish a strong legal framework for coastal policies and coastal zone management, particularly in the tsunami-affected states. Better coastal protection is fostered by greater participation of civil society groups and communities in the policy strengthening process. The implications of the Swaminathan Committee report are far reaching, especially in terms of post-tsunami recovery and development planning (Swaminathan, 2006). The recommendations from this review will assist the UNDP in its future collaborations with the MoEF, particularly on the subject of integrated coastal area management. Recently, Ramachandran demarked CRZ from the Coastal Regulation Zone Information of Tamil Nadu under the Environment Protection Act, (1986). A notification was issued on February, 1991, for regulation of activities in the coastal area by the Ministry of Environment and Forests (MoEF). As per the notification, the coastal land upto 500 m from the High Tide Line (HTL) and a stage of 100 m along banks of creeks, estuaries, backwater and rivers subject to tidal fluctuations, is called the Coastal Regulation Zone (CRZ).

As the present work is intended to evaluate the coastal land, the study also reviews land evaluation method adopted by FAO and other agencies. In India, a major and regional study is Land Management for Rural development in the Kambam Valley (Aruchamy, 1986). The study has followed, in general, the FAO framework (two stages approach) with a quantitative methodology developed for land capability and suitability classes. Followed by, the similar type of study has been carried out by Jeganathan, 1994 who dealt the land evaluation for Agricultural Land use Planning in Thevaram basin with a quantitative methodology developed for land use requirements and land suitability classification based on FAO framework. The modified methodology was adapted in Integrated Coastal Zone Management for Southern Tamil Nadu coastal tract done by Saravanakumar, (1995). This study has focused mainly on resource inventory and how to manage the different coastal resource mapping unit. Further Gobu, (2001) presented a well commissioned report on the study of land evaluation, using the FAO frame work and its two stages analysis.

Sivaprasad et al., (1968) describe the methodology for soil site evaluation, based on the parametric approach of Sys (10), which is a modified version of FAO framework. While compiling all these reviews, a flexible approach of the "GIS" is mainly used in the present study in which the coastal ecosystems are the core areas for coastal management. They include descriptions of coastal zone modeling for the management of coast, satellite and air photo remote sensing techniques for conventional mapping of the coastal zone. Since the major part of the study area falls under littoral zone under various ecological units, it is imperative to assess their strength and weakness related with agricultural suitability, in order to evaluate such strength and weakness, the FAO land evaluation method has also been applied in the present study.

Accordingly the present study is a judicious blend of the qualitative with quantitative analysis, especially to remain practical and rooted in coastal habitats realities in the Tuticorin coast and to provide for objective assessment of a coastal ecosystem based on the Methodological Guide to Integrated Coastal Management, formulated by UNESCO Intergovernmental Oceanographic Commission Manuals and Guides 36$^{th}$ on July 1997.

Though the coast is a very sensitive region without proper protection, the Government does not produce proper protection policies and does not draw the defined boundary for conservation of coastal ecosystems and people living in the

coastal area also lack of awareness regarding the allowing distance from the shore line. So, there is a possibility for the extermination of marine resources by habitat destruction, over harvesting of resources more localised extent and civic pollution that will induce the environmental degradation in this coast. The present study strives to make management of coastal land within the coastal zone boundary.

## 1.7 THE PROBLEM OF THE PRESENT STUDY

The present study on coastal land evaluation for sustainable development uses physical attribute and socioeconomic analyses. The study relies on remotely sensed data in the form of satellite images (1:5000) and the references related to the land use. Sustainable development is an improvement in quality of life. Without endangering the government, it is to create a different type of activities and it is considered at the level of land mapping unit. This makes the aim of the research of planning for sustainable development and the viewpoint is that of coastal land evaluation and suitability classification.

The study focuses on Coastal land management and conservation problems. The problem analysed is that of evaluation of coastal land/land evaluation using remotely sensed data by delineating land mapping units and analyzing their physical characteristics. The study aims at suggesting coastal zone management for different coastal sectors.

## 1.8 STUDY AREA: AN OVERVIEW

Tuticorin Coast, the area chosen for the present study is located in the south eastern coastal zone of Tamil Nadu state in India. It lies between *$8^{o}41'49"$* and *$9^{o}22'20"$* north latitudes and *$78^{o}3'56"$* and *$79^{o}26'6"$* east longitudes covering an area of 1290 sq.km. It is one of the world's richest regions from a marine biodiversity perspective. The biosphere reserve comprises 21 islands with estuaries, mudflats, beaches, forests of the nearshore environment, including marine components like algal communities, sea grasses, coral reefs, salt marshes and mangroves. There are about 125 villages along the coastal part of the biosphere reserve which support some 100,000 people (*200,000 seasonally as of 2001*). Among Gulf's 4,000 plant and animal species, there are the globally endangered species sea cow (Dugong dugong) and six mangrove species endemic to peninsular India. The inhabitants are mainly

Marakeyars, a local community principally engaged in fisheries. Major ecosystem types available are Coral reefs, mudflats, beach, island, shallow water, mangrove etc., of coastal / marine components.

Conservation and management of coastal land resources and society have transformed the self-regulating character of land and its coastal ecosystem into a deep concern for rehabilitation. Considering all these factors, the area is peculiar and it is highly sensitive to the changes because of its unique geomorphological, meteorological and soil conditions. The impact of all these factors leads to the changes in economic and social constraints. Thus there is an urgent need to study each of the land facets of coastal land. Delineating the coastal sectors and identifying the ecosystems and ecological mapping units for analyzing the advantages and disadvantages of land requirements and land characteristics are the most vital research activities.

## 1.9 AIM AND OBJECTIVES

The study aims to drawing up an ***Integrated Coastal Zone Management (ICZM) for Tuticorin coast*** so as to be able to manage and develop its coastal zone in a sustainable manner by having the following objectives:

1. To demarcate ***coastal sectors*** and to identify the different ***coastal eco-systems***, a relatively self-contained system composed of a natural community along with its physical environment.
2. To evaluate the present strengths and weaknesses of physical attributes of land, land use and land utilization types of each coastal ecosystem in a way that bring out the lacunae and point out the desirable package of (land) suitability.
3. To study and understand the socio-economic characteristics of the farmers/people of the area and to determine how their utilization of land (littoral and terrestrial space) / coastal ecosystem speaks of their related management characteristics in the present landuse circumstances existing.
4. To formulate management strategies, polices and a planning methodology for different coastal ecosystems of each sector.

## 1.10 RESEARCH METHODOLOGY

***The array of techniques employed to fulfill the above objectives are:***

- *Base map* of the study area has been prepared from the topographic sheets (58K/4, 8, 11, 12, 15, and 16; and 58O/3, 4, 7 and 8; and 58L/1&5 and 2), published by the Survey of India (SOI) on 1:50,000 scales.
- After having set up the objectives of the study, primary and secondary base line data have been collected from the published and unpublished reports/data of different departments and analysed in order to understand the *existing condition of the study area* (profile) in detail on various physical, economic and social attributes.
- In order to conduct the Integrated Coastal Zone management, the ICZM guidelines (UNESCO, 1997) have been referred to understand the content of Integrated Coastal Zone Management for a *holistic approach*. Further, *the Land Evaluation procedure* (FAO, 52, 1983) is followed for the demarcation of different coastal ecosystem and also to assess the strength and weakness of each facet or land unit of each coastal ecosystem.
- To make a sound and complete Coastal land conservation plan, two sets of information are needed. One is the *inventory of land (resources)*, which is more conveniently recorded (physical attributes) on a map to understand the *Land Characteristics* of each land facet of various coastal ecosystems. The another fact is about the farm business/usage, available facilities and present limiting factors related to *Land Use/Land Utilisation Types (LUT)*. These facts are pre-requisite to understand the existing conditions of the coastal land on various physical, economic and social characteristics and their utilisation. Further, it reveals the interaction (physical, biological and anthropogenic components) between man and land. An understanding of such interaction and the relationship is a precursor to any evaluation study on how the present status/usage could be preserved, changed or improved. By weighing these facts, the present strengths and weaknesses of terrestrial and littoral space of Tuticorin coast have been evaluated.
- The *spatial land uses* (General) of each coastal ecosystem are brought out from the satellite data of IRS-1D LISS III image by on screen visual interpretation using different band combinations and enhancement techniques. The field checks for doubtful areas have been carried out to confirm the identified features. The

*Land Utilisation Types* (*crop cover/use of coastal environment*) have been identified and selected based on General Land Use derived from the remotely sensed data, available material (crop census), pre-filed study and socio-economic data, Descriptions of relevant materials and explanations for events, including land use requirements have been made after the field survey.

- Resource inventory: As the study area runs for about 193 km length with a width of 10 km, it is divided into *six sectors* based on Taluk boundary (*Administrative Unit*). It is for the convenience of the planners/policy makers/administrators so as to implement the results towards any development plans. To evaluate and interpret the present status of coastal land (*terrestrial and littoral*), and its related attributes of coastal sectors in detail need some basic unit of the study in order to assess the *Land and its Characteristics* of each facet and propose the *Land Suitability Class*. The coastal ecosystem also called Land Systems, is uniform and relatively permanent geomorphic division. It is an ideal basic unit for any physical criteria tends to be relatively permanent while those boundaries are based on socio-economic criteria are more susceptible to change. Land Units/facets (*micro units within the system*) are ideal units. Thus, the process based on geomorphic divisions under the Fluvial Fluvio-marine and Marine origins are considered as *coastal ecosystems* (UNESCO, 1997). Each coastal sector have been identified and demarcated based on Image recognition elements using of IRS 1D LISS III satellite data by on screen visual interpretation through ERADAS Imagine 8.7 application software after carrying out geometric correction. A total of 28 coastal ecosystems are identified which are presented in 378 locations due to their recurrence and they have been demarcated from satellite imageries. Each coastal eco-system contains distinctive groups with geographically and geomorphologically described. The areal and linear measurements were calculated by the application software ArcGIS 9.1.
- In order to understand the coastal Land Characteristics of each coastal eco-system, the thematic maps on physical attributes (*like physiography, drainage, geology, geomorphology, relief, soil, present land use etc.*) were prepared and interpreted. The interpreted details are compared and transferred to the base map for eventual consolidation and modification of definite coastal ecosystem. The details are processed through ArcGIS 9.1 software and Coastal Land Evaluation Tables for each coastal sector.

- The processed and tabulated data contains coding and numbering for each coastal eco-system and Land (*mapping*) Units. The tabulated data give the information on eco-system, physical details (with reference to various thematic maps and field details), land use/land cover, limitation and other characteristics.
- By overlaying the land use requirements with coastal land characteristics, the proposed Land Use (*land suitability*) classes have been made along with remarks. After preparation of Coastal Land Evaluation Tables, the table details are verified in the field. The proposed land use maps and Coastal Land Evaluation Tables for each sector are very much useful for planning and conserving the sensitive coastal eco-systems.
- The economic details such as land use, crops and their application techniques, recurring and non-recurring input details of each land units are also collected through socio-economic survey during the field checks to verify the interpreted details and refined.
- Finally, summing up all merits and demerits, the *management strategies, policies and planning methodology* are made.

## 1.11 LIMITATIONS AND RELIABILITY

For fulfilling the objectives, both primary and secondary data are needed. Different types of secondary data have been collected from various government and quasi-government offices. The population and administrative divisions have been collected from the Statistical Office, and the National Informatic Centre (*www.tn.nic.com*). Geological data have been collected from Geological Survey of India (GSI). Climatological data (*rainfall, temperature*) have been collected from the Indian Meteorological Department (IMD) of Meenambakkam, Chennai. Rainfall data are collected for the years of 1963 to 2003.

Soil particulars are collected from Tamil Nadu Agricultural University, Coimbatore. The Survey of India topographic sheets of 1:50, 000 scale have also been used for base mapping. Satellite images of 1: 250, 000 and 1: 50, 000 scale (*Digital format*) are used, for mapping kharif and rabi seasons. IRS-1D, LISS III images have been used for delineating geomorphology, forest, coastal ecosystems and ecological mapping units. The primary survey on socio-economic and crop management practices and land utilization types has been made on a random and purposive

sampling of 120 villages. In the preparation of the present work, a number of important published and unpublished reports are used. Most ideas in the early chapters are assembled from books and research articles from several libraries in the state of Tamil Nadu and *Google* search engine in the web.

## 1.12 ORGANISATION OF THE THESIS

The present research report of this thesis is organized into seven chapters. The **First** chapter is **introductory**, which defines the problem and analysis and drawing it from a careful review of literature on related aspects. A review of relevant literature is attempted to pinpoint the relative position of Integrated Coastal Zone Management in the several countries that has been implemented and also to draw lessons for India to implement it with minimum of environmental disturbance and stress. A detailed methodology is outlined in accordance with the objectives of the study. The **second** chapter is a **descriptive account of the physical and socio-economic details** to understand the profile of the study area. The **Third** Chapter explains the **spatial distribution of Land Use / Land Cover based on Satellite data and Land Utilization Types** based on socio-economic and field survey. The **Fourth** chapter brings the **characteristics of different coastal ecosystem**, **ecological land units** and their areal extent, occurrence, land characteristics and landuse and utilization types and limiting factors to assess the coastal land ecosystems and ecological mapping units. The **Fifth** Chapter **evaluates the Land Suitability classification** by assessing each land unit and their characteristics, which are given in Ecological Land Unit Table of each ecosystem. This attribute table has been given to solution for suitability classes and suggestions about characteristics of coastal ecosystems. This chapter examines the key issues surrounding the human use and abuse of coastal zone. The chapter **Six is to formulate management strategies, policies and a planning methodology** for identified different coastal sector and also to prepare current and future conflicts which result from them. This chapter explains the way in which conservation and management policies and practices can protect the productive and diverse eco-system. The **seventh chapter summarises the findings and conclusions,** which outlines the implications of the study for the coastal zone management of Tuticorin coast.