INTEGRATED MANAGEMENT FOR SUSTAINABLE DEVELOPMENT OF COASTAL ZONES - A GIS BASED STUDY ON THE CENTRAL KERALA COAST

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by

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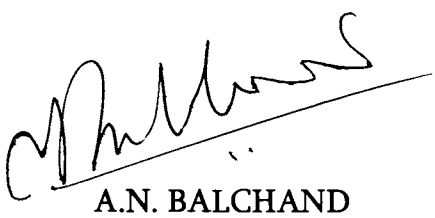
CERTIFICATE

This is to certify that this thesis titled "INTEGRATED MANAGEMENT FOR SUSTAINABLE DEVELOPMENT OF COASTAL ZONES – A GIS BASED STUDY ON THE CENTRAL KERALA COAST" is an authentic record of the research work carried out by Sri. Madhusoodanan M.S., under my supervision and guidance at the Department of Physical Oceanography, Cochin University of Science and Technology, in partial fulfilment of the requirements for the Ph.D. degree of Cochin University of Science and Technology under the Faculty of Marine Sciences and no part thereof has been presented for the award of any degree in any university.



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Chapter 1

INTRODUCTION

1.1 The Coastal Zone

The coast is a distinct and extremely important feature of the earth's surface, which marks the three-way boundary between the major environmental domains of the planet: land, sea and air. Carter (1988) defines the coast as "that space in which terrestrial environments influence marine environments and vice versa". Although in popular terminology, the term coastline is frequently used in practice the coast has width, depth as well as length, so the term coastal zone is preferred. Of the landscapes and habitats that exist on earth, the coastal zone is present in every climatic region of the world.

The coastal zone is the meeting place between land and sea, where the saltwater meets the freshwater and/or the land meets the ocean. The coasts are exposed to extreme physical forces, which ultimately affect the lives that thrive there. At high tide, parts of the coastline can be under water. The same area can be exposed to the elements of air, heat or cold at low tide. During storms, coastlines are ravaged by wind-driven waves, which crash against the shore with great force.

Coastlines also experience the elements of rain and sun, which with the tides create an incredibly variable environment. Plants and animals must adapt to these variable conditions. Despite these seemingly harsh circumstances, this region is a rich environment which provides a place to observe many unique species of plants and animals. Creatures not only live there round the year, but many species visit the region during migration or spend part of their early life there, making the biological environment highly vibrant.

The coastal zone contains some of the planet's most productive ecosystems with rich biodiversity reserves and supports the majority of the planet's human population. This region is integral to the social and economic life of the region and is the zone in which most of the infrastructure and human activities directly connected with the sea are located (European Environment Agency, 1995). It includes both the area of land subject to marine influences and the area of the sea subject to land influences which can be divided into three main components: the sea, the beach, and the land behind the beach. The sea, or offshore area, extends from the low water mark seaward. This area covers the shallow marine habitats of the coast, such as the sea grasses and the coral reefs among others. The beach zone extends from the low water mark to the seaward edge of the coastal vegetation. In some cases, the base of a cliff or a dune may mark the end of this highly changeable environment. The last component of the coastal zone is the adjoining coastal land. This zone extends landward for some distance from the end of the beach. The definition of how long this distance is may vary according to each country. As with all environmental systems, there are no clearly defined and universally accepted boundaries to the coastal zone. Where the land is flat, the coastal zone may extend for a considerable distance inland and may consist of sand dunes,

swamps or lagoons. Where the land is steep the coastal zone may be very narrow. The definition also depends on aspects relating to the ease of management of the coastal zone. The narrower the area covered by coastal zone the easier it is to manage. The wider it is, more complicated are the environmental systems. Often numerous agencies are involved in the management process, resulting in the development of complex scenarios.

The three subsystems interact in many ways and the boundaries between them fluctuate. Obviously, the coastal zone is not an isolated system. Rivers and waterways may carry pollutants and sediments resulting from inland activities to the coast where they have an impact on the habitat. Agricultural and forestry practices, for example, are known to bring increased sediments and chemicals to the marine environment where they may degrade the health of the coral reefs. Water currents may carry pollutants from one country's coastal zone to another's. The coastal zone is a complex, highly productive environment and the health of one ecosystem is intimately tied to the health of the other ecosystems in the area and often to areas some distance away. Valuable ecosystems of great productivity and biodiversity are present, such as mangrove forests, sea grass beds, other wetlands and coral reefs.

1.2 Natural Resources of the Coastal Zone

1.2.1 Coral Reefs

Coral reefs are among the most important resources in the coastal zone and are also among the most productive. Coral reefs occur along most shallow, tropical coastlines, where the water is clear and warm and the salinity is constant.

1.2.2. Sea Grass

Large sea grass meadows usually occur in the protected waters landward of coral reefs. Sea grasses are true flowering plants with male and female flowers capable of sexual reproduction, although most of the reproduction is performed asexually via the rhizome system in the sediment. Grazers, such as turtles, fishes and sea urchins feed directly on the grasses. Sea grass blades provide surfaces for epiphytes like algae and invertebrates to attach on. Sea grass beds also serve as nursery grounds for the juveniles of many commercially important species, such as snappers, grunts, lobsters and conchs. Sea grasses help to keep the water clear too. The blades of the grasses act as baffles, inducing the settling of sediment particles, while the rhizome and root system stabilize the bottom, preventing the resuspension of sediments. Note that clear water is an important requirement for the maintenance of healthy coral reefs.

1.2.3 Mangroves

Mangroves are found along the coasts of tropical and subtropical regions. The term mangrove refers to both the forest and the tree. The different mangrove species are not taxonomically related, but are grouped together because they can tolerate having their roots submerged in salt water. Their prop roots provide a surface of attachment for marine organisms in a muddy environment where hard surfaces are in short supply. Mangroves also trap and bind sediments and filter land based nutrients, promoting water clarity. Mangroves, like sea grasses, serve as nursery grounds for the juveniles of many commercially important fisheries species, while also providing habitat for a

variety of small fishes, crabs and birds. Mangroves protect coasts against erosion by breaking storm waves and dampening tidal currents.

1.2.4 Estuaries, Wetlands and Watersheds

Estuaries, coastal lagoons and other inshore marine waters are very fertile and productive ecosystems. They serve as important sources of organic material and nutrients, and also provide feeding, nesting and nursery areas for various birds and fishes. These ecosystems act as sinks of terrestrial run-off, trapping sediments and toxins, which may damage the fragile coral reefs.

An ecosystem is more than a habitat. A habitat is where animals and plants live. An ecosystem includes all the organisms in a specific area (such as a beach) together with their physical and chemical environment (salt, temperature, currents, etc.). None of these ecosystems exists independently. While it is difficult to define the boundaries of any coastal ecosystem, using the concept of an ecosystem provides a basis for looking at the coastal zone in totality.

1.3 The Coast and Human Society

Human societies have always enjoyed a close relationship with the shore. Traditionally, the coast had provided societies with opportunities for trade and conquest, migration and defence; and, in some cases, a focus for cultural and spiritual identity (Bartlett and Carter, 1988, 1990). Today, over 40% of the world's human population live on or near the coast (Carter, 1988); while in the United States it has been estimated that approximately half the population will soon be living on coastal belts equating to about 5% of the total land (Salm and Clark, 1989). In some parts of the world, entire countries and districts (e.g.

The Netherlands, Bangladesh, Atlantic and Gulf coasts of the United States and many Pacific islands) may lie wholly within the coastal zone.

The coastal zone also provides access to physical and other resources. For many countries of the world, the oceans and especially the continental margins provide an important primary source of protein. It is estimated that more than 99% of the world's catch of marine fish species are now caught within 320km of land, and more than 50% of the total biological production of the ocean takes place in the coastal zone (Holt and Segenstam, 1982). Minerals and vital hydrocarbons also come from many of our coastal waters while we also use the off-shore zone as a convenient disposal ground for sewage and domestic and industrial wastes, including toxic and radioactive materials. The coastal fringes of our landmasses are becoming increasingly sought after for leisure and tourism developments besides attracting industry. All of these activities may contribute significantly to regional, national and international economic performance (Bartlett, 1993a).

The coastal system not only facilitates the workings of society but sometimes it can impede or restrict the range of available options, for example by acting as a barrier to trade and communications, while many of the most popular coastal regions are also the most dynamic and, consequently, among the most hazardous locations to live in (Bartlett and Carter 1988, 1990; Devoy and Bartlett, 1991). Such considerations are especially important for low-lying, densely-populated countries of the less-industrialized world, but are also of growing concern to the more affluent parts of the world including the Atlantic margins of Europe (Carter, 1990), and the eastern seaboard of the United States

(Titus, 1987), particularly if recent warnings about possible near-future rises in world sea-level are proved correct.

1.4 Importance of the Coastal Zone

The coastal zone provides a source of income, recreation and a way of life that affects millions of people. It functions as a trade and transportation route. It supplies nurseries for fish stocks, contributes vast quantities of food and supports an economy based on nature. Coasts also provide tourist centres by attracting people who want to explore these unique environments.

The natural community benefits greatly from the coastal zone. The various ecosystems that border the coast provide a home for many different species of plants and animals. Coastal ecosystems also help to maintain a healthy environment, by storing and funnelling nutrients into surrounding areas. This unique interaction attracts people who want to learn and conduct scientific research about the ecosystems of the coastal zone. Various coastal ecosystems are crucial spawning or nursery grounds for fish and their prey species. Although the coastal zone is rich in animal and plant life, it is very vulnerable. The health and stability of the ecosystems in the coastal zone are under constant threat. Sand is removed from dunes, salt marshes are filled in, and nesting habitats for endangered species are destroyed. For centuries, people have thrived on the abundance of marine life in the coastal zone. Nevertheless, recently, this abundance has diminished and so has the vitality of the human communities associated with it. If the coastal zone is to remain healthy, the different ecosystems must remain healthy and diverse. We need to be informed about the importance of the coastal zone for human and animal well being. If we utilize its natural resources, we must do so in a sustainable

manner, without causing irreversible damage. We must protect the coastal zone, so that our children and their children will be able to enjoy this unique area for years to come.

Coastal nations have a particular interest in safeguarding their coastlines. Apart from being rich in minerals, it has potential for exploitation of tidal energy and ocean thermal energy for the benefit of development. Ecologically significant, the coastal zone in India is characterized by diversity of habitats, the extensive beaches of silvery sand, spits and dunes, rugged cliffs or slippery domes of rocks, salt marshes, estuaries, lagoons, mangrove swamps, coral reefs, sea grass beds and marshy wet lands which are locus of lot of lilies. Developmental measures in the zone have created problems. Establishing of housing colonies, selection of the coast for industrial sites and conversion of lands for non-coast uses adversely affected the self-sustaining traditional economy of coastal villages. The evolution of harbours and urban centres in the coastal belt led to degradation of the natural habitat and ecosystem. Mechanisation of fishing industry resulted in monopolisation by vested interests and threw traditional fishermen out of their lifeline. In turn, over exploitation of natural resources wise planning necessitates the regulation of coastal activities. The Coastal Regulation Zone (CRZ) Notification 1991 was the result. It defines and classifies coastal zones and lays down procedure for their protection.

1.5 Organizational Setting of Coastal Management

Wherever and whenever conflicts of interest over the allocation and use of any resource are found, decisions have to be made. Given the multiplicity of uses of the shore, both actual and potential, and the growing number of individuals

and organizations who claim an interest in, or a share of, various coastal resources, it is clear that enormous potential for conflict exists between different sectors and, especially, between the natural functioning of the coastal system, and the needs and expectations of societies who share the same space. This latter dialectic was expressed succinctly by Soucie (1973), who suggested that 'the real conflict of the beach is not between sea and shore but between man and nature' (quoted by Komar, 1976). The concept of coastal management acknowledges the need for coastal spaces and resources to be administered, and seeks to provide a framework within which the resources of the coastal zone may be conserved, protected or exploited according to the varying needs of society.

Traditional coastal management focused on modifying or adapting coastal habitats and processes to suit human needs. Under such conditions, coastal management has generally been driven by political and socio-economic concerns, implemented by civil engineers, and geared towards attempted control over the physical and/or biological aspects of the coastal system through the application of technological 'solutions' to coastal problems (Bartlett and Carter, 1988, 1990). Examples include armouring the shore against erosion; construction of harbour walls to protect shipping against ocean storms; dredging of mobile sediment from harbours and channels, so as to facilitate navigation in otherwise shallow waters; and building fields of groins in areas of alongshore drift of sediment, in order to create or stabilize beaches for recreational purposes. On a larger scale, land reclamation schemes aimed at increasing the amount or quality of land for living on, such as those of the Netherlands or East Anglia in England, can also fall into this category.

While human populations remained small, and technology was relatively limited, the capability for long-term damage arising from such activities was generally minor. However, society's technological capabilities in the late twentieth century have been expanding rapidly. This, coupled with growing population and industrial pressures, and an increasing complexity in the way that society is organized, have all led to much higher intensities of impact on the shore, so that 'the vitality of the coast is becoming increasingly at risk through human mismanagement, ignorance, indifference and neglect' (Bartlett and Carter, 1988, 1990).

Against this background of human-oriented coastal management, the past two or three decades have witnessed a growing list of environmental disasters taking place within the coastal zones of the world. Some of these have been sufficiently spectacular or catastrophic as to have reached the popular media:

e.g.

- the 'red tides' of the Mediterranean and the Skaggerak seas
- the phocine distemper epidemic which severely reduced seal populations around the coasts of Britain in the 1980s
- numerous oil tanker collisions and spillages, such as the Braer off the coast of Shetland in Scotland, Exxon Valdez in Alaska etc.

Disturbing, signs of environmental stress are also being seen around many of the shores, including evidence of eutrophication of coastal waters, changes in water quality, perturbations in sediment transfer, and apparent changes in the breeding, feeding and migration patterns of coastal bird and fish populations.

These disasters, as well as mounting concern from coastal scientists, and the 'whistle-blowing' activities of pressure groups such as the (UK) Marine Conservation Society and Greenpeace, have led to the emergence of a newer 'environmental' ethos in coastal management. This new ethos draws heavily on concepts of bioethics (O'Riordan, 1976), which are having growing influence in other, broadly similar, areas of environmental resource administration. In National Park management in Britain, for example, it is now policy that in any conflict between the workings of the natural landscape and the perceived needs or desires of human societies, the former should have priority over the latter (Sandford, 1974, O'Riordan, 1976). Similarly, in coastal management, it is increasingly accepted that the health and vitality of the marine environment and its coastal fringe requires the implementation of rational, integrated and sustainable management strategies based on longer-term planning, more regional scales of investigation, and greater use of so-called 'soft engineering' methods of shoreline protection (Carter, 1988; Bartlett and Carter, 1990). Indeed, the terms 'Coastal Zone Management' (CZM) or, occasionally, 'Integrated Coastal Zone Management' (ICZM) are nowadays mostly used to refer to this latter type of coastal management. The primary objective of CZM may be stated as being to 'devise a framework within which Man may live harmoniously with nature' (Carter, 1988).

While there is growing acceptance that coastal management has to be sympathetic to the workings of the natural coastal system, coastal management still has to take place within the context of society's administrative structures. There is great diversity, worldwide, and also occasionally within individual countries, regarding the manner in which coastal management is organized, as may be seen by reference to a few selected examples.

In most countries, coastal management has to date been conducted on the basis of inadequate conceptual, methodological or administrative structures, and often has appeared lacking in any clear goal (Eichenberg and Archer, 1987; Carter, 1988). The United Kingdom and Ireland are both examples where coastal management has traditionally appeared almost as an afterthought to more 'terrestrial' or 'oceanic' policymaking. In both countries, responsibility for coastal management and research is devolved among several levels or administrative hierarchy, and divided across a similar number of distinct organizations and professions.

In the United Kingdom, legislation regarding management of the coastal zone goes back at least to the 1949 Coast Protection Act. Despite this relatively long tradition, however, no one single government body has executive powers over coastal zone decision-making. Instead, administration of the coast is divided among District, County and Local councils, while responsibility for coastal zone research is shared between a number of bodies, including the government departments of Agriculture and Fisheries and of the Environment, and various research councils and agencies. In Ireland, responsibility for coastal management and research is similarly dispersed, with fifteen County Councils, two Corporations, six County Borough and Borough Councils, fourteen Urban District Councils, and seven Town Commissioners each sharing responsibility for managing the shore. In addition, these local authorities have to answer to a number of national bodies with regard to their performance in specific sectors of coastal management.

In contrast to these examples of fragmented management, a few notable cases may be recognized where traditional and localized coastal management has

taken place against a reasonable background of administrative co-ordination and consistency of policy. In the United States, for example, a Coastal Zone Management Act was implemented in the 1980s, and was backed by the so-called Federal Consistency Doctrine, which seeks to ensure that Federal policies with regard to the coast (and elsewhere) remain consistent with more localized policies and vice versa (Eichenberg and Archer, 1987). The Netherlands and Denmark offer other examples. However, against this it should be remembered that a large part of the world's coasts (probably the majority, although the actual length will be decreasing) remains completely unmanaged and subject to wholly natural processes (a good option?).

1.6 Sustainable Development (SD)

The increasing concern about the effects of economic development on health, natural resources and the environment lead the United Nations to publish the Brundtland Report in 1987. This defined Sustainable Development as "*development which meets the needs of the present without compromising the ability of future generations to meet their own needs*". In June 1992, the Rio Earth Summit declared that "*the right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations*".

Sustainable Development is not just about the environment, but about the economy and our society as well. It encourages the conservation and preservation of natural resources and of the environment, and the management of energy, waste and transportation. SD is development based on patterns of production and consumption that can be pursued into the future without degrading the human or natural environment. It involves the

equitable sharing of the benefits of economic activity across all sections of society, to enhance the well-being of humans, protect health and alleviate poverty. If sustainable development is to be successful, the attitudes of individuals as well as governments with regard to our current lifestyles and the impact they have on the environment will need to change.

1.7 Integrated Coastal Management (ICM)

Integrated Coastal Management (ICM) can be defined as a continuous and dynamic process by which decisions are made for the sustainable use, development and protection of coastal and marine areas and resources. The process is primarily designed to overcome the fragmentation inherent in both the sectoral management approach and the splits in jurisdiction among levels of government at the land-water interface (Cicin–Sain, 1992). This is done by ensuring that the decisions of all sectors and all levels of government are harmonized and consistent with the coastal policies.

1.7.1 Goals of ICM

The goals of ICM are to achieve sustainable development of coastal and marine areas, to reduce vulnerability of coastal areas and their inhabitants to natural hazards. Maintenance of ecological processes, life support systems, and biological diversity also included under them. Integrated coastal management is multipurpose oriented. It analyses implications of development, conflicting uses, and interrelationships among various physical processes and human activities. It also envisages linkages and harmonisation between coastal and ocean activities in different sectors.

The need to establish a programme of integrated coastal management in a particular nation may arise because of a number of reasons. Depletion of coastal and ocean resources through over fishing or exploitation of coral for building materials (particularly in developing nations) is a powerful trigger. Environmental pollution that endangers public health or poses threats to water-based industries such as aquaculture, fishing, and tourism may be another important catalyst. A desire to increase the economic benefits obtained from use of the coast and ocean may also point out the need for planning and management. The desire to develop uses of the coastal and marine area previously not exploited in a particular country, such as extraction of offshore oil or other minerals, marine aquaculture, or new forms of fishing for under exploited stocks or in different areas may be a related catalyst.

In the coastal-marine spectrum classification can be performed as inland areas, which affect the oceans mainly via rivers and nonpoint sources of pollution; coastal lands – wetlands, marshes, and the like – where human activity is concentrated and directly affects adjacent waters; coastal waters – generally estuaries, lagoons, and shallow waters – where the effects of land-based activities are dominant; offshore waters, mainly out to the edge of national jurisdiction (200 nautical miles offshore); and high seas, beyond the limit of national jurisdiction.

Although natural processes in these zones tend to be highly intertwined, it is difficult to integrate management regimes across the zones because the nature of property, the nature of government interests, and the nature of government institutions tend to differ in these zones (Cicin-Sain, 1992). With regard to the nature of property in coastal areas, there tends to be a continuum of

ownership: in inland areas, private property tends to predominate; on coastal lands, there tends to be a mix of public and private property; and in coastal and offshore waters, public property concerns are dominant. This generalisation varies from country to country according to cultural conceptions of private and public property.

With regard to the nature of government interests, local or provincial interests tend to predominate in inland areas, whereas there tends to be a mix of local, provincial, and national interests on coastal lands and in coastal waters. In offshore waters and the high seas, national and international interests become most important. The nature of government institutions also differs in the various zones. On land, there are often well-established 'multiple-purpose' government institutions at the local and provincial levels to address such questions as control of land use and conflicts among uses. On the waterside, there tends to be only provincial or national agencies operating, each concerned primarily with a single use of the ocean, such as fisheries operations or oil and gas extraction.

In the context of ICM and its proper application to coastal zones, the types of "integration" often practised are listed hereunder.

1.7.2 Intersectoral Integration

Integration among different sectors involves both 'horizontal' integration among different coastal and marine sectors (e.g., oil and gas development, fisheries, coastal tourism, marine mammal protection, port development) and integration between coastal and marine sectors and land-based sectors that affect the coastal and ocean environment, such as agriculture, forestry, and

mining. Intersectoral integration also addresses conflicts among government agencies in different sectors.

1.7.3 Intergovernmental Integration

It is the integration among different levels of government (national, provincial, local). National, provincial, and local governments tend to play different roles, address different public needs, and have different perspectives. These differences often pose problems in achieving harmonised policy development and implementation among national and sub national levels.

1.7.4 Spatial Integration

It is the integration between land and ocean sides of the coastal zone. There is a strong connection between land-based activities and what happens in the ocean involving water quality, fish productivity, and the like. Similarly, all ocean activities are based or dependent on coastal land and different systems of property ownership and government administration predominate on the land and ocean sides of the coastal zone, often complicating the pursuit of consistent goals and policies.

1.7.5 Science-Management Integration

It is the integration among the different disciplines important in coastal and ocean management (the natural sciences, the social sciences, and engineering) and the management entities. Although the sciences are essential in providing information for coastal and ocean managers, there often tends to be little ongoing communication between scientists and managers.

1.7.6 International Integration

Integration among nations is needed when nations border enclosed or semi-enclosed seas or there are international disputes over fishing activities, transboundary pollution, establishment of maritime boundaries, passage of ships, and other issues. Although in many instances, coastal and ocean management questions are within the purview of national and sub national governments within national jurisdiction zones.

The above approaches have been pooled up in the concept of Integrated Coastal Zone Management.

1.8 Integrated Coastal Zone Management (ICZM)

The coastal zone is a highly sensitive area, where a number of ecosystems exist in a state of dynamic balance. The coast is affected not only by local conditions but also by events and conditions long distances away. Pressures from human habitation and economic development are common in the coastal areas of the world. The management of such an area is of strategic necessity at an integrated level and with multidisciplinary efforts.

Coastal zone management encompasses the concepts of integrated resource management and sustainable development. Integrated coastal management requires balancing a wide range of ecological, social, cultural, governance and economic considerations. An important concept is co-management, where local stakeholders share aspects of governance with the government, and community participation is an essential part of such management processes. Active research and monitoring programs play a key role in providing sets of management options and potential consequences. With sustainable

development, the needs of the human population can be met without compromising the ability of future generations to meet their own needs. Sustainable development must not endanger the atmosphere, water, soil and the ecosystems that support life on earth. In case the scenario is turned for sustainable development, the use of resources, economic policies, technological development, population growth and institutional structures are in harmony and enhance current and future potential for human progress.

Integrated coastal zone management was defined at an International Coastal Zone Workshop in 1989 as "a dynamic process in which a coordinated strategy is developed and implemented for the allocation of environmental, socio-cultural and sustainable multiple uses of the coastal zone".

The key words and phrases in this definition can be expanded to make the definition more understandable:

"Dynamic process" indicates the constantly changing nature of the coast. The process of coastal zone management must be flexible to accommodate these changes.

"Coordinated strategy" is a plan or a program which may be spread amongst different groups or agencies working together.

"Allocation of environmental, socio-cultural and institutional resources" refers to apportioning and balancing the various natural and human resources in the coastal zone.

"To achieve the conservation and sustainable multiple use of the coastal zone" refers to the need to preserve the coastal zone and to maintain and strengthen its many uses.

A strategy for integrated coastal zone management is the key for ensuring the survival and sustainable development of the coastal resources in the region.

Integrated Coastal Zone Management can be divided into two fundamentally different bodies of knowledge and understanding, both of which are critical to the development of an effective coastal management programme.

For this we will have to understand the technical aspects of the coastal zone first. These include

- key physical processes – erosion, along shore drift, estuarine circulation, sediment flows, river delta behaviour etc.
- key biological processes – mangrove and wetland ecology, variability in fish abundances
- the fate and effects of various types of pollution found in the coastal zone (sewage out falls, industrial effluents, agricultural and urban runoff etc.

The existence of framework of organizational capability and an understanding of the institutional aspects of the coastal zone.

We must understand

- which governmental agencies have what kinds of management and regulatory responsibilities in the coastal zone and how well they are performing
- what legal authority exists for management of the coastal zone and what new legal authorities is needed

- what are the differing roles of the Central Government and the provincial and local governments concerning resource and environmental management. How the coastal and environmental policies are set and enforced and what new policies may be needed

1.8.1 The Dimensions of ICZM

In a coastal management problem it is necessary to integrate over several important dimensions

- the spatial dimension (i.e. the land-water interface)
- the sectoral dimension (i.e. consideration of all of the various sectoral activities that can interact in the coastal zone like fisheries, pollution, shoreline use etc.)
- the intergovernmental dimension (i.e. the interplay between national, provincial, local governments decision making
- the disciplinary dimension (i.e. physical sciences, economics, law etc.)

The variety and types of demands that are made on its space and resources can gauge the significance of the Coastal Zone in terms of its economic value and potential to a country. The economic value of this zone is derived from four major activities.

Products of direct market value from the coastal and marine environment, such as commercial and recreational fishing, oils and gas, shrimps and fish culture, seaweed cultivation, recreation and tourism

- coast-dependent activities such as transport, shipping, beach-related pastimes, ports and harbours

- coast-linked activities such as fish processing, marine equipment and gears
- coastal services that are provided to interests such as real state, education and research, business, industries and other professional concerns

The questions to be answered by an integrated coastal zone management programme are

i. What is the total value of the coastal zone?
ii. How can a coastal zone programme enhance the value of a nation's coastal resources?
iii. Has the coastal zone programme, wherever it has been implemented, enhanced the value of the coastal zone?
iv. How can the value of the coastal zone be preserved and enhanced for the future generations?

In fact, market forces drive the development of the coastal zone. "The role of governments is to respond to these forces, correct failures and ensure that coastal resources produce goods and services, which are not produced by market forces (public goods), such as conservation of natural areas, preservation of aesthetic beauty and a long term view is taken in contrast to the short-run, profit maximization criteria of the market" (OECD, 1993).

The coastal zone resources are divided into

- Natural and Manufactured Capital
- Renewable Living Resources (RLR)

Renewable Living Resources are further divided into

- tangible (marketable)
- intangible (non-marketable)

Tangible resources include all the species that have market value, such as food, cattle, fisheries, forests, fuel wood, substrates embodied in plants, seaweed, and plant and animal genetic material, pharmaceuticals, transgenic materials etc.

Intangible resources (whose economic value is not known) include: non-use species that are essential for survival of others that are tangible; coastal ecosystems, such as coral reef, mangroves, wetlands, grassland, pasture, wild animals and plants, ocean habitat, natural environment with aesthetic beauty and biodiversity, the economic value of which has to wait further investigations for possible exploitations.

1.8.1.1 Natural Capital

Cultivated Natural Capital includes: mariculture, cash crops, plantation, forests, rubber plantation, herds of cattle bred for certain characteristics, many species of microbes such as bacteria, fungi, etc., used in biotechnology and genetic engineering, and cultivation of any other form which may prove to have economic potential.

Renewable Non-living Resources include: ground water, solar energy, wind energy, energy derived from waves, tides and hydroelectric power.

Non-living Resources (NRR) (also known as exhaustible resources) include: metals, minerals, coal, oil, gas etc., used both as a direct source of energy, and for producing other NRR (e.g. Plastics and fertilizers). Some RLR can be converted into NRR, for e.g. Alcohol from sugarcane as a substitute for

petroleum, and biogas from faecal waste, but their utility is so judged in terms of economic cost as well as the supply limits.

1.8.1.2 Manufactured Capital (MC)

Manufactured Capital includes: all goods produced through economic processes including innovative technologies, machines, buildings, factories, tractors, roads, managerial services such as use of technologies for planting, spacing, culling, fertilizers, control of plant disease etc. Manufactured Capital and Renewable Living Resources are complements and not substitutes.

1.8.2 Basic Problems in Valuing Natural Systems

Both the mainstream ecologists and environmental economists now recognize that valuation of a natural system, its biodiversity and functional attributes are fundamentally important, since it is through their proper valuation that natural systems can be conserved and a policy aimed at balanced economic use of its goods and services can be developed (Ehrlich and Wilson, 1991; Pearce, 1996).

Difficulties in valuing ecosystems and their products arise from differing perspectives of various disciplines that hamper a unified or integrated approach. To the ecologist the structural and functional attributes are the basis for valuing the ecosystem. For the economist values are determined in accordance with human behaviour, response and choices, which in turn are determined by what the people are willing to pay to maintain or restore an ecosystem. The social value of an ecosystem is determined largely by the political process, and through its consequences to the community (Haq, 1997).

Also there are other considerations, such as rights, obligations and moral values economic cost is not a matter of more money (Pearce, 1996).

1.8.3 Economic Approach to Resource Valuation

Three main purposes of economic valuation of environmental goods and services can be identified.

To provide estimates of economic value or benefits of natural assets in the absence of a market and an adequate basis for their effective management. Implicit in this approach is the idea of protection of the rights of both the present and future generations.

On the basis of cost benefit analysis, to provide environmental and economic justification for alternative uses of a natural resource to support development activities (e.g. conversion of mangrove for shrimp farming, forest into crop land / grass bed, or grassland into an industrial base etc.)

To provide options and alternatives for remediating the negative impacts of human actions on the environment and its valued resources, not only to ensure long term benefits of environmental goods and services, but also to assist in decision making process (e.g. pollution, degraded ecosystem etc.)

During the last decade, a significant contribution for environmental evaluation has come from environmental economists. Environmental goods and services have functional values, which provide economic services. De Groot (1994) identifies twenty three functions of the environment divided in to three categories.

- regulatory functions
- production functions

- carrier functions

1.8.4 Economic Values of Coastal Ecosystem

A use value (UV) is a value that arises from the use of productive functions of natural systems. Three categories can be differentiated.

- direct use value (DUV)
- indirect use value (IUV)
- option value (OV)

A direct use value (DUV) refers to actual use of extractive materials (fishing, mariculture, wood, products of food value, pharmaceutical, genetic material, minerals, tidal and wave energies, industrial products etc.) which serves as production input for use through economic processes and thus have market values and non-extractive resources which provide benefits that individuals derive by the use of services provided by the coastal systems for (eg. recreation) through visits and contacts with the resource (Barton, 1994, Turner *et al.*, 1993, Hoagland *et al.*, 1995). This category of direct use requires non-market approach to valuation.

An indirect use value refers to the benefits derived by individuals from the various functions of the natural systems (eg. coastal defence from storm surges, salt water intrusion and flood control, protection of coastal ecosystems/habitats, breeding and nursery grounds and sanctuaries of species of commercial importance, other adjacent wetlands and forests, assimilation of wastes/pollution generated from various sources so as to maintain the health and integrity of the ecosystems, and human settlement).

An option value is the value that individuals might place on the expected benefits from conservation of a system or a certain component (eg. species, biodiversity, marine reserve, coastal resort) and are willing to pay to preserve access to and use of the resource at a later date. For example, research may lead to discovery of medicinal value of a plant. Some environmental economists use an additional sub-category of option value, the quasi-option value which is a value of information gained by delaying a decision to proceed with uses of marine resource, referred to in option value, which may result in irreversible effects.

The non-use value (NUV) is rather problematic as it is intrinsic in nature and is not associated with direct use, not easily quantifiable in economic terms. An existence value (XV) is a value that individuals may be willing to pay for establishing a resource (e.g. threatened reef habitats, endangered species, aesthetic sites) even though the individual is certain that the resource will not be visited or used. A Bequest value (BV) is a value that individuals are willing to pay for the satisfaction of preserving a particular resource for future generations (e.g. species habitat, way of life connected to traditional uses) (Turner *et al.*, 1993, Barton, 1994, Hoagland *et al.*, 1995).

The total economic value (TEV), used in the sense of benefits of environmental goods and services, is expressed by a simple formula following Pearce (1996) as follows.

$$TEV = UV + NUV = (DUV + IUV + OV) + (XV) + (BV)$$

The net economic value is then equivalent to TEV minus the other costs that are incurred due to damage caused to the environment and resources.

1.8.5 Economic Methods of Valuation

A number of analytical procedures have been developed by the environmental economists to evaluate unmarketed environmental goods and services (Dixon *et al.*, 1992, Winpenny, 1991, Turner *et al.*, 1993, Pearce and Morgam, 1995, Barton, 1994).

1.8.5.1 Effect On Production method (EOP)

EOP method is designed to measure the effects of an activity on output, cost and profitability of procedure through its effect on the environment. It is often based on damaged function approach, which is, in turn, based on ecological data.

1.8.5.2 Contingent Valuation Method (CVM)

CVM involves the use of a number of techniques for collection of information through questionnaires to evaluate a hypothetical problem relating to the environmental goods and services, whose value cannot be measured directly. It is based on public willingness to pay or to accept. There are several constraints in using this method in developing, countries including, uneven income distribution, lack of proper knowledge or information on the part of respondents to assess the value of goods or environmental quality, and often the lack of appropriate ecological data that are intelligible to people locally.

1.8.6 Ecological Input for Economic Valuation

Considerable progress has been made in defining the needs for valuation of natural environment and natural resources (Pearce and Morgam, 1995, Barton, *1994*). Ecological studies have advanced to a level where they can provide measures of productivity of the coastal ecosystems and the critical role of biotic

and abiotic variables in maintaining the integrity of the system as a whole (Odum, 1975, Odum, 1988).

Integrated Coastal Zone Management is a dynamic process in which a coordinated strategy is developed and implemented for the allocation of environmental, socio-cultural and institutional resources to achieve the conservation and sustainable multiple use of the Coastal Zone.

Objectives of ICZM are

- to increase benefits to be derived from resource or non-resource use of the Coastal Zone
- to minimize detrimental effects on the marine environment
- to reduce conflict of use situations

In order to achieve these objectives, it is imperative that we adopt certain principles that are consistent with the philosophy of Sustainable Development (WCED, 1987).

1.9 GIS Applications

The development and implementation of integrated coastal management policies are now established and internationally recognized as ideal but the tools and methodologies for achieving such goals are still very much under development. It is clear, however, that for any management of the shore to be effective, it is necessary for the policies to be based on informed decision-making. This in turn requires ready access to appropriate, reliable and timely data and information, in suitable form for the task at hand. Since much of this information and data is likely to have a spatial component, one branch of information technology with the apparent potential for contributing

significantly to coastal management, is Geographical Information Systems (GIS).

Geographical information is vital to the functioning of modern society. Its availability and use is essential for almost all decisions concerning infrastructure development and maintenance, trade, and a large number of other socio-political and economic matters relating to territorial administration. However geographical information is of use only if it is reliable, timely, accurate, appropriate, and presented to the right person at the right time and in the right manner. Under such conditions, geographical information becomes a resource, of great value to an organization whereas, if such conditions do not prevail, then the same information will be worthless or may even become a liability.

Computer-based geographical information systems (GIS) are increasingly being used in order to assist the process of capturing spatial data, storing and retrieving them, processing relevant information from them, and making this information available as required. The use of GIS, therefore, has great potential to optimize the value of information as a resource within an organization. Besides all of their utility and cost-effectiveness, currently available GIS still present significant weaknesses with regard to a few important areas of application. These limitations may arise through any combination of a number of factors, including: lack of awareness of the possible uses of GIS within certain sectors; problems over the supply and availability of suitable data for processing; technical problems relating to GIS hardware or software; and the inadequacy of appropriate discipline-oriented concepts and theoretical frameworks against which the GIS is expected to operate.

1.10 Coastal Zone Information and the Role of GIS

The application of GIS technologies and methods to problems of coastal zone management (CZM) embodies many of these difficulties. Despite all these limitations, GIS can be a useful tool for the solution of most of the coastal issues (Bartlett, 1993c). Examination of the literature relating to information processing, as well as that from the coastal sciences, reveals a paradox. On the one hand, there is clearly an interest in, and a demand for, automated tools to assist in processing coastal data; and yet, despite at least twenty years of sporadic effort, this need has still not been adequately resolved. Many important difficulties and impediments remain before operational GIS are used as a matter of routine for coastal management. Bartlett (1990, 1993b) has suggested that many of these difficulties arise because of the inherent nature of the coastal zone. Current GIS are optimized for dealing with terrestrial data, and most coastal data have quite different characteristics and processing requirements. Thus, he argues, development of truly effective GIS applications for coastal zone information-handling probably requires a return to first principles, and construction of dedicated coastal zone information systems.

The benefits that might result from applying GIS-related technologies to coastal resource management have been discussed in a number of physical and administrative contexts, over at least two decades. One of the earliest references encountered in the literature is that of Ellis (1972) who suggested the need for a coastal zone information system which relates data, information, predictive techniques, environmental interactions, methods of analysis and applications into one system of procedures, tools and instructions for use by planners. More recently, the topic has received the attention of Bartlett

(1990), Clark *et al.* (1990), Law *et al.* (1991), Frederiksen *et al.* (1991), Michener *et al.* (1989) and Coleman *et al.* (1991) among others. A number of national and international agencies have also started to conduct investigations into these areas. The International Geographical Union, through its Commission on Coastal Systems, has for some years been sponsoring a project aimed at investigating and promoting the use of GIS for coastal management purposes; while more recently the Marine Cartography Working Group of the International Cartographic Association has also started to investigate the topic.

GIS have the potential to contribute to coastal management in a number of ways. These include:

The ability to handle much larger databases and to integrate and synthesize data from a much wider range of relevant criteria than might be achieved by manual methods. This in turn means that more balanced and co-ordinated management strategies may be developed for considerably longer lengths of coast; GIS encourages the development and use of standards for coastal data definition, collection and storage, which promotes compatibility of data and processing techniques between projects and departments, as well as ensuring consistency of approach at any one site over time.

The use of a shared database (especially if access is provided via a data network) also facilitates the updating of records, and the provision of a common set of data to the many different departments or offices that might typically be involved in management of a single stretch of coast. A shared database implies reduction or elimination of duplicated records, and thus the potential for significant economic savings as well as improved operational efficiency.

As well as providing efficient data storage and retrieval facilities, GIS also offers the ability to model, test and compare alternative management scenarios, before a proposed strategy is imposed on the real-world system. Computer technology allows the consideration of much more complex simulations; their application to very much larger databases; and also enables compression of temporal and spatial scales to more manageable dimensions.

It is very difficult to define boundaries of the coastal zone, or of the entities that may be recognized as lying within it. The coast is, nevertheless, a distinct part of the earth's surface, and is comprised of a multitude of objects that may, with varying degrees of precision, be described according to criteria of location or position. Thus, coastal information is a particular class of geographical information and it is only natural that there should be interest in the potential gains to be obtained by applying geographic information systems technology to coastal problems.

Even before the advent of integrated GIS, computers were being used for handling coastal data. Many of these early applications used isolated computer programs intended to perform specific, limited tasks with coastal data. Examples include simulation modelling of coastal processes such as sediment transport or ocean wave behaviour (Komar, 1983; Weyl, 1986; Neilsen 1988); the use of automated data loggers, as well as satellite and airborne imagery and associated remote sensing techniques, for capturing coastal data (TRRU, 1977, Loubersac and Populus, 1986; Pitchel *et al.*, 1991); the application of Computer-Aided Design (CAD) packages for designing civil engineering structure for the coastal zone (see, e.g., discussion in Clark et al, 1990); and the

use of computer-aided cartography (Carter, 1976; Mauriello, 1991) for coastal map and chart production.

While all of these types of application may overlap with, and may most certainly contribute to, the mainstream of geographic information systems, by most accepted definitions (e.g. Cowen, 1988; Maguire *et al.*, 1991; Dangermond, 1991); they do not constitute GIS in themselves. Nowadays, there is general consensus that a GIS is an integrated system comprising computer hardware and software, plus appropriate data and concepts and, according to some definitions, the users of the system and their organizational context. The purpose of such a system is the capture, storage, management, retrieval and processing of structured, spatially-referenced data, and generation of output from such manipulations in a variety of ways including graphical, statistical and tabular formats, in response to the requirements of the user. Like any other system, a GIS is bound together by unifying concepts (in this case including the concept of 'geography'), and the system as a whole acquires a synergy through this integration that would generally be lacking in a disorganised collection of separate software programs.

Examination of the literature shows that, particularly in the early pioneering days, the term 'coastal zone information system' (CZIS) is used to refer to applications of GIS and related information technology for coastal management purposes. For the purposes of the present paper, the term CZIS will be used to refer to any GIS application whose primary emphasis is to process information and data relating specifically to the coastal zone, irrespective of whether the system is based on bespoke software or on the application of commercial packages.

1.11 Objectives and Scheme of the Thesis

The present study focuses on the stability of the coast, exploitation of the coastal resources, human activities within the study area (extends from Fort Cochin at north to Thottappally at south, central Kerala State) and hinterlands, socio-economic problems of the coastal community and the environmental issues arising in the recent past due to human activities. The objective of the study is to critically analyse the coastal zone region and prevailing situation and to propose a comprehensive management plan for the sustainable development of the region under study.

To quote a few examples, the thesis covers varied aspects of coastal uses like fisheries, tourism, land use, water resources etc. To critically examine the above scenarios, the ILWIS (Integrated Land and Water Information Systems) – GIS software has been used. A satellite image of the area has been used for the coastline change detection and land use patterns. The area has been well visited and relevant data on the study parameters collected – also taking recourse to Kerala State Planning Board documents. The synthesis of the data brings out the impacts due to population growth, accelerated aquaculture development, (mis)management of water resources and lot more. The GIS tool has provided valuable analytical clues to the study and was helpful to visualize the problems and suggest management plans.

The doctoral thesis consists of five chapters. In chapter 1, a detailed description of the coastal zone and management approaches are given apart from the general introduction to the topic. A review on the various aspects of coastal zone management programme based on an analytical perspective is also presented. The theoretical approach to the problem and the methods of

observation, sampling and analyses of various data collected are given in chapter 2. The analyses of the data with salient features are included in chapter 3 titled as the Coastal Zone of Central Kerala. Chapter 4 deals with coastal regulation zones, its implications and details the management policy approaches. This chapter also addresses the Country's national coastal policy and guidelines along with critical appraisal of the study region and suggests future outlooks. Opportunities and issues are dealt in depth stating major interventions while considering separately port operations and the fishery sector in respect to coastal zone management and also the means to correct non developmental approaches. Chapter 5 deals with the summary and conclusion of the present study providing an extensive insight into the elements that are required for the preparation of management plans for this part of the coastal zones.

The outcome of the present study will be beneficial to the various stakeholders within the coastal region and its hinterlands. To further add, this study should find better applications to similar or near-similar situations of Southeast Asia where identical scenarios are noticeable.

Chapter 2

MATERIALS AND METHODS

2.1 Area of Study

The Kerala State comprises a narrow strip of land with an area of 38863km^2, extending between 08°17'30" and 12°27'40"N and 074°51'57" and 077°24'47"E (Fig. 1). The Western Ghats on the east and the Arabian Sea on the west are the natural boundaries of the State, providing distinctive physical features. The shape of Kerala resembles a scalene triangle with its base on the long coast (560km) and its apex on the Western Ghats. Width of the State ranges from a minimum of 11km to a maximum of 124km.

Based on the detailed study of the physiographic and slope maps, the State can be classified into five physiographic zones. These are the mountain peaks above 1801m, the highlands at altitudes of 601-1800m, the midlands at altitudes of 301-600m, the lowlands at 11-300m and coastal plains and lagoons at 0-10m, with respect to mean sea level.

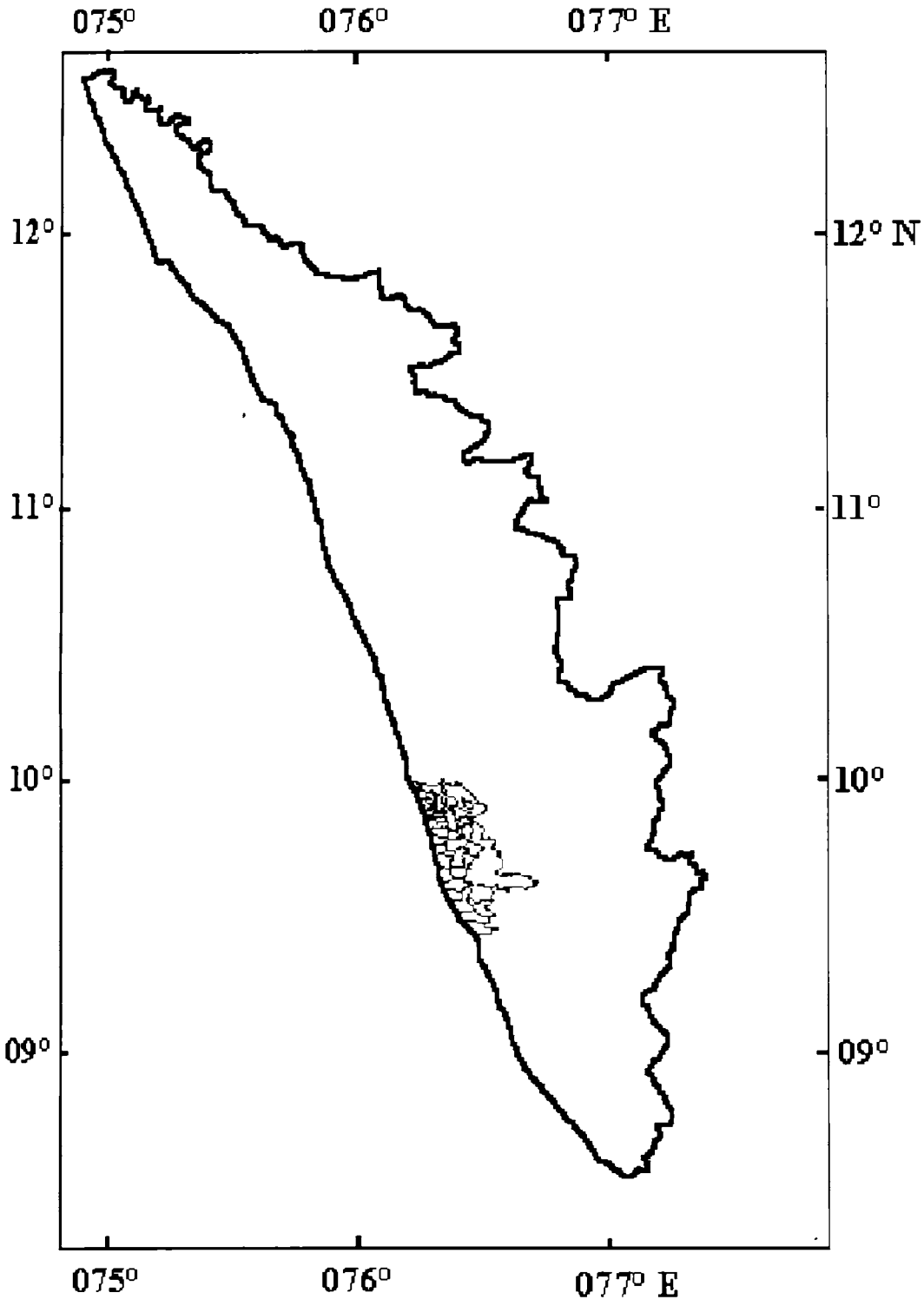


Fig.1. Map of the State of Kerala showing the region selected for this study.

Elevation (m) with respect to MSL	Physiographic Unit	Area (%)
>1801	Mountain Peaks	0.64
601-1800	Highlands	20.35
301-600	Midlands	8.44
11-300	Lowlands	54.17
0-10	Coastal plains and lagoons	16.40

2.1.1 Mountain Peaks

The land extends 563km from north to south, but varies in width from 122-10.2km. Next to the Arabian Sea is a narrow, flat coastal plain, immediately behind are rolling hills and winding river valleys. The elevation gradually rises to 2695m at Anai Mudi, the highest mountain in south India. Most of the eastern boundary is marked by hill ranges of the Western Ghats.

2.1.2 Highlands

The highlands form an important physiographic province. From the extreme north, the ranges run parallel to the coast as far as Vavalmalai to the east of Kozhikode.

2.1.3 Midlands

The undulating western fringe of the highlands and the rocky spurs projecting westward and parts of the crustal breaks form the midland region. While the midlands constitute most of the eastern parts of Kannur district, their area shrinks towards the west of Wayanad plateau where they occupy a narrow strip, coinciding with the steep slopes. From the west of Nelliampathi plateau

to the north of the Cardamom hills, the elongated spurs separated by extensive ravines are seen to merge with the relatively gentler slopes of the lowlands.

2.1.4 Lowlands

The area falling under the altitudinal ranges of 11-300m and consisting of dissected peneplains constitute the lowlands. The altitudinal range is quite asymmetric with the maximum area of 54.17% falling within this unit. Numerous food plains, terraces, valley hills, colluviums and sedimentary formations are parts of the lowlands. In the northern and southern parts of the State, this unit merges with the coastal plains with discernible steeper slopes than in the rest of the State.

2.1.5 Coastal Plains and Lagoons

This unit is important in terms of economic activity and demographic distribution. It constitutes 16.4% of the area of the State. Most of the area shows relief of 4 to 6m above mean sea level. Beach dunes, ancient beach ridges, barrier flats, coastal alluvial plains, flood plains, river terraces, marshes and lagoons constitute this unit. It has the maximum width in the Alleppey and Aluva - Kaladi regions. A characteristic feature of this unit is the existence of numerous beach dune ridges, parallel and sub-parallel to the coast, especially in the Alappuzha-Cherthala regions. Their orientation indicates that the strandlines belong to at least two ages, and the maximum width between the oldest and the youngest, close to the present shoreline which is 18km.

About 360km of this 590km coastal stretch is vulnerable to coastal erosion. The outbreak of the SW monsoon throws the beach into a dynamic mode with active erosion of the coast in different stretches. The low lying coastal tract is

largely made up of recent unconsolidated sediments. Apparently, nature of the sediments is an important factor in agraving the process of erosion because relative stability is evident in the semi consolidated and impermeable process. Various studies of the State PWD have shown that a belt of 600m of land is lost due to coastal erosion in just over a century (Erattupuzha and Varghese, 1980).

The coastal plain of Kerala has a few scattered hill rocks with rocky cliffs. In this area there are 34 lakes. These lakes provide ample scope for inland vegetation. In spite of so many rivers discharging into the sea at various points, no major delta has been formed anywhere. Certain sections of the coastal plain, particularly between Cochin and Alleppey, contain a series of parallel to sub parallel sand dune ridges.

Kerala coast experienced transgression and regression of the sea in the recent past. Even today, sections of this coast are affected by severe erosion. The continental shelf bordering the Kerala coast varies in width and depth. It appears to be widest west of Kollam.

A number of parameters contribute to the problem of coastal erosion and they include:

- Oceanic elements (tides, waves and alongshore currents)
- Atmospheric forces (wind and monsoonal rains)
- Various geological processes (nature of the sediments, imbalance of littoral nourishments, sea level rise and neotectonism)
- Biotic factors

2.2 Drainage

The drainage network of Kerala consists of 44 short and swift-flowing rivers. Out of these, 41 flow westward and 3 eastward. The general drainage pattern of the state is dendritic. At places, it is sub parallel and radial. Most of the rivers are structurally controlled and follow conspicuous lineaments, the general directions being NW-SE and NE-SW.

The study of gradients of some selected rivers indicates that the coastal plain extends far more eastward in the central part than in the northern and southern parts of Kerala. It is evident from the extension of high gradients to large distances from the sources of some rivers that they are in the youthful stage. The reduction in the water discharge during summer season makes navigation difficult as well as increases the salinity of the river water. Consequently, the drinking water wells, crops in the low land and near water bodies are also affected. A number of canals interconnecting lakes were excavated for navigation purposes.

2.3 Geology

The state shows four major rock formations.

- Quaternary sediments
- Laterite developed on crystalline and sedimentary rocks
- Sedimentary rocks (Cenozoic)
- Crystalline rocks (Precambrian)

Occurrence of sedimentary rocks belonging to Cenozoic age is found as discontinuous outcrops along coastal Kerala. This includes the Kollam and

Varkala beds (Mio-pliocene). These are found to extend to the offshore part of Kerala. Quaternary is represented by laterite, soil, alluvium etc.

Kerala coast is remarkably straight with a NNW-SSE trend to the Western Ghats. Gravity studies in the Kerala offshore (ONGC, 1968) indicate two gravity highs separated by a gravity low between Cochin and Alappuzha. The recent reactivation of the NNW-SSE trending faults presumably associated with the Western Ghat upliftment is thought to be responsible for foundering a greater part of the offshore basin of Kerala and shaping the present coastline (Varadarajan and Madhavan Nair, 1978). Since the ENE-WSW trending lineaments/faults are extending into the Mio-Pliocene sedimentary beds and displaces other trends they are considered to be the youngest (Prabhakar Rao *et al.*, 1985). The strike-slip component of the youngest lineaments cutting across the coastline at a number of places leaves rocky promontories (Nair, 1990). The neotectonic movements along the fault (Vaidyanathan, 1977) rendered the coastal belt unstable. According to Chatterjee (1983), the development of Kerala coast is due to the combination of both neotectonism and eustatic changes. The evolution of the Kerala coast is largely arrested due to the Holocene transgression since the coastal lagoons and estuaries are the sink of the sediment load from the hinterland.

2.4 Physiography

The peninsula is the oldest land mass and the present land features have been formed by the denudation and weathering of this land mass over a long period. Physiographically, the state is divided into three regions

- The highland region in the east consisting of the forest of Western Ghats, the important peninsular mountains and its slopes

- The midland region
- The lowland region in the west

These three regions run nearly parallel to each other from one end to the other. The land forms are mainly structural, denudational, marine and fluvial.

The high land is confined to the eastern portion. The range in elevation is 1000 to 2500m above MSL. The lowland is a strip of land having level topography running along the coast and is not more than 30km in width at any point. It is characterised by marine land forms. In several places they are liable to be flooded during monsoon. The elevation generally observed in the midland is below 100m above MSL. The soil here is mainly lateritic.

The state is drained by many streams and rivers. Out of the 44 rivers in the state, 41 are west flowing. Because of the undulating topography, most of the areas enjoy a good drainage system except the low lying areas.

2.5 Climate

The state enjoys a humid tropical to humid temperate climate with alternate wet and dry periods. The annual precipitation is around 3000mm distributed in two spells, the southwest monsoon and the northeast monsoon. The former sets in by the end of May and continues up to September. The latter commences towards the end of September and continues up to November. Maximum rainfall is obtained during the southwest monsoon. The diversity of physical features results in corresponding variations in climate.

The mean annual temperature of the state is 27°C. The mean minimum temperature varies between 19 to 20°C and the mean maximum 27 to 37°C. Heavy rainfall coupled with tropical climate is responsible for the high

humidity throughout the year. The average annual humidity is 70%. Moderately good spread of monsoon and relatively low variation in monthly temperature during the year permit the cultivation of wide variety of crops throughout the year.

The soil found in this area is generally coarse grained, highly porous with limited capacity for retaining water and fertilizers. This comes under the soil class Grayish Onattukara. These soils are acidic and are extremely deficient in major plant nutrients. Additions of sufficient organic matter and irrigation facilities improve the water holding capacity for cultivation of paddy, tapioca and other seasonal crops in addition to coconut.

2.6 Field Survey

Periodic field surveys were conducted in the study area and data were collected on various parameters (Fig. 2).

Seasonal beach profiling was carried out at regular intervals for monitoring the stability of the coast. Ground water samples were collected along the entire coastal stretch within the region and were analysed. Ground Control Points (GCP's) were also collected for geometric correction of the satellite imagery.

Secondary data on terrain features, agriculture, fisheries, land use changes, population and other parameters important in the coastal zone were collected from Kerala State Land Use Board.

2.7 A brief on rainfall, temperature and relative humidity

Fig. 3 provides the mean monthly rainfall distribution pattern for the study area. As expected, June-July months followed by a secondary peaks in

THE STUDY AREA

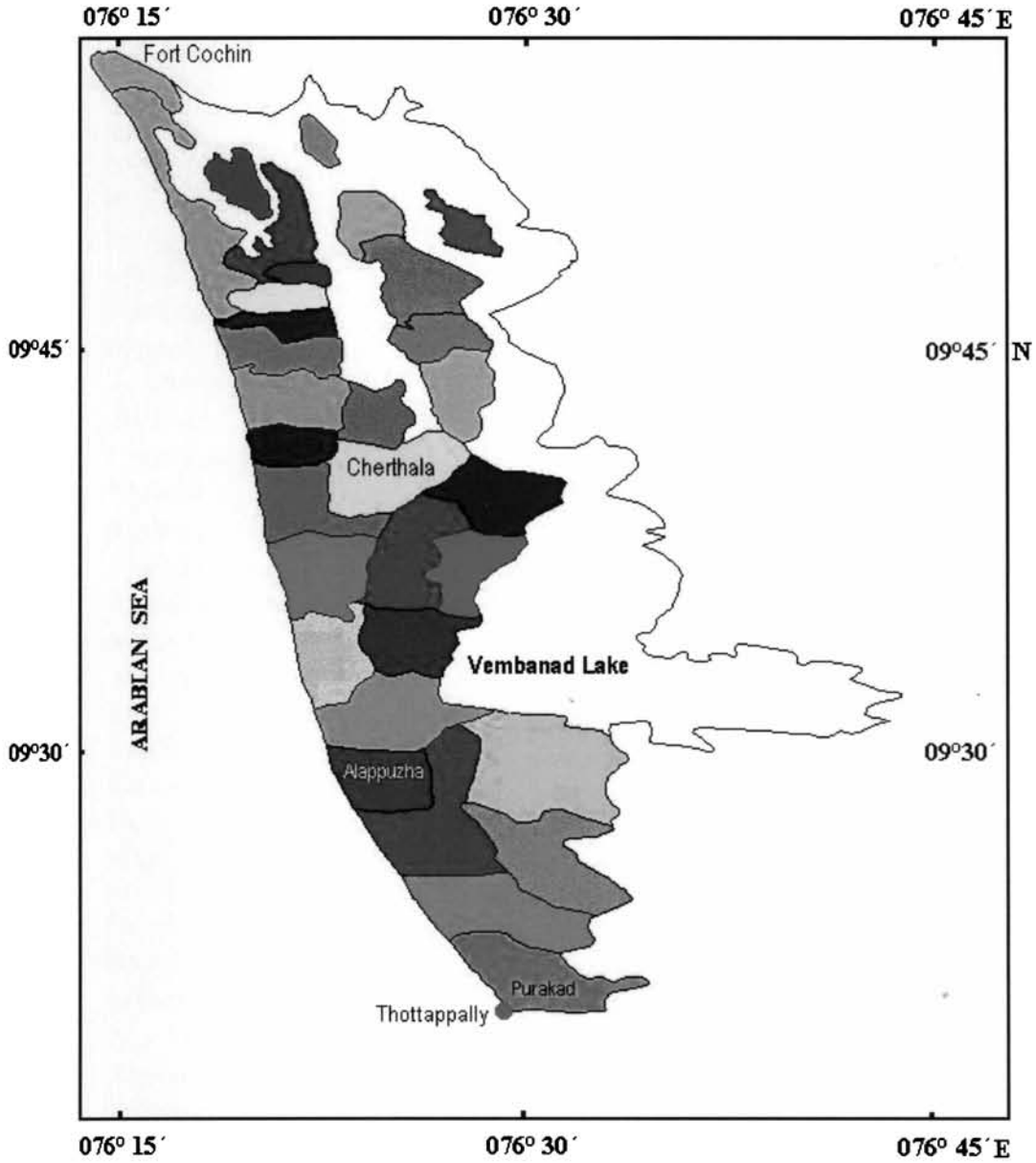
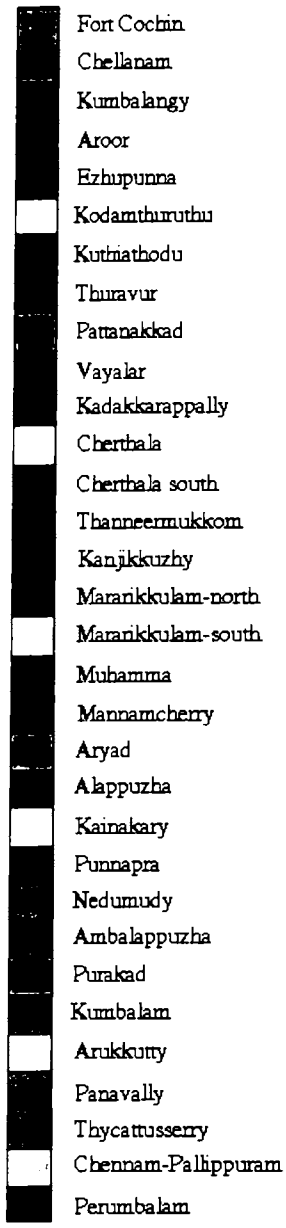


Fig. 2. Location of study area. Over leaf, the list of panchayaths by name against colour coding is provided.


Fort Cochin
Chellanam
Kumbalangy
Aroor
Ezhupunna
Kodamthuruthu
Kuthiathodu
Thuravur
Pattanakkad
Vayalar
Kadakkarappally
Cherthala
Cherthala south
Thanneermukkom
Kanjikkuzhy
Mararikkulam-north
Mararikkulam-south
Muhamma
Mannamcherry
Aryad
Alappuzha
Kainakary
Punnapra
Nedumudy
Ambalappuzha
Purakad
Kumbalam
Arukkutty
Panavally
Thycattusserry
Chennam-Pallippuram
Perumbalam

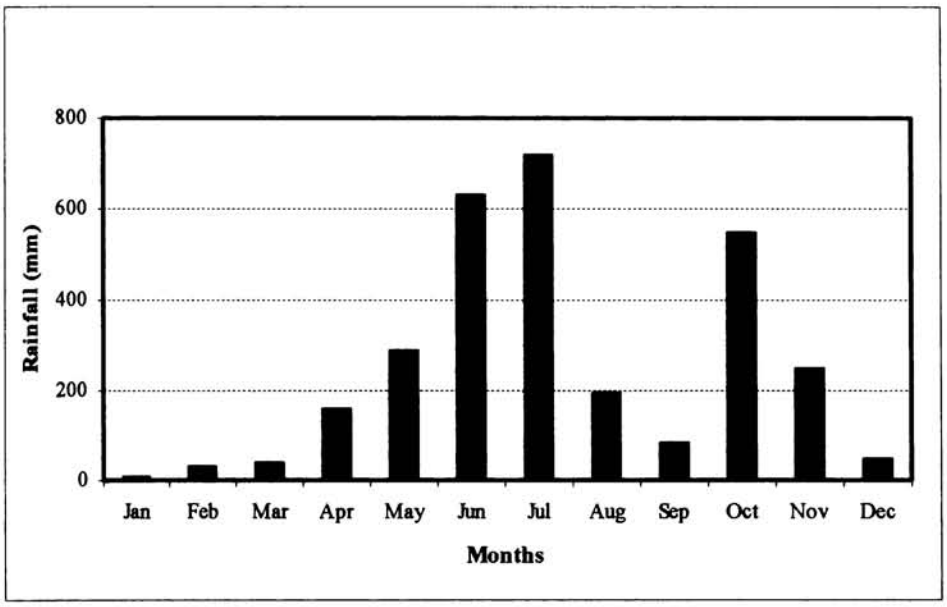


Fig. 3. The mean monthly rainfall distribution over the study region.

October-November indicate the bimodal distribution of rainfall over this region. The values are in conformity with the general rainfall pattern of Kerala.

Fig. 4 provides the mean monthly temperature over the study region averaged over a decade (also applicable to data in Fig. 3 and Fig. 5). A small decrease of 2-3°C as expected during the monsoon months has been recorded in this chart. The variations between the maximum and minimum values are more pronounced during November-February period.

The mean monthly relative humidity plotted (Fig. 5) for the study region at 0800 IST and 1730 IST brings about the changes on a seasonal basis. In conjunction with monsoon rainfall, the humidity values pick up and the morning-evening disparity is much reduced. During winter, though the morning values are around 80% where as by evening it falls in the range 65-75% range. Being a coastal region, the high values are obviously on the higher side.

2.8 IRS-1D LISS-III Data

IRS-1D is the second of the second generation Indian Remote Sensing satellite missions with improved resolution, coverage and revisit. This satellite is placed in a near circular, sun-synchronous, near polar orbit at a mean altitude of 780km and has three sensors on board.

i. Panchromatic camera (PAN)

ii. Linear Imaging and Self Scanning Sensor (LISS-III)

iii. Wide Field Sensor (WiFS)

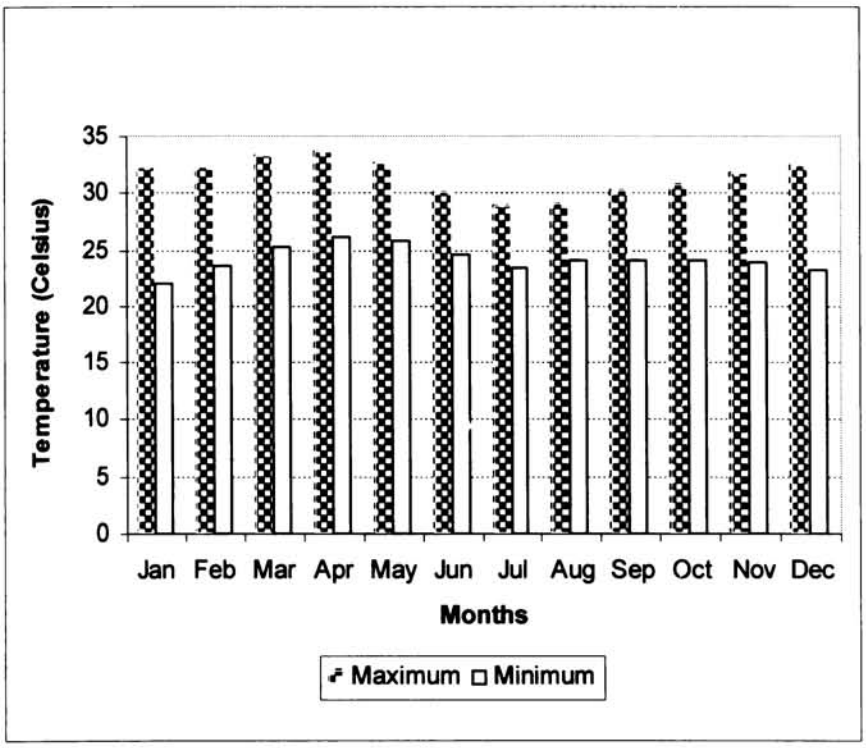


Fig. 4. The mean monthly temperature distribution over the study region.

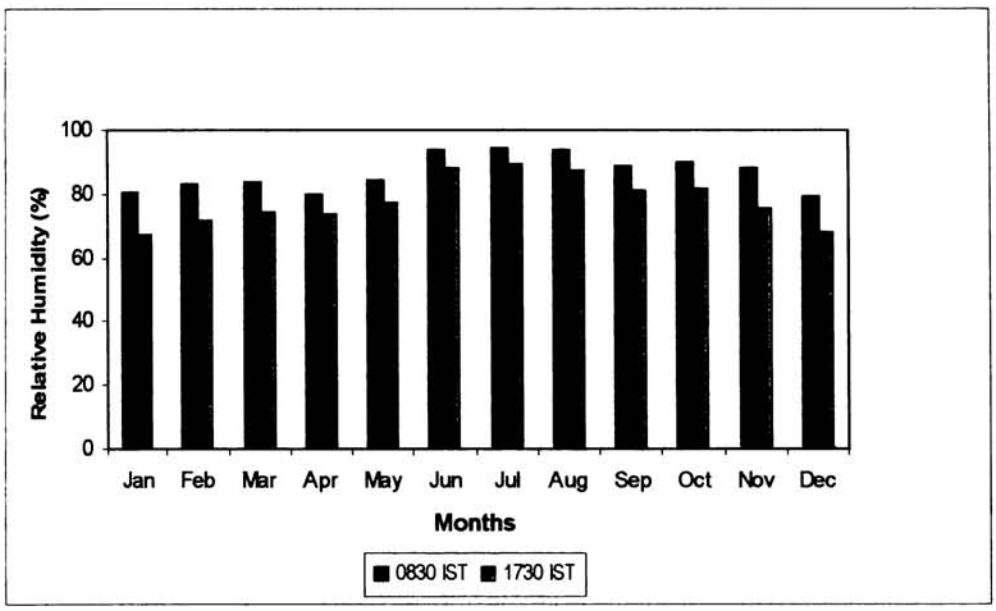


Fig. 5. The mean monthly relative humidity distribution over the study region.

The LISS-III sensor provides multi-spectral data collected in four bands of the visible and near infra red regions with a spatial resolution of 23.5m. LISS-III imagery was used for coastline change detection in the present study (Fig. 6).

2.9 Software used

The following satellite image processing and GIS software were used for the preparation of attribute maps presented.

2.9.1 ILWIS (Integrated Land and Water Information System) version 2.1

ILWIS is a Windows-based, integrated GIS and Remote Sensing application developed by the International Institute for Aerospace Survey and Earth Sciences (ITC), Netherlands. ILWIS functionality for vectors includes digitizing, interpolation from isolines, calculation of segment intensity and pattern analysis. Its functionality for raster includes distance calculation, creation of Digital Elevation Model (DEM), deriving attribute maps and classifying maps.

2.9.2 ENVI Version 3.4

ENVI (the Environment for Visualizing Images) is an image processing system developed by Research Systems, Inc., United States. From its inception, ENVI was designed to address the numerous and specific needs of those who regularly use satellite and aircraft remote sensing data. ENVI provides comprehensive data visualization and analysis for images of any size and any type - all from within an innovative and user-friendly environment. ENVI combines file-based and band-based techniques with interactive functions. When a data input file is opened, its bands are stored in a list, where they can be accessed by all system functions. If multiple files are opened, bands of

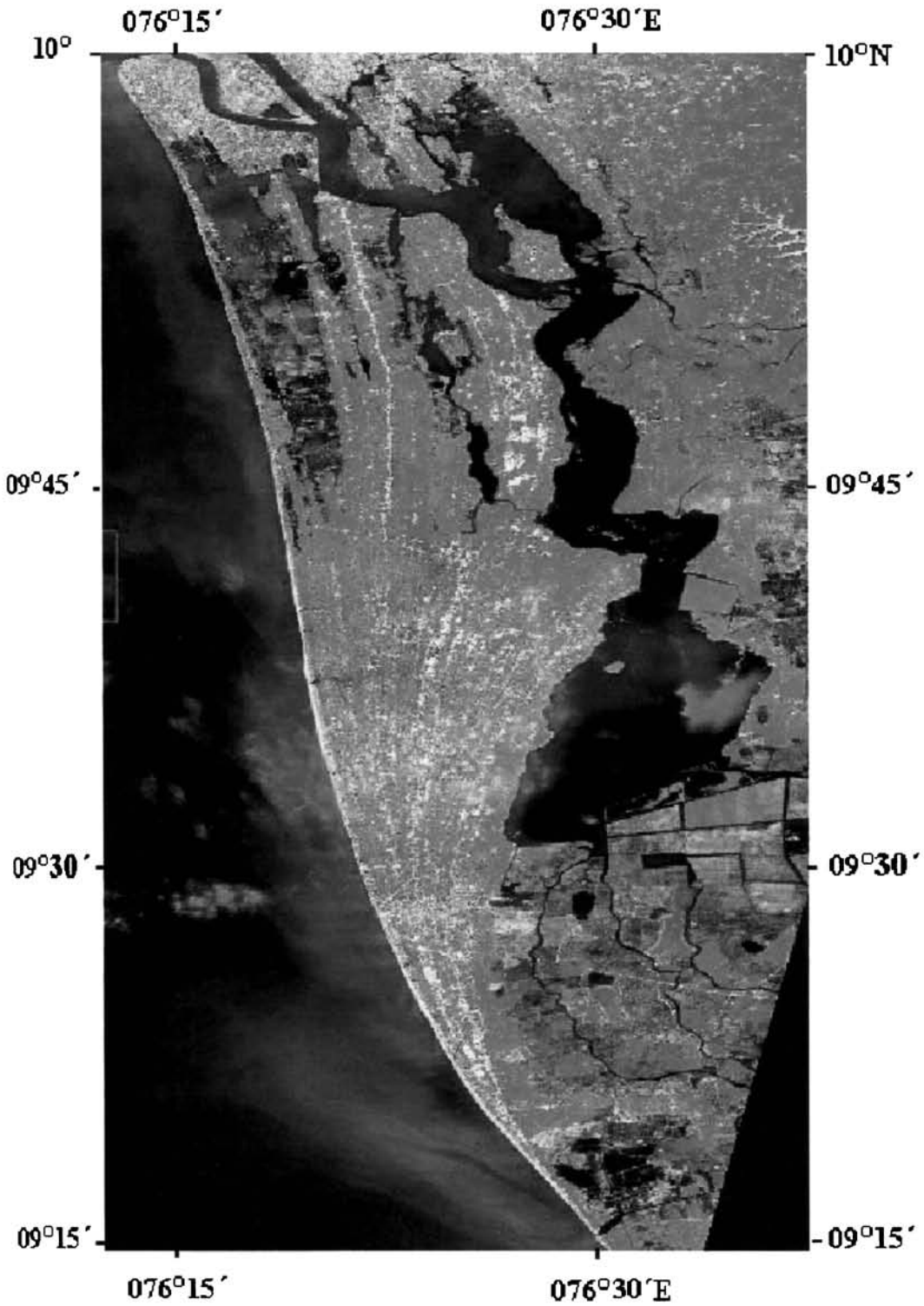


Fig. 6. LISS-III imagery of the Study region.

disparate data types can be processed as a group. ENVI displays these bands in 8- or 24 - bit display windows.

2.10 Methodology

The geographical map of the study area has been digitized using the GIS software ILWIS. Data on various parameters were incorporated into the system and attribute maps were prepared for various parameters. The attribute data on various parameters such as demographic data, climate elements, agricultural pattern, fishery practices, land uses changes, water resources etc have been collected from Kerala State Landuse Board and Kerala Sasthra Sahithya Parishath (KSSP).

LISS-III imagery of the study area was geometrically corrected by using the GCP's collected. The geo-corrected image and the digitized layer of the study area were subjected to overlay analysis for coastline change detection and erosion and accretion areas were demarcated.

2.10.1 Coastline Change detection

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. It involves the ability to quantify temporal effects using multi-spectral data sets. One of the major applications of remotely sensed data obtained from satellites is change detection because of repetitive coverage at short intervals and consistent image quality (Anderson, 1977, Ingram *et al.*, 1981, Nelson, 1983, Singh, 1984). Change detection is useful in such diverse applications as land use change analysis, monitoring of shifting cultivation, coastline undulations, damage assessment, disaster monitoring etc.

The basic premise in using remote sensing data for change detection is that changes in land cover must result in changes in radiance values and changes in radiance due to land cover change must be large with respect to radiance changes caused by other factors (Ingram *et al.*, 1981). These other factors include differences in atmospheric conditions, sun angle and soil moisture (Jenson, 1983). The impact of these factors may be partially reduced by selecting the appropriate area.

In this study, the area map of 1995 and IRS 1D LISS III Imagery of 2002 were used for overlay analysis and coastline change mapping.

Chapter 3

THE COASTAL ZONE OF CENTRAL KERALA

3.1 State of Management of the Coastal Zone

Most of the cities and towns of the State of Kerala are concentrated in the coastal zone with a high density of population and the region under present study is not different in this respect.

Year	Population density (per km^2)	Land available per person (hectare)
1836	68	1.471
1875	130	0.769
1881	134	0.746
1891	150	0.667
1901	165	0.606
1911	184	0.543
1921	201	0.498
1931	245	0.408
1941	284	0.352
1951	349	0.287
1961	435	0.230
1975	549	0.182
1981	673	0.149
1991	747	0.134
2001	819	0.122

The table above indicates population density and the land available per person for different years starting from 1836 for the state of Kerala which is not going to be much different for the study area. Conspicuous is the pressure that develops on any given coastal environmental region due to more than eight hundred persons occupying one square kilometre of land. More specific details are provided on a GIS platform in the following pages.

Translated in simple terms, this indicates in the actual number of people occupying physical space along with paraphernalia like households, means of transport, communication links, sewage networks and such other basic amenities. Comparing to a scenario when the population density was half the present number, some fifty years back, it is evident from experience of generations of that time, speaking of cleaner air, cleaner water and physical space for all human activities. A pertinent question in this context is the upper limit to the increasing densities when sustainability will no longer be of any concern or the very process of population dynamics would commence counter action with increasing number of commutable diseases, unhealthy surroundings, resource crunch and socio-economic and cultural conflicts. To add, the present natural settings do not afford opportunities to progressively enhance and sustain such trends in population growth.

The study area extends from Fort Cochin at North to Thottappally at south over a distance of 80 km (Fig. 2). The Arabian Sea is the western boundary and the Vembanad Lake lies on the east. This narrow stretch of land comes under the physiographic division of coastal sandy zone. The alluvial deposits of sand and clay are found on either side of the rivers and palaeo channels. Paddy had been the major crop in this area while the elevated portions supported coconut

palms. The marshy area around Alappuzha are being reclaimed and brought under cultivation. Similarly the fringe areas of the lagoons all along the coast are being reclaimed for cultivation purposes. In areas with marine sands under the alluvial deposits, the traditional practice had been to remove the top soil, heap them conveniently and use the underlying fertile soil for rice cultivation. This method of cultivation is extensively in vogue in the Alappuzha-Cherthala belt. During the rainy season, these areas are prone to inundation and consequent destruction of crops. So these areas are presently being left uncultivated.

Swamps have developed in the river banks within the coastal belt which are covered by grass. The soil is saline in areas adjacent to the sea and coconut is being cultivated in such areas. In areas of thick settlement, the natural vegetation includes Punna (Calophyllum Inophyllum), Murikku (Erithrinia Indici) and Kattadimaram (Casurina Equiselifes).

This coastal belt is one of the heavily populated areas of the world and a large number of small and medium scale industries are located in this region. It is endowed with renewable resources like surface water, ground water, agriculture and fishery. The non-renewable resources include the mineral rich sands, soil and shell deposits in the backwaters and the swampy areas. The marine fisheries production in the coastal zone of Kerala is estimated to be about 23% of the country's total production to which this coastal stretch also contributes richly. By way of exports of marine products, Kerala earns about 41% of the total national exports. The mudbanks which form along the coast during the southwest monsoon period contribute substantially to the fishery production though definite percentages of them vary widely.

The density of population in this region is higher compared to other parts of the state, which necessitated large scale housing development. The infrastructural facilities are not met to fulfil the needs of the people. The bulk of the state's wood and clay based industries, fish processing units, boat building yards and minor ports are situated in this zone.

The study area, covering thirty Grama Panchayaths, two Municipalities (Cherthala and Alappuzha) and the Fort Cochin region of the Corporation of Cochin, is divided into four zones (Fig. 7). The following table provides the details.

Zone-A	Zone-B	Zone-C	Zone-D
Fort Cochin	Cherthala Municipality	Alappuzha	Kumbalangy
Chellanam	Cherthala-south	Kainakary	Kumbalam
Aroor	Thanneermukkom	Punnapra	Arukkutty
Ezhupunna	Kanjikkuzhy	Nedumudy	Panavally
Kodamthuruthu	Mararikkulam-north	Ambalappuzha	Thycattusserry
Kuthiathodu	Mararikkulam-south	Purakad	Chennam-Pallippuram
Thuravur	Muhamma		Perumbalam
Pattanakkad	Mannamcherry		
Vayalar	Aryad		
Kadakkarappally			

3.1.1 Zone-A

This zone represents the north-west portion of the study area. The Vembanad Lake is the eastern boundary of this zone and this is the narrowest stretch of the area under this study. The coast here is erosional in nature (Fig. 8). It is due to the material energy imbalance caused by natural and artificial forces on the coast. This generally happens during the southwest monsoon season as a

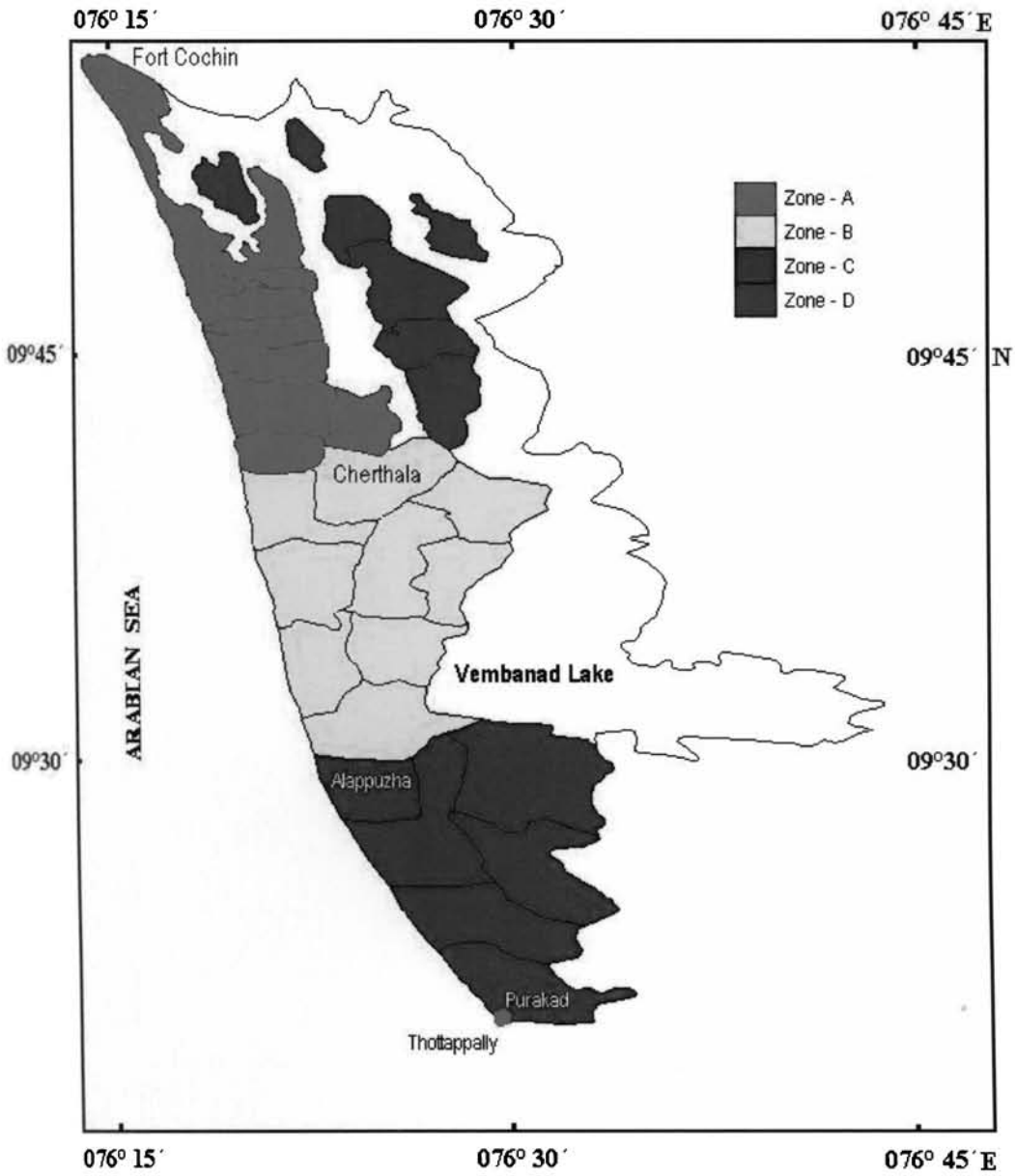


Fig. 7. The study region divided into four zones.

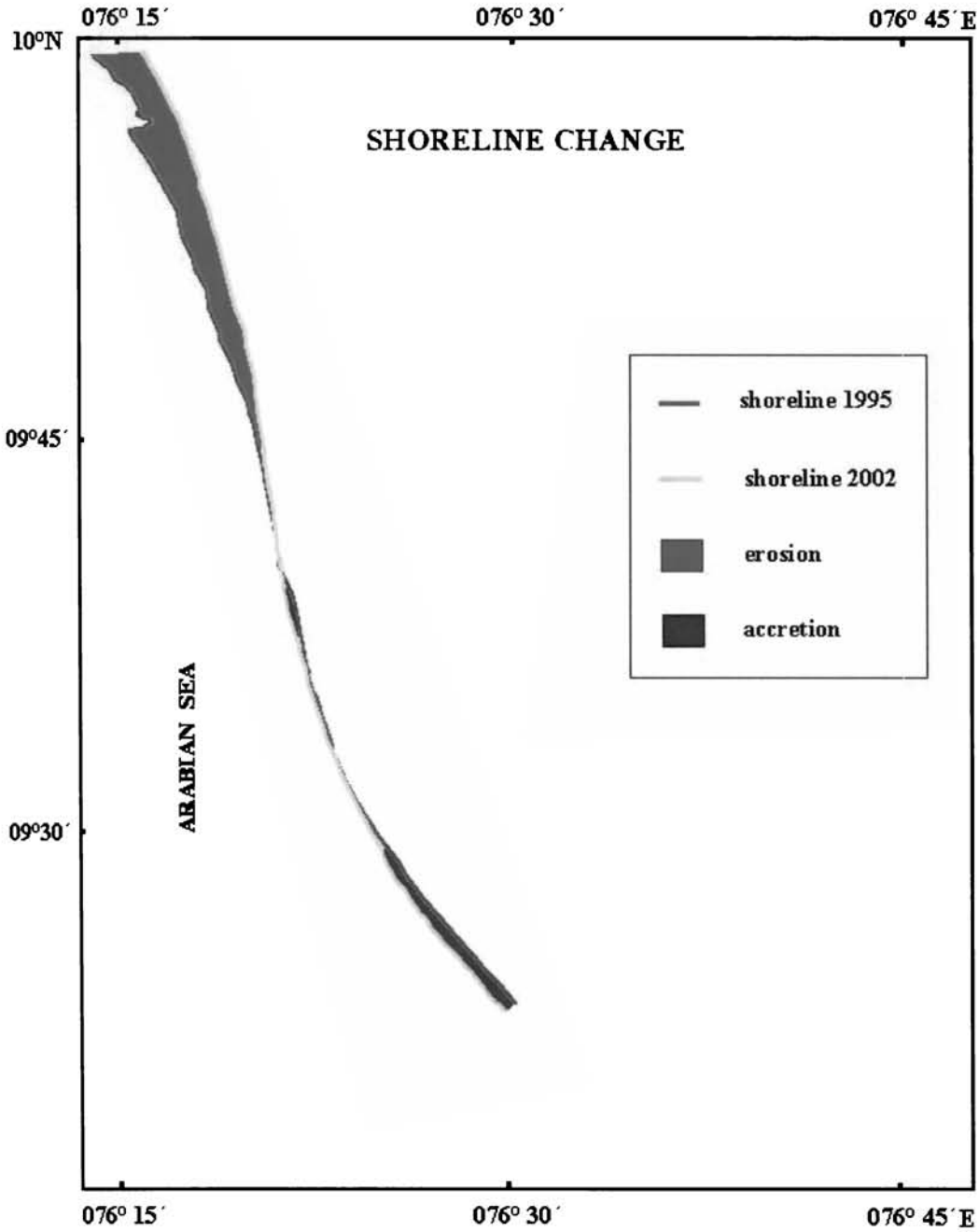


Fig. 8. Shoreline changes between years 1995 and 2002 in the region of study. The red area indicates erosion where as greens the regions of accretion.

result of high and steep waves and rise in water level. The lack of littoral supply and reaction of the beach to protection measures agrave the situation. Coastal erosion leads to dislocation of coastal population and loss of agricultural lands. It also adversely affects the scenic beauty resulting in loss of revenue to the tourism sector.

The population density of this zone is in the range 1200-2200/km^2 except at Fort Cochin where it is 4124 (state average is 747/km^2 as in 1991).

The Fort Cochin Region, which lies on the south-western end of Cochin Corporation, is a place of historical importance and attracts tourists from all over India and abroad due to its scenic beauty. Several historic monuments are located here. This region houses part of the Naval Southern Command and Coast Guard headquarters. This region is the southern inlet boundary of the Cochin Port. To particularly state, the Fort Cochin region alone is a location where multi religious races and multi cultural communities live along harmoniously (none so admixed and diversified in the study region selected). This site is now being treated as a national heritage.

The panchayath regions of this zone indicate the following features. The terrain in this region is more or less flat. Traditionally the eastern part (embanks of Vembanad Lake) has been used for rice (Pokkali) cultivation. The soil type here is the coastal alluvium which is slightly acidic in nature. The inland areas are not suitable for this purpose because of the lower capacity of the soil to hold water. Most of the people of this region are employed in the fish processing sector (now transcending to business and white collar jobs). Manufacture of coir and its products, baskets etc. has been the traditional labour practices of this region and they were manufactured in almost every

house. In the beginning of the twentieth century, there were several coir factories working here. Nowadays the number of people engaged in traditional labour is diminishing. Paddy and coconut are the major crops of this zone. Agricultural sector is also under severe threat as the agricultural fields are being converted into aquaculture farms or reclaimed for human settlements or left unused.

During 1970's prawn peeling units were started in this part of the coastal stretch. The existence of several natural canals, establishment of ice plants and availability of fresh water paved the way for prawn farms to flourish in the last two decades.

The people in this zone depend on rainwater for drinking and irrigation purposes. Well-water is saline adjacent to the coastline, particularly in the lean months. This zone which was once blessed with many natural canals and ponds now depends on tube wells for their needs.

Several ice plants and other small scale industries are located within this zone. The over utilisation of ground and surface water by these plants is one of the major reasons for the scarcity of fresh water for drinking and other domestic uses. This zone is severely affected by intrusion of saline waters into ground water aquifers. The water bodies are polluted due to effluent discharge from industries, domestic and community sewage, debris, silt, drainage from agricultural lands treated with fertilizers and pesticides and coir retting.

Agricultural pattern in the zone (hectare)

Region	Total Area	Paddy	Coconut	*Other crops
Fort Cochin	1401.38	0.00	0.00	0.00
Chellanam	1759.77	84.00	428.00	96.00
Aroor	1514.23	20.00	698.00	45.00
Ezhupunna	1408.40	17.00	89.03	155.00
Kodamthuruthu	1080.74	196.20	543.70	75.00
Kuthiathodu	980.03	227.00	240.00	173.00
Thuravur	1917.77	437.00	840.00	108.00
Pattanakkad	1536.26	75.00	325.00	84.00
Vayalar	1444.13	10.00	825.00	76.00
Kadakkarappally	893.93	25.00	341.00	93.00

(*Other crops include Banana (Musa Paradisiaca), Cashew (Anacardium Occidentale), Brinjal (Solanum Melongena), Chilli (Capsicum Annum), Carrot (Daucus Carota), Jack (Artocarpus Integrifolia), Mango (Mangifera Indica) etc.

Area wise, Thuravur and Chellanam are the largest in this zone and of these, Thuravur alone indicates proportionally high paddy culture. This is also true for coconut and other crop cultivations. In Chellanam, coconut palms well dominate over other agricultural practices. Glaringly, the Fort Cochin region is rather devoid of any worthy agricultural practices. Vayalar, Aroor, Kodamthuruthu, Kadakkarappally, Pattanakkad and Kuthiathodu are other regions where significant areas of coconut palms are spotted. In respect of paddy culture, Kuthiathodu and Kodamthuruthu have significant areas covered by this type of agriculture where as in almost all the other regions,

except Kuthiathodu and Ezhupunna, other types of crops occupy only a smaller segment of the sand which proves to show that only two types of agricultural likeness are entertained by the people.

3.1.2 Zone-B

This zone lies in the central part of the study region. The coastline of this zone is highly stable. This is the widest stretch within the study area. Mudbanks often form adjacent to the coast of Mararikkulam during the southwest monsoon period.

Several natural canals which were once freely flowing have now been reclaimed or narrowed down considerably. This resulted in water logging and destruction of agricultural fields in the rainy season. During flood times, heavy loads of silt and debris from the midland regions and urban centres are brought down by the seaward flowing sewage canals and spill them all over around the mouths due to tidal resistance. The resulting contamination of the coastal settlements makes them vulnerable to the spread of many waterborne diseases.

Population density in this zone ranges from 827/km^2 at Muhamma to 3500 at Aryad. Aryad is a panchayath where the population density is more than even the Cherthala Municipal region. But the infrastructural facilities are not yet developed enough to cater to the needs of the people there. Most of the agricultural farms are lying to the east portion of the zone along the banks of the Vembanad Lake.

Agricultural pattern in the zone (hectare)

Region	Total Area	Paddy	Coconut	*Other crops
Aryad	686.94	2.80	269.00	83.00
Mannamcherry	3451.46	121.40	1254.50	240.00
Kanjikkuzhy	1662.02	395.00	610.00	100.00
Mararikkulam-south	1907.24	80.00	964.00	142.00
Muhamma	2675.70	210.00	645.00	110.00
Thanneermukkom	3145.15	8.00	1258.00	230.00
Mararikkulam-north	1697.16	120.00	865.00	152.00
Cherthala	1617.85	176.00	578.00	140.00
Cherthala-south	1834.07	200.00	746.00	110.00

The Mannamcherry is the largest panchayath followed by Thanneermukkom where as Aryad panchayath having an area of 686.94 hectare is the smallest. In contrast to the total area, paddy culture is the least in Thanneermukkom panchayath where as coconut palms predominantly occupy more than one third of the total area. The other crops are more or less proportionally divided depending on the total area of most of the panchayaths. Kanjikkuzhy and Muhamma followed by Cherthala-south are places where paddy culture is well practised and these are also those panchayaths where salinity intrusion has not been a problem lately. Comparing the pattern in Zone-A and Zone-B, paddy culture is more prominent in the latter.

3.1.3 Zone-C

This southernmost zone includes Alappuzha Municipality and five panchayath regions. Alappuzha has the largest population density of 3735/km^2 in this zone while it is 578/km^2 at Kainakary.

Coastline here has been relatively highly stable and showed accretion tendencies in the last decade. The occurrence of mudbanks during the southwest monsoon season is a peculiarity of this zone. Mudbank formation along the coast of Purakad, Ambalappuzha and Alappuzha is very frequent which influence the economy of the coastal population immensely.

The soil here is highly fertile but slightly acidic in nature. The paddy fields are located in the eastern parts. All the regions except Kainakary and Nedumudy in this zone cultivate rice in all suitable areas. Many areas are left unused in Kainakary and Nedumudy. Numerous fish processing units and ice plants are working in the Ambalappuzha-Purakad region.

Agricultural pattern in the zone (hectare)

Region	Total Area	Paddy	Coconut	*Other crops
Purakad	2318.27	800.00	1140.00	156.00
Ambalappuzha	2417.10	950.00	715.00	380.00
Nedumudy	2597.97	260.00	856.00	432.00
Punnapra	2127.02	756.00	874.00	122.60
Kainakary	3660.90	384.00	916.00	145.00
Alappuzha	4676.47	748.00	1470.00	120.00

The Alappuzha Municipality and the five panchayaths of Zone-C occupy larger areas than many of those in Zone-A or Zone-B. Likewise, the respective area under cultivation for paddy or coconut or other crops stand amplified. The total coconut palm cultivation area well exceeds that of paddy culture in this zone. But compared to large panchayaths in Zone A or B, paddy cultivation is more popular in this zone.

3.1.4 Zone-D

This zone includes seven panchayath regions and is surrounded by brackish water. The population density in Perumbalam panchayath is 571/km^2 which is the minimum in the entire study area. Kumbalangy panchayath has the highest population density of this zone (1560/km^2).

Three soil types can be observed in this region:

i. coastal alluvium in the embanks of the Vembanad Lake
ii. the fertile inland plains
iii. sand with silica

The third soil type can be seen in Chennam-Pallippuram.

Several natural canals are present in this zone through which water flows into Vembanad Lake during the rainy season. These canals are blocked during the lean months to prevent saline water intrusion. Though the people of Panavally panchayath is mainly engaged in agriculture, about 150 hectare of fertile land is left unused. Perumbalam island suffers from shortage of fresh water for drinking and other domestic purposes. Traditional labour of this region finds occupation in fisheries and agriculture. Coconut and rice are the major crops of this zone for which the people depend on the seasonal rainfall.

Even though this zone is linked to the main land by bridges, transportation facilities are yet to be developed.

Agricultural pattern in the zone (hectare)

Region	Total Area	Paddy	Coconut	*Other crops
Kumbalam	2079.50	60.00	590.00	32.00
Kumbalangy	1576.99	300.00	350.00	43.00
Perumbalam	1637.83	98.00	400.00	102.00
Arukkutty	1109.83	65.00	370.00	52.00
Panavally	1955.66	238.00	800.00	168.00
Thycattusserry	1381.59	160.00	590.00	85.00
Chennam-Pallippuram	2551.86	222.57	390.52	85.00

The seven panchayaths which constitute Zone-D are particularly disassociated with the mainland running north-south. Most of the panchayaths are medium sized where coconut palms dominate the landscape. The other crops, as listed, are prominent in the Panavally panchayath only. These island panchayaths are surrounded by seasonal saline waters (February-May), brackish waters of medium salinity during post monsoon (October-January) where as fresh water conditions prevail during the southwest monsoon season (June-September). Being low-lying and surrounded by waters of different salt content, sustainable yields from paddy culture is not a guaranteed function.

3.2 Beach Profiles

The beach profiles at three locations Mararikkulam, Alappuzha and Purakad beaches are presented for observations made for December 1999, 2000 and 2001. All the sites in common are not protected by seawalls.

The Mararikkulam beach appears to be quite stable (Fig. 9) for distances up to 120m with a prominent berm crest around 115m from the reference point. Since 1999, the lower part of the beach has indicated accumulation of material though mild amounts of material may have been lost from the backshore. The face of the beach towards the seaward side has rather a steep slope. This feature is consistent with the earlier statement that the southern parts of the study region are more or less a stable part with respect to erosional/depositional behaviour.

The Alappuzha beach (Fig. 10), less wider than Mararikkulam beach is slightly placed higher with respect to mean sea level (MSL). However the beach slopes down rapidly. The berm crest appears to have moved further seaward by December 2001. Conspicuously, the profiles hold a point where the beach remained unchanged during the three years of study. The three profiles together indicate gradual decrease in height of the beach with respect to distances seaward, and likely that the eroded material moves forward raising the beach face as the study progressed. It appears that the beach is flattening and there may be a lack of material input into the backshore.

The Purakad beach ((Fig. 11) showed high variability during the period of study. The beach is stable at 40-50m from the reference point. A new berm crest was developed at 70m from the reference point in 2001. Backshore retained its original features during the period of study.

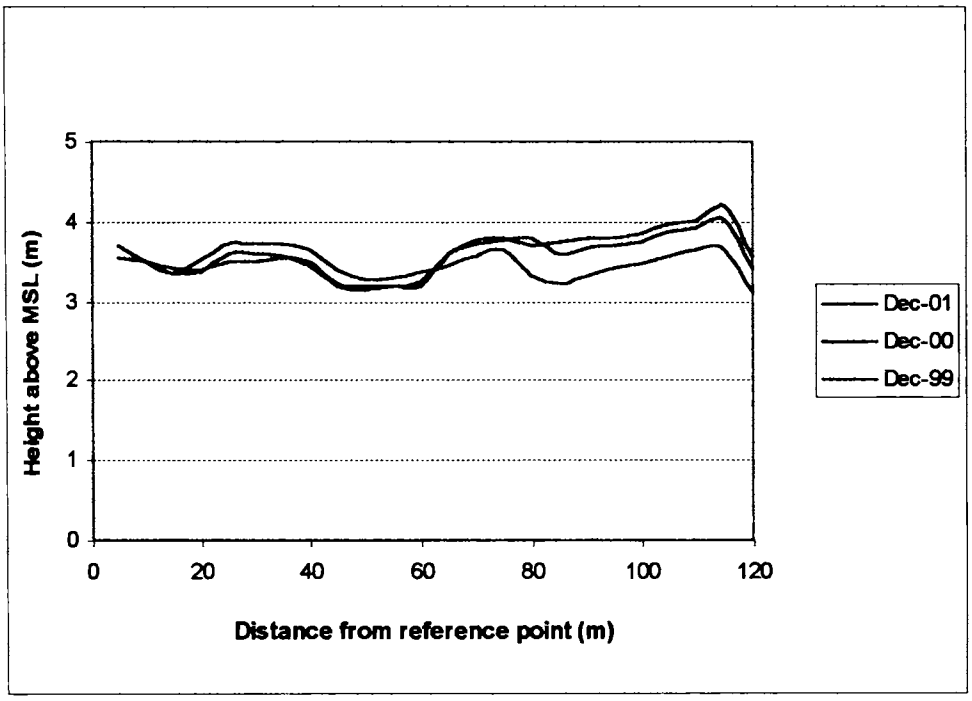


Fig. 9. The profile of Mararikkulam beach.

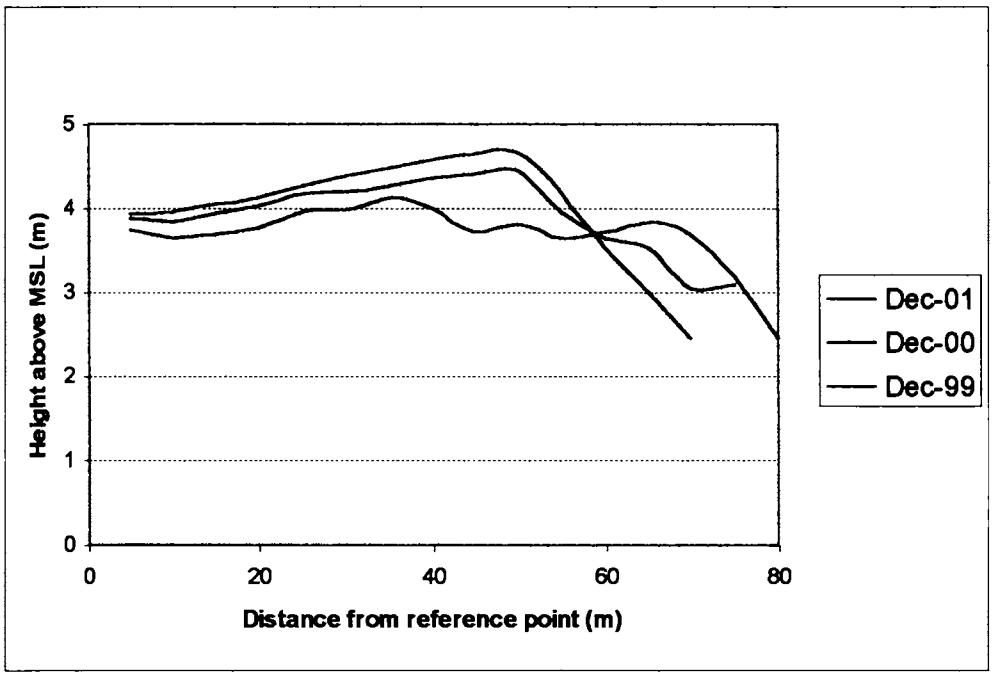


Fig. 10. The profile of Alappuzha beach.

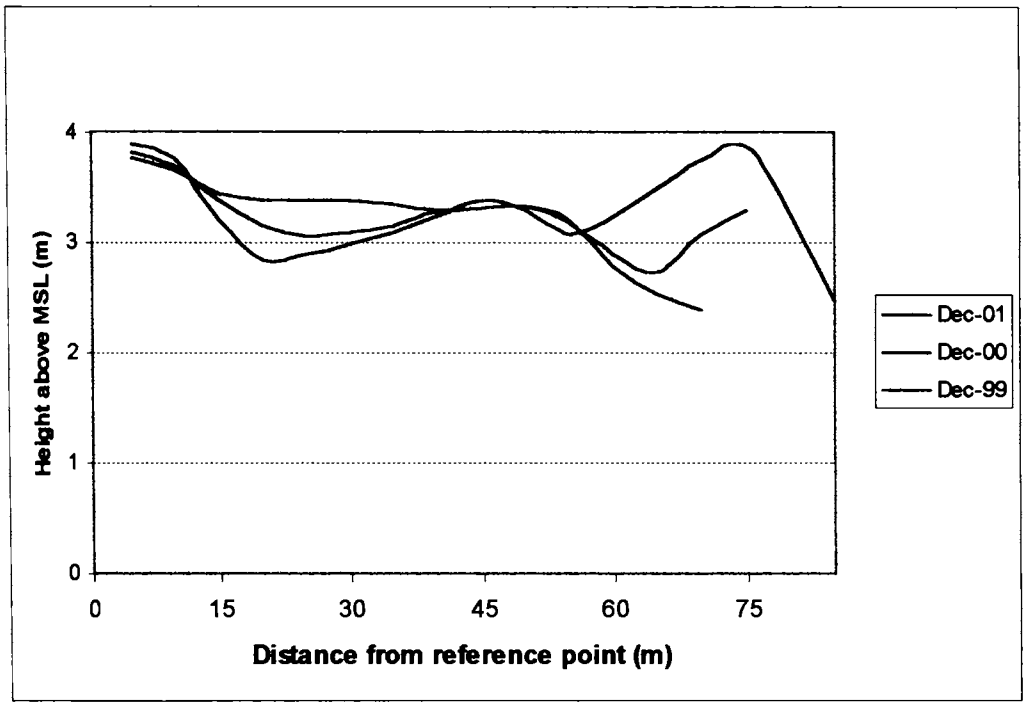


Fig. 11. The profile of Purakad beach.

Fig. 12. The eye-catching Chinese fishing nets along the Fort Cochin beach. On the farther side, the developing Puthu Vypene area is spotted. Noticeable are the decaying lumps of weeds (African Payal).

Fig. 13. On the rear open area at Fort Cochin, social forestry promotes coastal vegetation.

Fig. 14. The fury of nature at times brings about loss of coastal vegetation (Fort Cochin).

Fig. 15. Same as above where a groyne had restricted the damage.

Fig. 16. The lone mangrove plant opposite to Mundamveli church clearly showing the intertwined roots and the stem, just behind the seawall.

Fig. 17. The landward part of the strong seawall protecting the hinterland at Manasserry.

Fig. 18. The seaward view at the same spot facing south.

Fig. 19. The seaward view at Manasserry facing north. Note the height of the seawall around 2m just adequate to face the wrath of the monsoon breakers.

Fig. 20. Backwater aquaculture farms with nets regulating the fish holdings. The characteristic thick lush growth of coconut palms decorates the background. (Kannamaly)

Fig. 21. Towards the seafront a collapse of a seawall permits run up of waves onto the backshore. Left alone the chances of breach of the seawall and subsequently extensive damage to either sides of the wall and resultant erosion could be a serious concern. (Kannamaly)

Fig.22. The backshore of Kannamaly seawall where natural and anthropogenic impacts are very evident. Over toppling waves often push the loose sandy material further landward to form receding berms. On the other hand, human interferences to landscape the backyard of a seawall by cutting bars translocate the loose material as well as promote growth of coconut palms. The loose material may be used as land fill opportunistically.

Fig. 23. The broad upper plateau of the seawall at Chellanam which shows early indications of frontal collapse.

Fig. 24. Further south of Chellanam the Pallithodu seawall protects the northern flank.

Fig. 25. The sea gap opening at Pallithodu with the collapse of the seawall on the southern tip. This opening permits landing of small fishing crafts with out board engine.

Fig. 26. Artificial beach nourishment by means of sand filled gunny bags as practised at Pallithodu.

Fig. 27. The view towards south.

Fig. 28. A better view of the filled-up sand bags ready for placement along the shoreline at Pallithodu.

Fig. 29. Piles of sand collected and ready for transportation found adjacent to the seawall at Manakkapadam. The origin of these sand heaps may be the sand within or out of the seawall.

Fig. 30. The vast expanse of sand bar found at the natural tidal inlet at Andhakaranazhy.

Fig. 31. The view on the southern flank indicates portions of the collapsed seawall and presence of a small flat beach.

Fig. 32. The inlet portion on the northern sector of Andhakaranazhy permitting exchange of tidal waters between the sea and the bay.

Fig. 33. A closer view landwards while standing on the edge of the sand bar of the inlet.

Fig. 34. An objectionable act in the coastal zone by way of unauthorised mining of the beach sand for construction purposes. Three distinct heaps of sand has observed on the landward side of the seawall at Kadakkarappally.

Fig. 35. The well developed hinterland at Thaikkal as viewed from top of the seawall.

Fig. 36. The seaward view angled south bound indicates a broad beach, tall coconut palms, shrub vegetation on beach sands, two or more country boats and the tip of a temporary work shed.

Fig. 37. The berm crest on the beach face and the broad beach as observed towards the north side.

Fig. 38. Water logging often noticeable along the Kerala coast – the scenario at Thaikkal, indicative of small water sheds encompassed within vegetated sand bars.

Fig. 39. Similar to the broad beach at Thaikkal, Arthunkal too shows a slopping backshore where inland waters are trapped in small natural canals. Particularly observed is the establishment of a temporary dwelling in the middle of the picture.

Fig. 40. The view to the south where young coconut palms have been planted which do not afford any protection to the land within, or to themselves. Also the front bow of a medium sized fishing vessel with out board engine being rested inland while another one is left on the beach face.

Fig. 41. The agglomeration of inland waters, vegetated sandbars just within the seafront holds fresh to brackish waters (Chethi). On the farther side a canal opens out to the sea.

Fig. 42. The clean beach sands of Chethi viewed south which affords land for coconut palm growth.

Fig. 43. Landward portion of the beach at Chethi where a canal runs parallel to shoreline.

Fig. 44. The approach road to Mararikkulam beach along a canal linked to Chethi area also. Notice the white sand bar at the beach ahead.

Fig. 45. The relatively clean and welcoming Alappuzha beach. Faintly noticeable is the collapsed structure of the old harbour and its piers.

Fig. 46. A closer look of the backshore, where water logging has taken place.

Fig. 47. Conspicuously noted are the remnants of the old collapsed seawall over which thick vegetation has thrived. Further seaward is the beach of uniformly sorted sands. (Punnapra)

Fig. 48. The view south bound indicates a thick patch of coastal vegetation and a broad beach. The seawall is located far inland of the shoreline.

Fig. 49. The resting place of coastal fishing vessels. Evidence of mining of the beach sands is indicated by a ditch in the fore front of the figure. (Punnapra)

Fig. 50. Another view of the old seawall covered by beach vegetation.

Fig. 51. A broad beach decorates most portions of Ambalappuzha. The northern view – a shallow canal is visible on the north side with a notice board exhibiting the sign 'sand excavation prohibited'. Faint presence of heavy minerals is noted.

Fig. 52. Southern view of Ambalappuzha beach. The concrete poles serves the purpose for temporary cuts to hold fish landings. The presence of heavy minerals is clearly depicted in this photograph.

Fig. 53. A highly objectionable activity most often noticed and well evidenced in this photograph refers to the removal of the top sand layers by means of hand shovels. (Ambalappuzha)

Fig. 54. Of what that is left off the old seawall now located far within the land than the seafront. The beach has grown with sand deposits and presence of beach vegetation is prominent. An unauthorised semi-permanent hut is located on the middle of the beach. (Purakad)

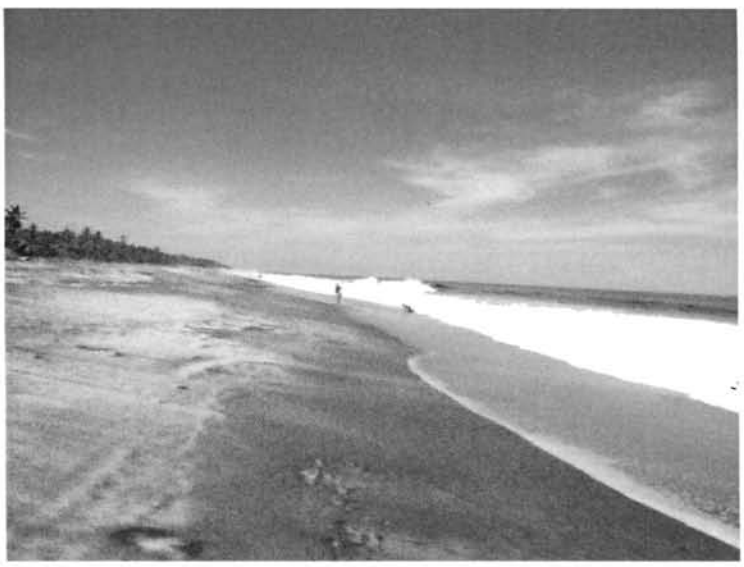


Fig. 55. The prominent presence of dark heavy minerals is evidenced on the face of the beach at Purakad.

Fig. 56. Thottappally Spillway viewed far from the beach which was supposed to regulate the flood levels in Kuttanad agricultural fields. The vast field of water in the fore front of the figure is the logging due to closure of the canal opening to the sea.

Fig. 57. The closed inlet at Thottappally. Often monsoonal set up piles water above the level of freshwater within the spill way and the operation comes to a standstill.

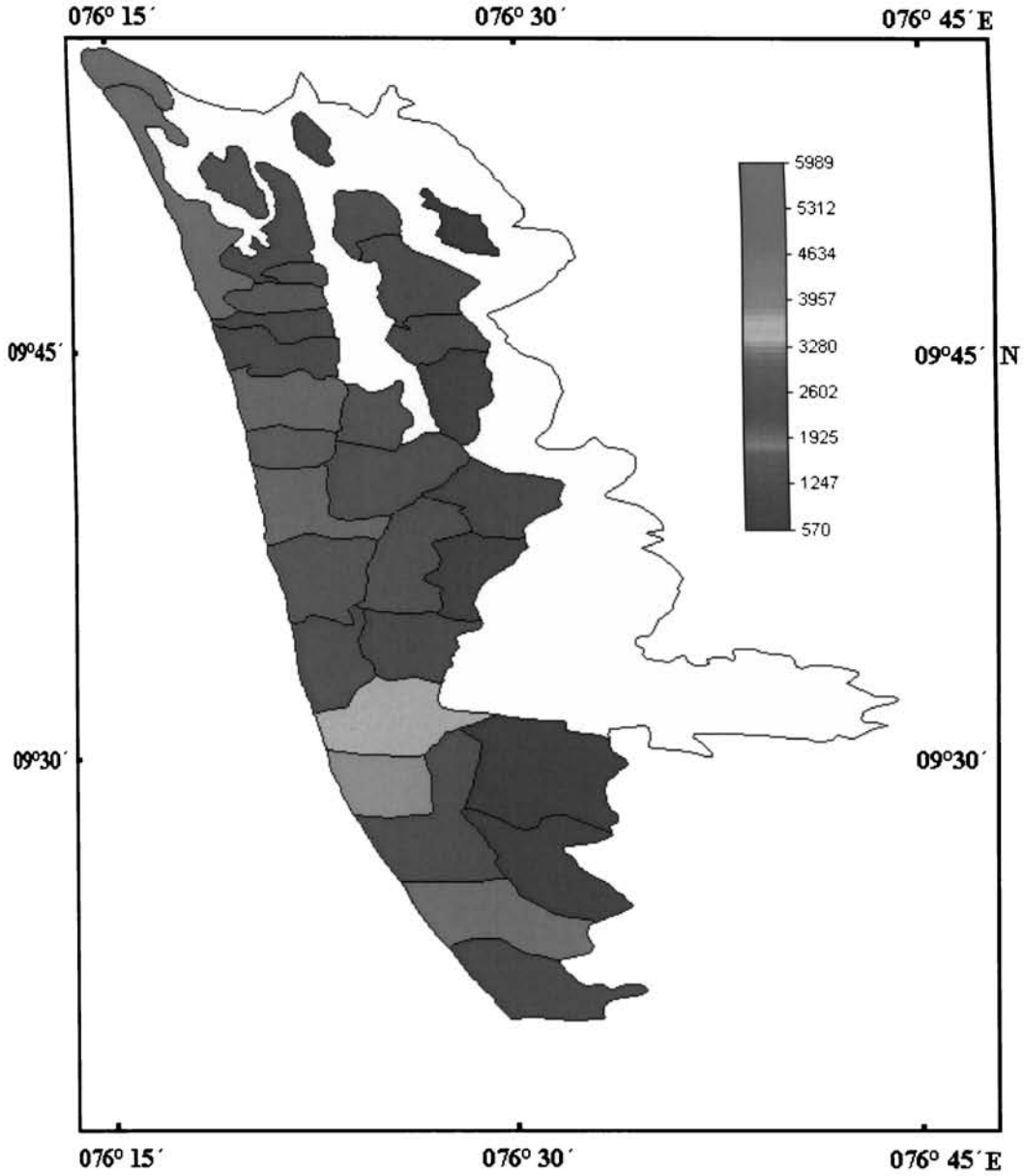


Fig 58. Map indicating panchayath-wise population density (persons per square kilometre) of the study region.

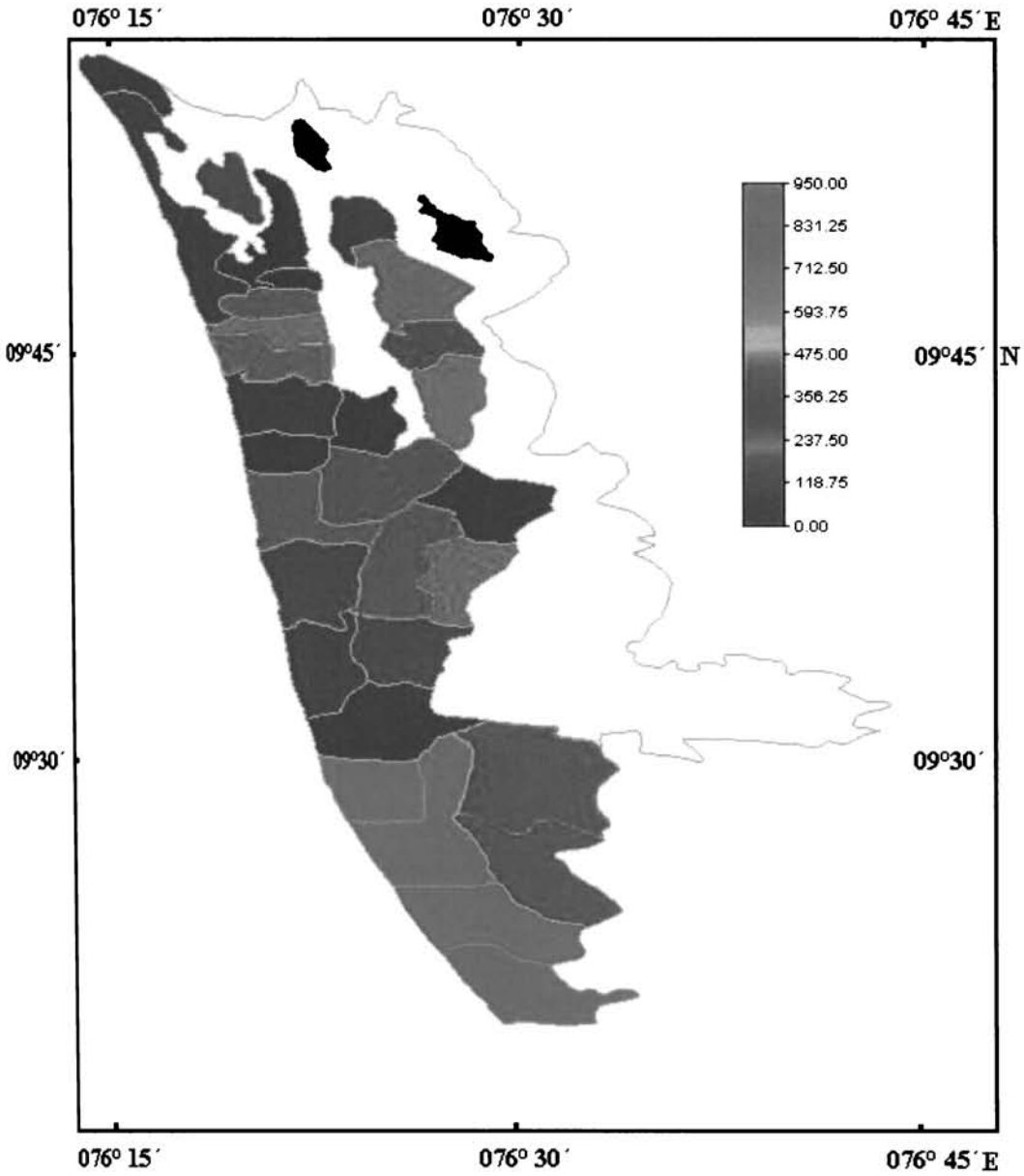


Fig 59. Distribution of paddy cultivation (hectares) in different panchayaths of the study region.

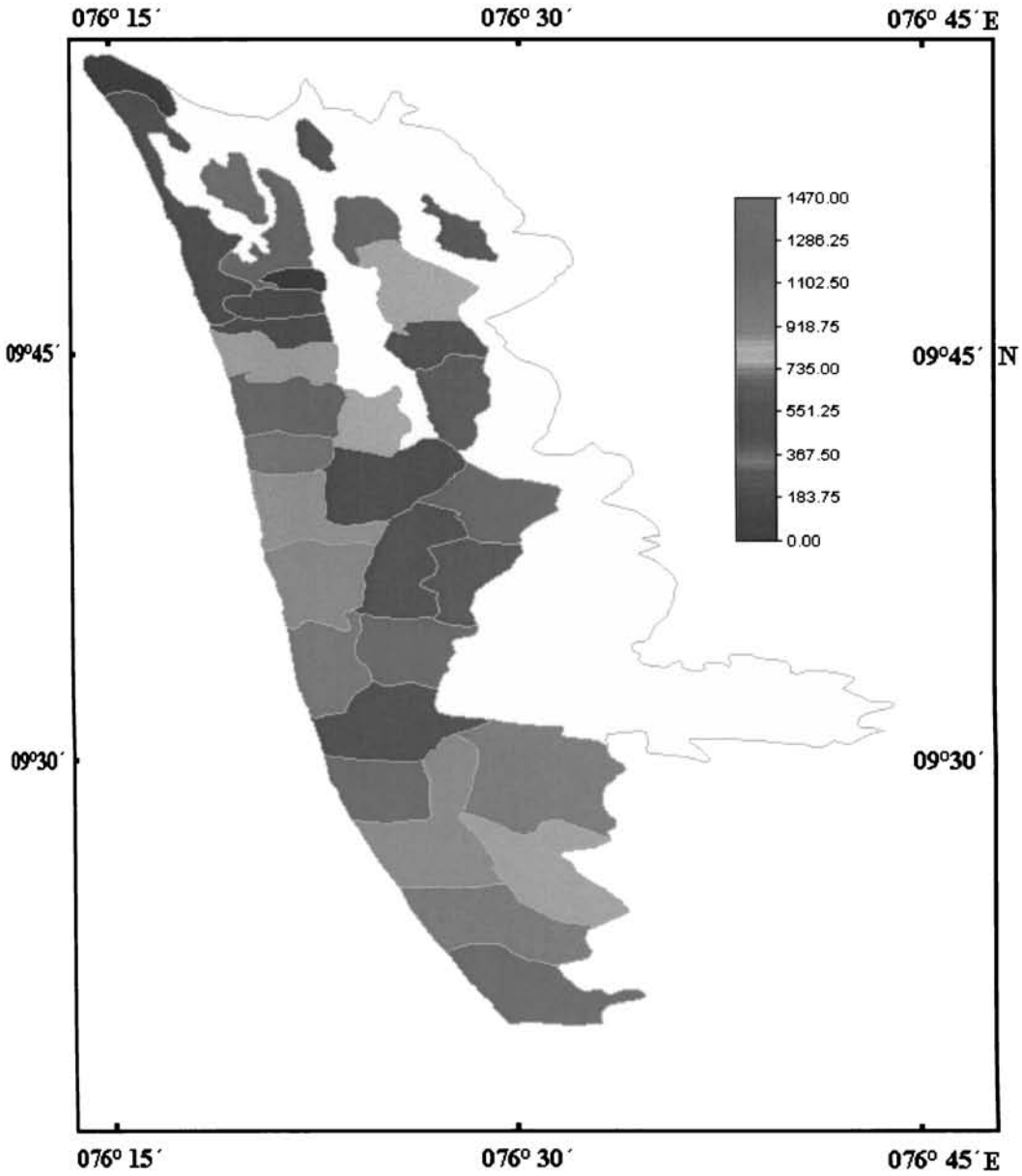


Fig 60. Distribution of coconut cultivation (hectare) in different panchayaths of the study region.

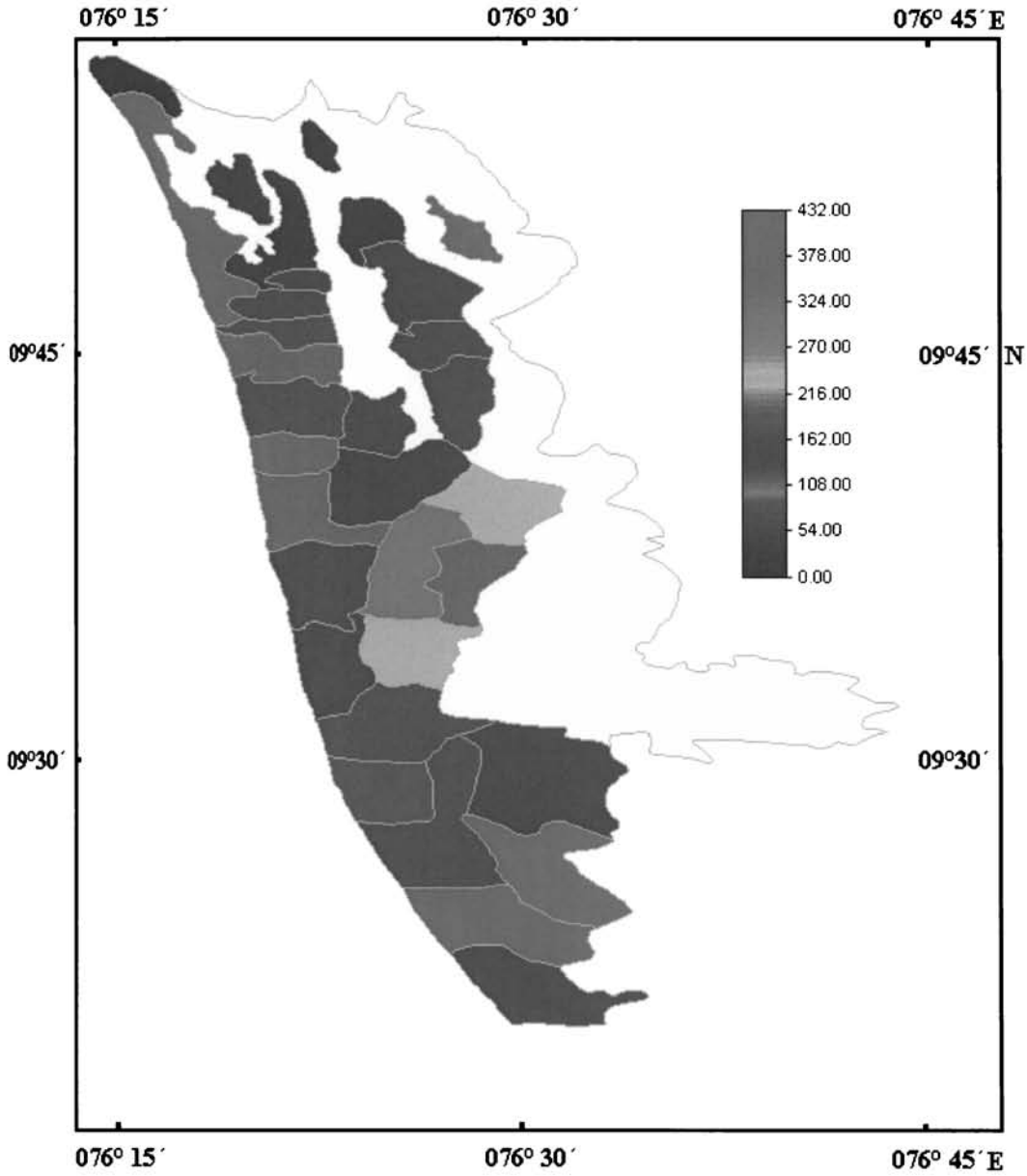


Fig 61. Distribution of other crops (hectare) in different panchayaths of the study region.

3.4 Mudbanks and their Implications

The patches of calm, turbid water with high load of suspended sediment, appearing close to the shore along the Kerala coast during the southwest monsoon season, are known as mudbanks (Kurup, 1977). The formation of mudbanks influence the socio-economic life of the fishermen community of Kerala by way of providing them calm fishing grounds during the monsoon season, when the sea is otherwise rough and inaccessible for their frail crafts. Besides, they also influence the shoreline processes along the coast. Acting as dampers to waves, the mudbanks protect portions of the beach from erosion and also help in trapping sediments from either side facilitating the growth of the adjoining beach.

The formation of the mudbanks at definite localities along the Kerala coast between Kollam and Kannur, a distance of about 240km, is an annual phenomenon. Generally they appear during the period June to September and popularly known as 'Chakara', literally meaning dead or quiet land. The earliest know record of the existence of the mudbanks on the coast of Kerala dates as far back as 1678 (Kurup, 1977). R.C. Bristow initiated the first scientific investigation on the problem of mudbank formation and the results are given in Du Cane *et al.* (1938).

Mudbanks have been reported at twenty places where, according to available records, mudbanks have occurred some time or the other in the past. Within the present study area also mudbanks occur frequently at certain places (Fig. 62). They are Cochin, Cherthala, Mararikkulam, Alappuzha, Ambalappuzha and Purakad. At Purakad, mudbanks form almost every year. At other places also (except Cochin), mudbanks have formed in recent years.

The mudbanks are found close to the shore and extend more or less in a semi-circular shape towards the sea (Kurup, 1969). The seaward extent of the bank is usually at 10m depth at a distance of about 5km from the shore. The alongshore stretch varies from about 3km to 6km. From the shore, the mudbank can easily be distinguished by the absence of waves while heavy rollers break upon the shore north and south of the bank. Moderate swells separate the calm region of the mudbank from the wavy surface of the monsoon sea. Calmness and high turbidity are the apparent features of the mudbanks. The mud in suspension increases the viscosity of the medium due to its density and causes viscous damping of waves (Kurup, 1977).

From the foregoing statements on mudbanks, their presence or absence have large implications on the life and economy of the coastal people of Kerala State, particularly of those people residing in Zone-C. Cognizance on the impact of a mudbank though functionally important, has not been brought forth in the context of coastal zone management practices or from a view point of a proper management perspective. Questions like their functional importance to a local region, the implications on the biological triggering mechanisms to a coastal community, on the fruitful benefits arising on abundant fish landings or on the migration of fishing communities in search of better opportunities are scanty but deserve better analytical treatment. Within the purview of this study, an utmost ecologically important site appears to groom itself, propagate in better healthier terms, bring about sustainable yields and gradually with time, this phenomenon disappears. Though many theories have been suggested on the formation, movement and dissipation of mudbanks, from a coastal management view point seldom has received any attention in terms of human interactions, environmental stress and strain and

the management strategies that evolved by themselves and keeps the phenomenon an essence of life. In simple terms, consider thousand or more people finding opportunistic jobs often coupled with harvesting of living resources and amassing proportionate wealth in a short duration of time. The event resembles something like a festival where money is pocketed by each actor for his self-assumed role. In terms of coastal zone and its management, the stress is non-quantitative and non-measurable since hundreds of water crafts discriminately or otherwise plough the calm waters for their abundant fisheries, after netting the catch run on to the beach face, unload the cargo, followed by sale bargains and the commodity is moved via hinterland narrow roads by means of mini vans, trucks and lorries. To some extent, sorting is also practised with bulk amounts of ice used as a preservation media. This implies that both the land as well as the adjoining sea area experiences dynamic movements of people transacting business with no special or particular care on the implications of their activities on the environment nor there are controls by the acts prescribed within the CRZ notification. A pertinent question is whether a management control is necessary on the operations within the mudbank region, what precautions are necessary to lessen the impacts so that the catch could be further enhanced (within sustainable limits) and better justice be served to the cause of protecting and developing the coast. A closer introspection and a detailed critical commentary are provided in Chapter 4 of this work.

3.5 Critical Appreciation of the Four Zones

To make statements on water and water resources related coastal environmental issues, the ground water resources in this region suffer from salinity intrusion and contamination by unhygienic practices. This leads to scarcity of drinking water, particularly in the lean months. Advantages of having artificial water reservoirs have not gained popularity to a great extent in this region since they are very far away from the coast. Several industries which require large quantities of water are also situated in this region.

Drinking water supply has been extended to most of the settlements at all levels. However, most of the panchayath regions are suffering from inadequate storage capacities. In the municipal areas, the under ground pipe lines often get damaged within a very short period after installation, resulting in contamination of drinking water. Proper maintenance of water supply lines is often handicapped due to leakage in pipe lines which are deep buried and high recurring costs. As a result, the people in this area rely on open wells and dug-out pits.

About $300m^3$ of ground water/day/km^2 is being withdrawn in this area (Baba *et al.*, 1987). Such quantum of withdrawal from the shallow unconfined aquifer adjacent to the shore, particularly in the absence of appropriate recharge mechanisms in the lean months cause lowering of the fresh water table which in turn promotes the landward advancement of the seawater interface and substantially reduces the space for fresh water storage besides adding salt content to the potable water.

Contamination of drinking water, use of polluted water for domestic purposes and the unsanitary conditions prevail through the practice of dumping of

human wastes in open areas, together, lead to the spread of various epidemics. During the months of September-November, diseases like cholera, gastro-enteritis, meningitis, jaundice and typhoid plague this region with a cyclic periodicity.

From another view point, mudbanks play a decisive role in the stability of the shore in this region. They trap the littoral material and the down drift region is often subjected to erosion. Most often overall accretion takes place in the area of mudbanks. It is sometimes observed that the regions off mudbanks are subjected to mild to moderate erosion.

Five major rivers namely Manimala, Meenachil, Pamba, Achencoil, and Muvattupuzha discharge through this region. During summer (February to May), tidal intrusions of saline water from the backwaters are predominant. It was closely observed that during floods, nutrient-rich alluvial sediments transported by rivers from inland areas settle over the low land regions. During 1930's, first field studies were conducted on two term cultivation (Balchand and Nambisan, 1988). This survey revealed that the southwest monsoon flood water will have to be drained off effectively and salt water intrusion from backwaters in the lean months prevented from entering the paddy fields for this purpose. Accordingly, a channel to the sea was constructed and named Thottappally Spillway (commissioned in 1955). To regulate and control the saline water intrusion, the Thanneermukkom Bund was constructed (commissioned in 1974). Additionally, a link road of length 42km between Alappuzha and Changanasserry running across the mainland for better transport and communication was built. The objectives of these environmental modifications were to prepare the agricultural fields for a

double cropping cultivation every year, apart from establishing a better socio-economical order and life style. But the systems failed miserably to achieve the objectives (Balchand, 1983).

The three projects mentioned above have introduced various environmental problems and socio-economic disorders (Balchand, 1983). The practice of cropping every year was conducted as floods receded leaving exposed fertile soil nourished by a layer of freshly deposited alluvial sediment. Alternately, the tides during summer had free passage providing flushing action. This restrained the weed growth and reduced soil acidity. Moreover, prawn culture was prevalent every year in low saline waters. Today, by summer, the Kuttanad region forms a closed water body. Once the salt water entry prevented from entering the fields, the stagnant waters picked up anthropogenic wastes, highly toxic pesticides and insecticides. The shallow water regions used as retting grounds for coconut husk, raw material of coir industry, were causing severe organic pollution (Remani *et al.*, 1981).

The resulting environmental problems are

i. The growth of African Payal (Salvinia and Eichornia) adversely affecting paddy culture, water transport along the inner channels, fish catch and accelerated water pollution by blocking sunshine.

ii. Crop cultivation has decreased sharply. The farmer community turned their attention to large scale frog catching for economical and other reasons. Consequently, as frogs disappeared, water snakes too perished. Eventually there was a considerable rise in the population of mice, pests and flies harmful to paddy culture. To drive them away, insecticides were used in large quantities.

iii. The un-experimented use of these highly toxic insecticides wiped out flies, pests, lower order animals and aquatic life in certain parts of Kuttand.

iv. A section of the inhabitants of this region was engaged in prawn culture in low saline waters. The regular fishing operations used to net around five tonnes per day in the peak summer months. Many species identified before the implementation of the water regulating schemes are now extinct in this locality. Prawn culture was carried out in summer when salt water filled the low lying fields. The high productivity and good sunshine supported the programme. The conditions reversed with the commissioning of the Thanneermukkom Bund. Once the salt water entrainment was prevented, prawn culture nearly came to an end.

v. Vembanad Lake was rich in shell growth. Low saline water and loose bottom clay facilitated the abundant shell life. Now days a sharp decrease has been observed due to variations in the salt concentration.

vi. The retting grounds for coconut husk were situated in the shallow waters of Vembanad Lake. The husk was conditioned in semi-saline waters during summer. This industry has now been affected badly due to non-availability of salty water, after the imposition of the regulator control. The husks will have to be treated for a prolonged period of eleven months in fresh water in place of three months of saline water treatment. Consequently the quality of coir products has degraded. Another important aspect is the enhanced organic pollution of stagnant waters during summer due to retting operations.

Having discussed the above environmental problems, as of now, consider a case scenario of status-quo being entertained, salinification and thereby tidal actions are visibly noted only during the opening of the Thanneermukkom Bund or Thottappally spillway. The appropriateness of applying CRZ provisions to Kuttanad area appears to be either segmented or restrictive. Is this a plausible option which would advance or degrade the present coastal boundaries? In strict terms, the coastal embanks of Kuttanad paddy fields will be embraced by CRZ provisions thereby limiting those works practised to protect the embanks. In another context, failure to do so may turn these potential paddy fields redundant. We are also at a point of time where, those efforts aim at improving the paddy output from Kuttanad field have failed miserably and a few bold thoughts reflect upon welcoming those times from pre-project water resource programmes. This would imply that free exchange of water between ocean and rivers do take place with in the boundaries of the Kuttanad region thereby inviting those provisions of CRZ to be advocated in these sensitive coastal regions. Only this issue is taking a closer scrutiny in next chapter.

Time and again, the gains and losses of human intervention in Kuttanad region may have impacted the coastal zone. Or does the coastal zone on the western region of Kuttanad has had significant impacts on those traditionally bound practices within Kuttanad region? Consider the increase in population density, conversion of land for habitat development, lower yields from land cultivations, increasing incidence of water pollution and water borne diseases, limitations in resource availability and wrong practices in utilising them, the absence of any regulation or regulated activities (except traditional) and more over, given the back ground of this location, one has to consider the coastal

front versus the hinterland area interaction to bring about a mutually acceptable harmonious co-existence. A simple example in water and water-related practices goes a long way to prove the above point. A number of canals, natural or otherwise, present in this region was augmenting water distribution, runoff, flood controls, recharge of aquifers, prevention of salinity intrusion, ground water recharge, flushing actions and so forth from a purely aqua environment operational view point. For any maritime state experiencing monsoon and thereby abundant runoff, rivers ply the coastal plains and drive most of the fresh water of the hydrological cycle back to the ocean, thereby transporting nutrients which are vital to the survival of the coastal ecosystem and habitat. Reduction or alterations is bound to impact the status in a highly biodiversified environment. The unwelcoming acts, without doubt, the construction of the Bund as well as the spillway, the damming of the rivers, diversion of the flowing waters, changes in land use patterns, construction of the embanks and narrowing down of canals, direct discharge of sewage or other polluting substances, over or under harvesting living and non-living resources played undetermining consequences on the health and sustainability of such a coastal region. Basically the people here survive on rice and fish, with add-ons such as tapioca, spices and variety of plantains. This points out to the necessity for the co-existence of two well-differing (mainly coastal waters and inland fresh water) water bodies having seemingly unknown bondage. This aspect is dealt in more detail in the next chapter.

3.6 Ocean Space Utilisation

Ocean management in India is primarily carried out through the endorsement of legislation by both the central and state governments. The differences in perception and policy lead to confusion and even public disagreement, over critical development issues, quite often. The numerous organisations and agencies; with overlapping jurisdiction, controlled by both the central and state governments, compound the problem. However, attempts at overcoming such obstacles are becoming increasingly apparent leading to the notification of Ocean Regulatory Zones (ORZ) in 1996. Although this is yet to be finalised, it can be seen as a major step towards integrated coastal and ocean management in India.

The physical features of India and its geographical location in the Indian Ocean indicate its dependence on the sea for both prosperity and security. The nation's interests include a coastline of 6,100km extending deep into the Indian Ocean, augmented by about 1,400km of island and rock territories in the Arabian Sea and the Bay of Bengal. Almost all of the foreign trade of India is transported over the sea; in 1990's it was estimated to be about 20% of Gross National Product (GNP). In addition, as much as 80% of the demand for oil is met from the sea, either carried aboard ships (46%) or extracted from offshore areas (34%). In view of higher economic growth rates expected in the future, an increase in trade with greater dependence on the import of oil from the Persian Gulf will take place. This will increase further the importance of India's sea lines of communication in the Indian Ocean. Further, the prospective exploitation of metallic nodules from the seabed could meet India's

demand for precious metals, as it currently imports all its nickel and cobalt, and about half its copper requirements.

In view of the Maritime Zones Act (1976), India began to actively demarcate boundaries with its seven maritime neighbours. In order to effectively cope with the multiplicity of activities relating to the sustainable development of the Indian Ocean, the Department of Ocean Development (DOD) was created in July 1981. The underlying philosophy of the DOD is the sustainable and environment-friendly exploration and exploitation of living and non-living coastal and marine resources for the socio-economic benefit of the country. The programmes and activities of the DOD involve polar sciences, marine living and non-living resources, marine environment and coastal zone management, ocean observation and information services, and marine research and manpower development.

One of the acts of the DOD was to formulate the first, and only, Ocean Policy Statement (OPS) of the country (Sharma and Sinha, 1996). This was a major achievement as it attempted a declaration on ocean-wide perspective and its economic importance to the country, for the future, which also made India the first country to adopt such a policy. The OPS of November 1982 sets out the basic principles through which the development of the ocean was to be carried out, along with considerable emphasis on the sustainable exploitation of both living and non-living resources of the EEZ (Exclusive Economic Zone). It advocates the control, management and utilisation of the natural resources of the sea through knowledge of marine space, along with the development of appropriate technologies. In addition, it stresses the importance of infrastructural support, as well as effective systems of management and control

(DOD, 1982). Notwithstanding the strengths of the OPS in being simple and open, its major weakness has been poor implementation and enforcement over the years.

Two additional aspects of India's ocean policy under the purview of the DOD merit attention. In 1987, India became the first developing state to be accorded the status of a "pioneer investor", which provided it an area of 150,000km^2 in the central Indian Ocean for deep seabed mining. In March 1996, India was also elected as a member of the Council of the International Seabed Authority under the "Investors Category".

With the increasing cost of transportation over land, the high capital cost of developing roads and railway lines and the non-availability of land for this purpose, the relevance of inland water transportation is being increasingly emphasized. Waterways constituted the main means of transportation even from historical times. The coastline of the study area is traversed from east to west by many rivers which near the coast flow into lagoons and backwaters. Artificial canals, in places, connect these backwaters and lagoons and form an inland line of water transport - in this case, extending between Alappuzha and Ponnani for about 130km. This system is a striking feature of the central Kerala coast. Now a days, several canals have silted up and water weeds choke the others. Reclamation of land along the banks of the backwaters further worsen the problem.

The coastal oceanic region of the study area plays an important role not only in the economy of the coastal community but that of the state of Kerala as well. This is the region where mudbanks form during the southwes
season. Notedly, fishing is the major occupation of the coastal p

There are several fish processing units in the coastal zone, major concentration being at Fort Cochin, Cherthala, Alappuzha and Purakad regions. A sizeable proportion of the fishing crafts are mechanised, with boat building facilities mainly around Cochin. Traditional fishermen dominate the backwaters and lagoon fisheries. The total fishermen population in Kerala as per 1991 census was 0.964 million. It was 0.995 million in 1997-98 which include 0.77 million under marine and 0.223 million under inland sector.

There are number of other scenarios which have applications in ocean space utilisation. Some of which have much relevance to the Kerala coast and the study region. One simple example pertains to engineering feats such as attempts to install, run and achieve success by use of beach-savers which have been found useful in certain coastal regions – these prevent erosion by damping the waves as well as arresting and modifying alongshore transport. In effect, use of beach-savers actually promotes beach development. Such an attempt around Chellanam region may be highly beneficial to win back land which was lost to the sea due to erosion. Some time back, proposals were afloat on inducting hovercrafts and such other bulk containers for passenger and cargo movement along the Kerala coast. Being open and less utilised, the ocean space is quite ideal for the promotion of marine navigation purposes.

Another area is with regard to open ocean sand mining. Given a reasonable limit to the sustainability on the amount of sand which can be excavated from the ocean, this is a good proposal provided necessary clearance is given after the conduct of appropriate studies. The area under study can also be improved by having a number of new ports and harbours, especially fish landing centres.

These could be minor engineering activities. However the most important scenario is with regard to fisheries which has been dealt above.

The people of Kerala promote tourism and related activities. Open ocean space abundantly available now, is an ideal choice for development of water related and nearshore recreations. Except during the monsoon season, the central part of Kerala is suitable for attempts in this direction. Of course not much has been thought about, demarcating marine parks or zoning those predominant areas where mudbanks often occur. In the modern era many number of coastal states are attempting to alter their coastal open ocean space into a built up area. Such regions could provide offshore facilities for ships, holding areas for bulk cargo, serve as airports and leisure sports and may be in future would serve as permanent habitat locations for human beings or other living forms. In particular, of immediate concern of the coastal open ocean space will be to protect and conserve the present status, provide better opportunity for fishery operation, make constructive attempts to win back the lost lands and stage by stage progress towards implementing more innovative ideas in the available open space.

3.7 Traditional Practices and Modern Approaches

The basic features of traditional practices in coastal zones are the conservation based ethics, regulated harvest methods, application of ecologically and culturally evolved compatible management techniques oriented on sustainability of resources (Balchand and Nambisan, 1988). The practice was socially sound but administered by natural laws than dictates of changing needs of society. The basic rule was to keep the interference with natural ecosystems at a low key so that deleterious effects are negligible. Each action

remains conducive in maintaining harmony between independent functions of the environment. The use of marine areas were confined to fishing for subsistence, to sand and coral rocks for land reclamation/construction, to shells for ornaments and canoes for passage but with minimal disturbance to the ecology of the zone. To add, the population density was low and their ambition reasonable and restrictive.

The traditional practices in fisheries, within the area covered in the present study, was evolved in the village based community programmes. Conservative fishing operations by rudimentary methods often resulted in low harvests. Fish catch was distributed within the community and surplus, if any, sold at pretty low prices. Climatic conditions too influenced the seasonally regulated harvests in the economically backward villages. The rough seas during monsoon and scarcity of fish at times have had adverse effects on the condition of the fishermen through decades. The fishermen were driven by the above factors to take refuge in other types of part-time jobs. In spite of assured abundant resources, the limitations on harvest and absence of steady selling markets for the commodity have remained unresolved for long. Traditional techniques hence limited fishing to subsistence only.

However a transformation has taken place in the traditional management since bilateral agreements between Governments of India and Norway paved the way for mechanisation of fishing gear in 1960s (with special relevance to Kerala State). The Indo-Norwegian Project aimed at mechanisation of fishing boats, introduction of new fishing gear, improved fish processing and curing methods and finding suitable export markets (Sandven, 1959). The net result was a radical transformation in the approach to fishing and associated

industries. Immense marketing opportunities arose for crustaceans (prawns, shrimps and lobsters) in Japan, United States and European countries. The traditional setup was altered to commercialisation - medium to large scale operations in coastal waters. As a result, use of mechanised boats and trawlers with nylon drift nets increased considerably to enhance the fish catch from a near zero in 1953 to over 90,000 tonnes during the period 1974-79 (George, 1980). The complex nature of the marketing process, polarisation of the socio-economic structure and the opening up and delinking of product and factor markets mainly reflect the changes.

In spite of transformations, many of the traditional practices still continue. The co-existence of the ancient method of fish handling and marketing adopting new techniques of preservation, processing and transporting can be seen even today. Traditional practices are retained in the handling of internally consumed seafood where as selective methods of harvesting, processing and preservation is applied by modern procedures for exported products (Kurien, 1978). The commercialisation has improved the economy of the villages though the community outlook has changed giving prominence to individuals rather than the society. Within the social structure, two sectors of people have evolved, the traditional and the modern, with large economic disparities on account of mechanisation (Willmann and Bhaskaran, 1980). This has also come about by the polarised commercial enterprises gaining access to better fishing gear and equipment (Kurien and Willmann, 1982).

In recent years there has been acute competition for fish harvest in the coastal zone of India. Over investment and over exploitation by the modern sector, disproportional to the available coastal resources beyond sustainable levels

have depleted the fish catch leading to conflicts with traditional people. For the state of Kerala, new regulations have set offshore limits for trawlers to operate (beyond 22 km from the coast) during the southwest monsoon period (June-September) to mitigate conflicts, since more than a decade. This control would help to revive inshore productivity and at the same time to meet the demands of commercial sector, thus leading to a harmonious two-tier fishery movement in the coastal regions.

Traditional methods were restrictive and conservative but self-generative in approach based on natural principles of evolution. The valuable information gathered by generations through the traditional system provides an insight into the present system management subjective to natural changes. The modern practices are better evolved from the scientific and skilful analysis of the gains and disadvantages of the traditional practices. In order to further exemplify the above statement the table given below lists the traditional practices and modern management principles for the coastal zone area under study.

Traditional practices and modern management principles for Coastal zone (in the area of study)

Activity	Traditional Practices	Current (Modern) Management	Remarks
		Settlements	
Villages	Long standing societies-culturally bounded-strong community functions, sharing of good shelter and land. More conservation based	Disintegrating systems. Urbanisation trends noted- Land rights invoked- Diminishing resources- Critical habitats left unprotected.	Evolve land sharing mechanisms. Priority on resource management, reverse urbanisation trends.
Towns and Corporation	Little or no traditional values noticeable. High population density, business like scenario.	Regulated and diminished supply of essential commodities. Ill-effects of urbanisation well noted, Transmigration observed.	Promote diversification of habitats, encourage resource conservation, carrying capacity based approach is a priority

Land and land use pattern			
Landscape planning	Little or limited land changes made	Vast alterations affected, ill-effects of urban planning noticed. Flooding, loss of soil fertility and pollution often reported.	Reversal of damage to be encouraged. Water waster urban planning to be promoted.
Land practices	Priority on farming and promotion of water resources	Industrialisation and mechanisation impact land use and practices.	Environmental Impact Assessment (EIA) and post EIA evaluation essential. Zoning of land is a novel approach.
Recreation			
Festivals and cultural events	Part of day to day social life linked to natural events.	Commercialisation promoted, artificial elements present, ethics are being challenged.	Social and cultural revitalisation desired
Tourism	Not an essential ingredient within traditional taste. More linked to health and psychic activities.	Generally encouraged. Impacts social life and the physical environment. Monetary gains.	Better integration practices desired. Promotion with cultural values and traditional health practices are welcome.

Water			
Utilisation	Conserved – mostly for agriculture, irrigation and livelihood	Multi-utilities – industry power generation and commercial use	Resource based utilization most advocated
Quality/ Quantity	Quality more or less unaffected. Regulated use	Pollutional effects often observed. High demands against supply.	Enforcement of Standards and resource based quantification
Navigation	Natural innocent passage entertained	Large-scale build-up of passages. Extensive dredging, oil spills, engineering operations destabilise the region	Scientific approach sought - avoidance of drought and flood with improved hydrological models suggested
Resource	Restrictive use – lesser demands, minor abstraction	Multidimensional projects. River - river connections, large reservoirs and canal systems.	Need based activities are acceptable. Resource allocation to be prominently addressed

Fisheries			
Rights of harvest	By convention	Legally regulated, License, permit, etc.	Demand versus supply becomes a critical balancing force
Fishing methods	Simple methods. Nets, pole hook	Use of boats and trawlers, blasting	High yields versus need based harvesting
Fish landing practices	At subsistence level only	Indiscriminate landings	Biodiversity overlooked with respect to short term gains. Enforcement to be practised
Aquaculture methods	Natural habitats promoted	Artificial methods practiced, high yield species attempted	Yields not in conformity with sustainability often leading to mortality
Culture practices	Not practiced intensively	Intensive cultivation.	Unethical manipulation has lead to Supreme Court's intervention
Eco-fisheries and development	Resource-sensitive, naturally tuned.	Market forces dominate	Controls to be enforced - sustainable yields yet to be proclaimed
Mariculture	Not as a commercial venture.	Practiced off Andhakaranazhy	Limited but noticeable.

Agriculture			
Cropping practice	Common variation relied upon	Extractive farming	Marginal allowances often made
Types of farming	Large area farming at pre-determined areas	Land fragmentation leads to multiple farm types	Yield based approach
Land fertility	Natural fertility protected	Acidification often reported	Restrictive practices often noticed
Cropping patterns	Seasonally regulated	Rapid growing high -yield varieties attempted	Short-term gains but long term losses
Crop selection	Mostly local specimens	New varieties attempted	Mixed response
Pest control methods	Not actively practiced	Indiscriminate use	Caution is advised.
Fertilizer inputs	Bio-fertilizers were only attempted.	Artificially made chemical substances applied	Side effects often noticeable, fields may be identified
Irrigation system	Dependent on natural sources	Natural and artificial means attempted.	Enhanced output observed but in the long run not much favoured

Forestry			
Tropical forests	Naturally evolved	Social forestry promoted	Not prominent in study area
Shrubs and thicks	Naturally evolved.	Promoted through social forestry	Well accounted for but diminishing in area
Mangroves	Patchy growth reported	Well encouraged and part of forestation drive	Public awareness promotes upkeep of green carpet
Defence			
Coastal protection	Subject of concern but alternatives were limited (sea walls prominent)	Multiple approaches available but seldom practiced (high cost)	Regional importance is highlighted and advancement of appropriate techniques solicited
Vulnerability	Not a topic of concern	Global climate change highlights the issue	Long term strategic planning assumes importance
Coastal vegetation	Of not much importance	A topic of current importance	Should be practised
Strategic importance	Limited due to remoteness from foreign nations	Highly valued – access to Indian Ocean	Base of Southern Naval Command

Trade and Commerce	Most valued - trading point to European nations for more than two centuries	Location of Cochin Port Trust and regionally significant	Long term planning is suggested to achieve better goals
		Engineering feats	
Port and harbour development	Location of old Alappuzha Port	Location of (new) Cochin Port	Regionally significant Advancement sought
Minor ports	None designated	Andhakaranazhy designated	Awaits future development
Fisheries harbour	None specific	Pallithodu, Purakad, Alappuzha, Thottappally designated	Poised for development
SBM (Single Buoy Mooring)	None heard of	Proposed site off Andhakaranazhy or north of Cochin inlet	Awaits commissioning
		Human Habitats	
Race	By natural selection	Transmigration	Part of urbanization drive
Demography	Balanced	Over burdened	Very high population density, migration to be promoted
Life style	Conducive to natural forces	Modern amenities well accounted for	Infrastructure stands developed but not fully conducive to local

			interests
Cultural interactions	Controlled by ethical beliefs	Highly diversified and near harmonious	Acclaimed for cultural diversity
Industry and people	Not well inclined	Mid fifties and mid sixties witnessed industrialization and acceptance	Generally welcomed but impacted by failures in recent times for non expansion and associated pollution problems
Public awareness	Acts were conducive with natural laws	Driven by environmental consciousness borne out of frequent calamities	Environmentally conscious and pro-reactive

Chapter 4

COASTAL MANAGEMENT PLANS FOR SUSTAINABLE DEVELOPMENT

4.1 The Coastal Regulation Zones (CRZ)

The most concerned and controversial environmental problem in the State of Kerala in recent times has been the management of the coastal zones. The crisis was heralded by the Government of Kerala publishing in July 1996 the Coastal Regulation Zone (CRZ) notification, issued by the Government of India in February 1991.

The notification seeks to protect the fragile ecosystem of coastal areas by classifying them into four zones and prohibiting or controlling certain activities in each of these zones. The four zones are:

CRZ-I includes ecologically sensitive and important areas, such as national parks/marine parks, sanctuaries, reserve forests, wild life habitats, mangroves, coral reefs, areas close to heeding spawning grounds of fish and other marine life, areas of outstanding natural beauty, historical/heritage areas, areas rich in genetic diversity and areas likely to be inundated due to rise in sea level consequent upon global warming.

CRZ-II includes those areas which have already been developed up to or close to the shoreline. For this purpose, developed area is referred to as that area within the municipal limit or in other legally designated urban areas which were already substantially built up and which have been provided with drainage and approach roads and other infrastructural facilities such as water supply and sewage mains.

CRZ-III includes areas that are relatively undisturbed and those which do not belong to CRZ-I or CRZ-II. Coastal zone in the rural areas (developed and undeveloped) and areas within municipal limits or in other legally designated urban areas which are not substantially build up also come under this category.

CRZ-IV covers costal stretches of the Andaman and Nicobar, Lakshadweep and small islands except those designated as CRZ-I, CRZ-II or CRZ-III.

Under para-2, thirteen different activities are declared as prohibited within the CRZ and under para-3, all other activities expect those prohibited in para-2 above, will be regulated as given in the notification. Annexure 1 deals with coastal area classification and development regulations which are briefly given as above. In brief, the above notification has been proclaimed by many nature-loving people as a bold step in preserving our valued coastal zone.

4.2 Management Policy

The primary aim of developing any policy is highly functioned by the need to protect, preserve and develop the topic at hand. The coast, as they are known for their brittleness, but rigidity, are looked upon as critical regions of the world where numerous phases interact. This is also the place where the living and nonliving critically interplay to present multitudinal features. Over the

years, the need to manage such regions have been self-expressive, involved from within and did crystallise in the minds of planners, administrators, scientists and like minded people.

The rationale to create and protect coastal areas is as follows listed numerically:

4.3 Coastal Management

To conserve resources of the region by

a. Support life systems and maintaining the ongoing ecological processes.
b. Protecting the tropical or other genetic diversity and preserve the system.
c. Ensuring sustainable development and continued use of the region.
d. Preserving and providing natural venues for education, research and development and lastly
e. Derive social and economic benefits.

4.4 Systems Approach

To evolve a plan and policy regime

a. The policy proper
b. Associated legislation
c. Preliminary planning
d. Systems planning
e. The management plan
f. Management practises

The systems approach can be further synthesised for system analysis which has more relevance in evolving a management plan for the coastal zones. Some of the major subheadings are.

1. Problem definition
2. Problem structuring
3. Problem analysis
4. Objectives
5. Alternatives
6. Cost
7. Criteria
8. Models
9. System synthesis
10. Planning
11. Implementation
12. Programming
13. Installation
14. Monitoring
15. Evaluation

It is often stated that such a system analysis and its application in costal zone management would refer to

1. Research
2. Planning
3. Development
4. Implementation
5. Operations
6. Management

The actual areas where the above stated systems approach would find its application, are short listed below

1. Coastal weather monitoring and prediction
2. Water quality monitoring and control
3. Water resources management
4. Waste management
5. Coastal engineering and construction
6. Commercial and sport fishing, prediction and services
7. Fishery resource management
8. Regulation of fish and gain
9. Water borne transportation development and management
10. Recreational Services
11. Habitat development
12. Coastal zone planning development and conservation
13. Coastal zone surveys
14. Mapping and charting
15. Resource exploration and development
16. Aesthetics, enjoyment and coastal zone
17. Social practices (traditional or otherwise) and status.
18. economy and coastal zone development
19. Legal aspects and administrative options
20. Others and many more-site specific

4.5 Legislative and Institutional Support

To effectively bring about the desired objectives in it's full perspective, the following aspects may be considered:

a. Traditional practices
b. Prevailing conventions and laws

c. Local and regional aspects.

d. National aspects and policy guidelines

e. International aspects

f. General guidelines and practices

4.6 Coastal Environmental Scenario

To appreciate and evolve proper methods of planning, for

a. Coral reefs

b. Lagoons and estuaries

c. Tidal inlets and river openings

d. Open sea

e. Small islands

f. Coastal wetlands

g. Paddy and coconut farms

h. Aquaculture and mariculture areas

i. Coastal vegetation

j. Mangrove ecosystems

k. Inter-tidal areas

l. Specific sites such as mudbanks

m. And others

The above systems approach would be greatly beneficial.

4.7 Environmental Stress on the Coastal Zone

To appreciate the functions of the highly dynamic coastal zone which is under heavy pressure, the following may be considered:

a. Population growth and economic development

b. Degradation of natural resources
c. Changes in biological productivity
d. Loss of species with decreasing bio-diversity
e. Dynamic changes in coastlines
f. Exposed to natural and human-induced hazards
g. Accumulation of wastes and resultant pollution

The above aspects can also be viewed with the following items, importance attached to:

1. Degradation of resources
2. Population pressure
3. Resilience of natural coastal zone systems to cope-up with natural hazards
4. Vulnerability to climate change
5. Tendencies for annual flooding
6. Lack of waste disposal site and
7. Overall degradation of the ecosystem

n this connection, the inefficiency and resultant impacts on use or misuse of oastal resources are attributed to

1. Lack of data and misunderstanding of processes
2. Short-term thinking in terms of quick profits
3. Limited available technology
4. Limited financial resources
5. Weak organisation and lack of capabilities
6. Inadequate instruments and facilities available
7. Existing traditions

Another area of concern is the prevalence of natural hazards or otherwise in the coastal areas such as

1. Earth quakes
2. Typhoons/ Cyclones
3. Volcanic eruptions
4. Storm surges
5. Heavy precipitation and floods
6. Man-induced engineering works on rivers and shore lines
7. Land reclamation
8. Withdrawal of oil, gas and water
9. Sea level rise
10. Mining and dredging

From the above it is summarised that a systems approach to the protection, preservation and development of coastal regions is best suited to solve the issues at large.

This also helps to identify the weak and strong linkages between marine, coastal and terrestrial realms. As an example, consider a situation where coastal or marine protected area would be degraded considerably having influences and impacts on the inland areas such as those on the water sheds; these will have to be managed to a great extend so as to maintain the water balance of the designated protected area. In this context, a protected area is one about which certain amount of recognition is made but this essentially is a technique evolved for marine conservation. Area protection is usually aimed at achieving practical goals.

An area may be "protected" for one or more of the following reasons (Day *et al.*, 1989).

1. It is typical for an important ecosystem or habitat type
2. It has high species diversity
3. It is a location of intense biological activity
4. It provides a critical habitat for many particular species or groups of species
5. It has special cultural values (such as historic, religious or recreational importance) and
6. It facilitates necessary research or determining the "natural" baseline conditions

In many instances, the habitat, species and communities and thereby the full ecosystem that is conserved, have commercial/potential uses. As resources, these may be exploitable, are being exploited or over exploited. In terms of conservation this means that attempts are made to avoid conflicts and integrate most of the elements of a system analysis theme to bring about worthy development. For any given coastal zone, most of the following resources are put to extractive use within short to long term activity cycles. To name a few, they are listed here under:

Sl. No.	Resource and extractive use	Primary resource
1	Commercial fishing	Fisheries
2	Aqua culture	Shore zone biota
3	Desalination	Ocean chemicals, drugs
4	Mineral exploration	Marine minerals
5	Petroleum production	Seabed exploration

6	Landfill	Beach protection
7	Dredging	Coastal protection
8	Energy	Wave, tide, currents, wind
9	Commercial shipping / land-air transport	Navigation
10	Underwater parks	Undisturbed seabed
11	Habitat development/housing	Shore zone
12	Recreation	Unpolluted beaches and water
13	Waste disposal	High carrying capacity/offshore area access
14	Agriculture	Land/water availability and primary inputs
15	Flood control	Water management plans
16	Industry	Land/water availability and raw materials

In addition, the prominent biological life aspects are fish and fisheries, migratory birds, spawning grounds, zones of high biological productivity, nutrient inputs and recycling, abundance of trace metals, upwelling zones, terrestrial runoff and hydrological cycle, unique habitats, toxic algae and such other organisms and special features like mangroves, mud banks etc.

It is imperative to recognise that most of the human activities and their impacts have had a telling effect on the coastal zone and its stability. The human interference include direct uses of living resources such as

a. Extractive use of food
b. Use of marine products
c. Recreation

d. Science, research and education, and

Other uses which may vary from waste disposal to extraction of inorganic material and lot more.

A short list on the human activity may encompass the following

a. Marginal land use and patterns
b. Solid waste disposal and pollution control
c. Building sites
d. Ports and harbour construction
e. Shoreline modification and beach stability
f. Ocean shipping and navigation
g. Other transportation means – oil, gas etc.
h. Power generation and industry
i. Ocean mining and dredging
j. Communication
k. Military uses
l. Fisheries
m. Recreation
n. Agriculture
o. Technological interventions

Conceptually the above human activities should help the betterment of man's living and his environment but contrary, in many instances, degradation or destruction have been noticed. This takes many forms

1. The replacement of entire habitat by new settlers or harbours or defence structures or other human constructions like plantations, green lands, crop lands or by mining and quarrying

5. Conversion of traditional agricultural lands to aquaculture ponds
6. Environmental Impact Assessment (EIA) on hydraulic structures in the lower delta regions for a highly populated area
7. Public/political awareness
8. Establish a healthy linkage between-people-technology-economy-politics
9. On the construction of river bank and near shore protection
10. Construction of power supply dams
11. Construction of irrigation reservoirs
12. Land use patterns and their impacts
13. Such others

The early studies in coastal zone were mostly directed to understand the natural background and enhance our knowledge on disaster management, storm surges and tropical cyclones, prediction of these events, coastal sediment budget, watershed management, ground water and its exploitable resource, salt water intrusion problems and further extend our knowledge on human impact studies with specific cases on pollution, aquaculture, mining etc. The general studies in this subject were to formulate coastal zone management plans, legislation, capacity building etc.

In whereas the above topics have been repeatedly attempted in recent years, the current emphasis has been on coastal zone itself and open ocean coasts. The issue addressed herein are natural variability, greenhouse warming, subsidence or uplift, tectonics, weather systems and coastal response, large climatic changes and so forth. In the Indian context and mainly for the study

area covered under this thesis, the management policy on the coastal zone has the broad objectives listed hereunder:

a. Prevention of costal erosion, beach front protection and development
b. Controlled mining of sand for placer deposits, beach nourishment and reclamation
c. Pollution control and conservation of ecosystems
d. Control on habitat development
e. Regulated recreational and tourism development
f. Controlled development of coastal wetlands
g. Development and management of coastal waterways and land transport systems
h. Energy development and transmission schemes

4.8 India's National Coastal Policy

India's initiatives in CZM concerns from 1981 when the issues to conserve beaches came up before a national committee. The 1986 Environment Protection Act and the 1991 CRZ notifications are two great milestones. Though approval for coastal zone management plans for each state was desired in 1986, not much has really taken place in the direction visualised. Henceforth in 2001, a National Coastal Policy was mooted. The positive impacts are due to emerge, may be in another couple of year's time. The salient features of national coastal policy proposed and the management guidelines are

a. Adopt a holistic view of the coastal zone

b. Identify the ecologically sensitive areas and bring about their development by providing adequate financial inputs
c. Each state shall prepare an ICZM plan
d. All coastal states adopt permit/regulation criteria for activities at local level
e. Conduct of EIA becomes mandatory
f. It is advisable to have fixed set back dates
g. All developmental activities be linked or integrated to environmental upgradation
h. Evolve intersectoral co-operation in all activities proposed with in a segment of the coastal zone
i. Adopt conflict resolution mechanisms for coastal issues
j. Promote interstate co-operation
k. A viable and working administrative setup is given due importance
l. Encouragement in public participation is visualised within this policy, and
m. All activities implemented in the coastal zone will be monitored and reviewed.

These new policy guidelines proposed since 2001 upholds the popular approach to adopt a holistic view of the coastal zone. In other words, the systems analysis and approach as discussed above, will fully satisfy the above concept to integrate a number of activities and conduct interactive programmes and promote processes onto one single plain such that the relative merits and demerits are counterbalanced and a justifiable solution can often be arrived at. The long due recognition (accepted of late) that the coastal zones do contain ecologically sensitive life forms, stands justified in the Indian

context by the promotion of its development through adequate finances. Next on the agenda, the guidelines to incorporate ICZM and EIA are not new, however, their continued inclusion for management purposes is a welcome step. A word of caution is sounded when ICZM planning should function in its full perspective (as discussed in chapter 1), it may be truncated to simple CZM practises. This is so because adequately trained man power (say, a coastal manager) is still not functional in this state or elsewhere. Already the state council which deals with coastal policy and management for Kerala has evolved a working mechanism by issue of permits for specified activities. Another policy directive is to fix set back dates - the viability of this concept is rather doubted as the impacts on the coastal zone are so marked that retrieval to status-quo or implementing an action plan on a date bar schedule appears impractical. Probably in a few more years and more, concerted efforts are required before bringing about fruitful implementation of the next three items on the guidelines programme. These are integration of environmental upgradation with development, intersectoral co-operation and conflict resolution and interstate co-operation which require larger extent of practical working knowledge so that once again those activities which are ongoing and those proposed, work harmoniously along a longer stretch of the coastal zone. One topic, that is, conflict resolution could be the one which can be attempted.

Regarding the administrative setup to manage our coastal zones, this subject matter alone comprises the most difficult task because of the existence of multiple authorities, multi-functional roles, diversified objectives, conflicting opinions, lack of leadership and so forth - the formation of a single authority within a democratic framework should ease the problems - the formulation of such an authority in these times, of course, appear incomprehensible.

The most striking feature is the People's Participatory Programme (PPP) which has been implemented in Kerala since 1997 and the same has found positive within the above stated guidelines. Public participation is one such forward step so that collective responsibility is assured, when people feel a sense of commitment and their governance is bound to bring about positive results in the area of coastal zone management. Normally through this move, implementation, monitoring and review should form part of any healthy management programme, contemplated in the geo-environment.

4.9 Beneficial impacts of CRZ

1. Zoning, a concept by itself promotes the development and sustainability of a geographical area in a positive manner.

2. The promulgation of the CRZ notification generated considerable interest and awareness among masses on the importance of the coastal zones and its implied message is bound to generate healthy traditions in managing coastal ecosystems.

3. Though the time was high and demanding, the concept of ICZM to be practiced for a coastal area will bring about the development in a phased manner; in the initial years some amount of resentment is bound to occur.

4. In the notification as well as in the policy guidelines, adequate provisions are incorporated to recognise the rights of traditional fishermen settle in the coastal zone.

5. Of late, much of the industrialisation leading to conversion of the coastal lands altered the built-in setup which was being promoted mainly for short-term gains (the development of aquaculture ponds, felling of

mangroves, locating new industries etc.). This approach has been put to a stop and even coastal tourism, much hyped about, now comes under control. This is a positive step of CRZ notification.

6. Without bias, it is a known fact that most of the coastal waters are polluted due to discharge of industrial wastes or city sewage and thereby the coastal regions are hub of toxic materials and in such places, contagious diseases often breakout. It is imperative that some form of very strict control is exercised so as to alleviate the hazards of pollution, thereby marginally improving "coastal health".

7. There are high expectations in the tourism industry when a well regulated policy will mutually work for the betterment of the coastal zones and the newly inspired enterprise on eco-tourism. Of course, a planned development in a coastal zone is likely to attract tourism and related activities (which ensures economic growth too).

8. Customary for any coastal zone of the world, fishery is one such activity which has a common bondage. All plans, implementation of projects, improvement measures, developmental activities or any related enterprises will invariability address the welfare of fishermen and fishing community. Probably the best impact out of CRZ notification will be benefits those traditional fishermen stand to gain, apart from the new generation which rely on more modern techniques for fishing.

9. The notification addresses in one way or another, some form of protection to be afforded for life and property in the coastal zones which are open to natural hazards. Predesignating such areas , providing sufficient warnings (currently practised), evolving such plans which are conducive in case a

hazardous events should occur, restricting the conventional form of development as seen in most coastal regions etc. brings consolation to the ever–menacing issues faced by the occurrence of many natural hazards.

4.10 Drawbacks of CRZ notification

1. The concept of fixed boundaries of 500, 300, or 100m as the case may be, in CRZ, is not a practical solution to address developmental issues. On a case to case basis, sector by sector, functioned by the geo-environmental settings, the activities have to be regulated in each of the zones or stretch having common features.

2. It is true that most people dwelling on the coastal zones come within the lower income group and being in the "No Development Zone" (NDZ), house constructions are prohibited for these people to dwell. And in the absence of alternatives, this group of people are put to greater hardships. In reality, the concept of NDZ promotes slum development and garbage dumping.

3. Now-a-days, mechanised fishing often requires better facilities – maintenance yards, fuel stations, storage houses, ice plants and so forth which are not envisaged to function in the coastal zone. These aspects require thorough introspection.

4. It is recognised that space is limited in the coastal zone and given the amount of effluents and wastes which gets accumulated in this region, proper treatment facilities ought to be permitted – however these stand banned.

5. Unchecked reclamation is of course not a welcome idea. However a total ban is not also advisable. This aspect will have to be looked into for amendments.

6. Ground water extraction close to the marine boundary actually invites salinification where restrictive methods are available based on quality checks; the concept of total ban should be recast.

7. The notification has often lead to inviting litigations in view of non-defined terms and absence of methods and means to arrive at a judicious ruling. The law should be explicit, clear and above ambiguity.

8. A glaring lacuna is the free and unchecked use of water front within the water body for expansion purposes where as the land front, facing the water body is placed under restriction for development. In practice, this means that tourist resorts can be established behind a curtain of unethical, unhygienic agglomerates and equally those activities in the water body need not necessarily support healthy (eco) tourism.

9. The CRZ notification does not have a built-in mechanism to create awareness among the people on the do's and don'ts within the coastal zone. Misinterpretation of the process has lead to delay, loss and economic instability to the people residing in the designated areas. A counter productive result was the obstruction of lawful activities and on the other hand failure to enforce the right legislation promoted unauthorised "development".

10. The coastal zone is (should be) a buffer between the sea and land in simple terms. If continuity is not ensured in infrastructure facilities both on land

and sea, it is bound to impact upon economic development. Such a scenario is likely to occur in CRZ-III which should be prevented.

11. As stated earlier in a different context, the regulations are not developed based on the coastal geomorphological features which govern most of our activities in any coastal zone. A new line of thinking will have to be evolved when considering development of conservation of any such region which has a bearing on its inherent geo-environmental scenario.

12. Lastly, a glaring drawback is the prohibition on building protective structures in ecologically sensitive areas. Amendments sought.

As time passes by, more contradictions are expected but these could be smoothly remedied since the spirit of preserving, protecting and developing the coastal zones are our prime concern now.

4.11 Critical Appraisal of the study area in terms of CZM

The salient features and (considered) opinion there on are expressed hereunder for different domains.

4.11.1 Agriculture

- For a century or more, major agricultural activity was paddy culture.
- Since 1970's the practice changed to paddy and coconut plantations.
- Lately in 1990's more emphasis has been on aquaculture.
- In step with population density increase and advancement in the concept of nuclear families, demand for house and housing plots brought about reduction in agricultural land and switch over to development in housing.

- Practical and economic reasons set a trend for short-term gains through prawn cultivation.
- Presently coconut plantation stands less profitable and unpopular.
- The coconut cultivation stands on drainable lands, clay filed areas, sand bars on nearshore regions and border areas of paddy fields only.
- Changes in natural drainage pattern has affected paddy culture and often saltish water prevents growth in coastal regions.
- Agricultural practices in paddy cultivation is threatened by

a. economic reasons
b. pest problems
c. rainfall pattern changes
d. absence of good seed stock
e. popularity for prawn farming
f. too small land holdings
g. increased availability of rice at low prices from elsewhere
h. poor irrigational facilities and
i. manpower availability issues

- Most of the low-lying coastal regions are converted to prawn farms. Prolonged use of these regions under higher saline conditions, render them unfit for roll back to paddy cultivation.

4.11.1.1 Future Outlook

- The trends speak of short-term gains at the cost of environmental degradation.

- Land conversion tendencies are still continuing and there is little hope of reviving large area cultivation with adequate irrigation facilities in the area of study.
- The agricultural sector is also facing added handicap due to globalisation and unsteady markets.
- Climatic patterns too have not favoured consistency which is an essential attribute to systematic cropping.
- Unless economic incentives and subsidies are made available, in the framework of a long–term plan proposal, the agricultural practices of this region appears to be bleak and is not sustainable.
- Small time "other crop(s)" (detailed in chapter-3) cultivation may thrive in this region.

4.11.2 Housing

- The area under study is densely populated.
- Land area for housing has been shrinking over the years.
- Economic prosperity is not consistent and hence housing sector has lately been much affected.
- Restriction on river sand mining has risen the cost of raw materials bringing about a near stoppage in development sector.
- People are accustomed to multiple professions, seasonally based and are on daily wages.
- Housing hence is a dream for most.
- Temporary, make-shift arrangements and slums are often noticeable with poor sanitation facilities.
- Many number of colonies and shore area houses, closely-spaced, render living conditions in poor light.

- Habitat development is unplanned. Existing good houses are three-four decades old but well maintained
- CRZ notification prevents build up of new permanent houses or full fledged modifications of existing but invariably has lead to a spurt in putting up makeshift houses or extension works to existing ones.

4.11.2.1 Future Outlook

- Affluent and old house owners enjoy the luxury in reasonably good houses.
- A larger proportion of the population "below the poverty line" still continue in make-shift or temporary houses.
- Absence of good developed area, sanitation and infrastructure inhibit further advancement in housing and invariably a trend is bound to set when people will be forced to migrate out of this region.
- In the next decade or so (super) saturation in housing is likely to be reported ignoring which the continuance of habitat development is bound to bring in more conflicts, hygiene issues and lack of harmonious living conditions in this part of the coastal zone.

4.11.3 Forestry

- Scanty and less found as the coast is low-lying and enjoys maritime climate.
- Once abundant mangroves have diminished but lately its re-dominance is being attempted.
- Coconut trees back the coastal belt. The other crops are mango trees, Jack fruit trees and such other varieties which grow to moderate heights.

- Coastal vegetation comprising of root grass plants or pine trees or shrubs are yet to catch up in popularity (except in certain parts of Purakad region).

4.11.3.1 Future Outlook

- Promotion of social forestry has been an activity with public participation.
- The area is not conducive for programmed, zones-segregated forest development.
- A proposal is called forth to implement a programme in promoting beach vegetation.

4.11.4 Transportation

- People of the region depend on road, rail and water for transportation.
- By road, national highways and coastal roads and a network of suburban and rural roadways provide reasonably good mode for land transport.
- The presence of large number of canals, open wetlands and shallow regions demand construction of bridges which is lacking.
- Coastal towns and villages are linked by coastal railways.
- Inland water navigation is yet to develop which is cheaper and cost effective.
- Generally roads are poorly maintained during monsoon and so are boats and jetties.
- In glaring contrast to most marine accessible regions, the area of study which has an oceanic boundary does not have adequate or minimal facilities for marine navigation.
- Helicopter landing facilities are possible at a number of locations.

4.11.4.1 Future Outlook

- Further progress in roadways is ruled out except massive flyovers are constructed.
- Currently there are no proposals for the expansion of rail networks, if any, it should be the doubling of present lines.
- Inland and small canal navigation is the main sector to be concentrated upon for easing the transportational bottleneck for the region under report.
- Another most important sector, by the promotion of marine navigation by means of hover crafts, large bulk carriers and so forth, should be seriously considered.
- In circumstantial conditions, air traffic (use of helicopters) may be attempted.

4.11.5 Power and Energy

- There is a chronic power crisis in the state (coastal region too) due to high population density (low supply, high demand)
- Scarcity of firewood, hydroelectric power or other forms of energy complicates the issue.
- Liquefied Petroleum Gas (in cylinders), kerosene and diesel help running of the essential sectors.
- The household sector uses more electricity power.
- Non conventional Energy sources are unfamiliar to most (bio gas plants are rare and very few people use solar lamps).
- Power cuts are a common feature of the region as well as the state.

4.11.5.1 Future Outlook

- Energy sector is not sustainable, with out massive investments.
- Life and life style will self-modify in due course of time, in tune with energy crisis.
- Is nuclear power plant a good option? (Hypothetically, siting in nearshore regions?)
- Extraction of ocean energy in the present scenario of known available technology is not worth considering (break throughs expected such as precipitation runoff harvesting, tidal current power generation, wave and wind energy extraction during monsoon and so forth).

4.11.6 Health and Drinking Water

- The area is surrounded by marine, brackish and fresh waters
- In old times fresh water sources were wells and ponds.
- This was augmented by water pipelines services, using river water; people began avoiding and misusing the old freshwater sources.
- Now a days, wells and ponds are mostly unfit for use.
- Presence of fluoride in parts of Alappuzha district is a cause of major concern.
- In last five years tube wells abundantly extracted ground water leading to an increase in inflow of saline waters and diminish ground water resources.
- Rain water harvesting has not been popular.
- Drinking water pipeline supply is largely inadequate to meet the requirement of the population.

- Summer months bringing about severe water scarcity and is a major problem of concern.
- Back waters and canals are polluted (open toilets and wastes from fish processing units plus city sewage - solid waste).
- Due to undulating topography and changes in land use pattern, the drainage system is poor and hence water logging incidences are common.
- This brings about sanitation problems, and stagnant polluted waters are a heaven for mosquitoes.
- Though sufficient medical institutions are available, water borne diseases such as cholera, typhoid, rat fever etc. are often reported.
- However infant mortalities are reported to be very low.

4.11.6.1 Future Outlook

- A systematic, methodic drinking water supply scheme has to be implemented on a major footing.
- The option to use backwaters during the monsoon months (when fresh water conditions prevail) after necessary purification is a worthwhile thought.
- Rainwater harvesting to be made popular.
- In reality, a sizeable population can actually dwell on a water industry.
- Schemes are now being thought on introducing desalination plants along the coastal region. This is a welcome step; economics to be separately worked out in long-term.
- The need to conserve ground water at a sustainable level is the need of the hour.

- Control on vector diseases and contagious forms of waterborne infections are equally important which otherwise indicate the ill health of the hydro-system and partly the geo-environment including the habitat.

4.11.7 Irrigation

- No concrete provisions or designs were observed in the region.
- No common irrigation plan has been evolved.
- Any activity has been restricted to local Panchayath level.
- People mainly depend on rainfall (unseasonal), backwaters, ponds and wells for irrigation purposes.
- Fresh to mild saline waters from the ground is also utilised for irrigation.

4.11.7.1 Future Outlook

- A good net work of irrigation canals and pipelines can boost the agricultural output.
- This would invite moderate to large scale investment and long-term planning.
- Large area irrigation maps have to be concurrently developed.
- As in other parts of the world, mainly Europe, all developmental activities are now relying on proper water management.

4.11.8 Communication

- The operational state of telephone, radio, TV, cable network, wireless communications are satisfactory.
- The fishing community is increasingly making use of mobile phones for trade purposes.

- Mail, parcel and such other services are adequate with good number of post offices.

4.11.8.1 Future Outlook

- The trend is healthy and could be improved.
- People make best use of these communication facilities for updating knowledge, education and (overall) welfare.

4.11.9 Industry

- High population density inhibits industrial growth.
- Absence of raw material, full-time power sources and infrastructure are handicapped to industrial expansion.
- Landscape is not much suited to locate heavy industries.
- Navy dockyard and other minor boat repair facilities enjoy privileged existence.
- Fish processing units, ice plants, small automobile works, glass factories, coir manufacturing locations, breweries, oil mills, furniture works and such others exist but with inherent drawbacks.
- Skilled, semi skilled manpower is in excess.

4.11.9.1 Future Outlook

- Industrialisation has not rather arrived in this coastal region.
- Information Technology-based software firms may flourish in due course of time.
- Fishing sector actually demands large scale expansion.
- Offshore sand mining may develop as an industry provided related environment hazards are mitigated.

4.11.10 Fish and fisheries

- 60% of the population is directly or indirectly related to fishery and fishing sector.
- For this part of the coastal zone, in the absence of other industrial concerns, fishing, fish processing and seafood trade are the major occupational areas.
- Mudbanks and associated biological activity bring large fish landings in this region.
- However fish-related industries are a major cause of pollution.
- There are ice plants, processing units and other supporting firms for the fishing industry which provide good support.

4.11.10.1 Future Outlook

- This sector has tremendous potential to grow.
- The harvest potential has been attempted not to full and provided there are better storage facilities with processing plants, the fishing industry could bring in large foreign exchange.
- Deep sea trawling is one area which requires expansion and promotion.
- Fishing harbours and similar vessel handling facilities have to be installed.

4.12 The coastal zone – Opportunities and Issues

The present status scenario generally applicable to the study region is as follows. The important constrains and opportunities available along the coastal regions of Ernakulam and Alappuzha district are evaluated for different issues often addressed; this is made readily available in the form of a table. This would be helpful in the preparation of addressing solutions and suggestion

which is essentially a part in planning as well as towards attaining sustainable development.

Opportunities	Issues Addressed	Constraints
Skilled manpower	High population density	Employment problems Economic development Upkeep of habitat Adequate housing Land use pattern Waste generation and pollution Availability of land Inadequacies in infrastructure Resource limitations
Agriculture	Resources	Fragmented lands Economically nonviable Climatic conditions
Aquaculture		Availability of aqua fields Salt water circulation Fish diseases
Marine resources		Lack of trawlers Inadequate landing facilities Deficiency in storage Options in export No long term planning

High consuming rate and man power	Industries	Non-suitability of land and landscape No raw materials Infrastructure is limited Deficiency in power
Inland navigation Agriculture Aquaculture developmental zone	Land features	Low coastal plain regions Water logging Poor canal networks Pollution events Surrounded by saline to brackish waters Inadequacies in fresh water availability
Clean well and pond water Rain water harvesting Recycling of used water Diversification of resources	Water resources	Water is not available adequately Seasonal cycling Solely depends on pipe line pumping No fresh water resources available nearly Accumulation of wastes High instance of water borne diseases Lack of public awareness
Inland navigation Improved boat services Siting of ponds and	Transportation	Low lands with large canal networks High cost in bridge construction Blockade in movements through

harbours		canals Poor maintenance of jetties No direct oceanic approach to shore Increasing vehicle density
Awareness Health campaigns Hospitals Pollution control Super speciality facilities	Health and hygiene	Poor environmental hygiene Poor living conditions Poor precautionary methods Poor sanitation conditions Water logging Presence of air pollutants Alcoholism and related issues
Advanced highly skilled personals Job oriented training Centres for excellence	Education	Poor infrastructure Economic Incentives No higher educational facilities
New installations Non conventional energy	Energy	Power cut and voltage drop Non availability of land for new power houses Environmental over reactivity Lack in accepting non conventional energy forms

4.13 Major interventions in the Coastal Zone

This refers to engineering feats which have lead to considerable alterations in the habitat and living conditions within the zone of interest

1. Cochin Port

The Willington Island and Port created during 1938-45 permitted sea traffic. This was accompanied by dredging which altered the sub bottom profile and still continues to do so with varying environmental impacts (Balchand and Rasheed, 2000). As a major port, this facility has had large economic implications for the state of Kerala. A railway terminal and airport are located within the island. Also, the location serves as the base to Southern Naval Command.

2. Thanneermukkom Bund

The bund was constructed on the southern part of Cochin backwaters to prevent saline water intrusion which will lead to two-time paddy cultivation in Kuttanad. In reality, however, the event has been a major misfortune since considerable environmental degradation has resulted in low paddy yields, breaking the natural cycle of flushing of water and particulates but holds back most of the pollutants. There are other biological perturbations when considering the failure of the bunds in it's primary objective(s).

3. Thottappally spillway

Completed in 1955, this construction should have permitted easy passage of river waters to coastal seas which would help in reducing floods on the southern parts of the study area. However, the canal connecting the spill way does not actually serve the purpose, but often carries sea water inland.

4. Embanks for rice cultivation

Many regions of Kuttanad as well as those in the study region have concrete, rubble or earth embanks to prevent flooding and sea water entry. Also the boundaries are strengthened so that cultivation can proceed unhintered.

However, only certain places have been benefited due to the unscientific construction techniques adopted.

5. Temporary regulators

In certain reaches of the canal networks, temporary regulators or barrages have been constructed to prevent sea water entry or contaminant. Not always have these been of much help in maintaining the eco-balance.

4.14 Port construction and coastal management

A comment is offered on siting and maintaining ports and harbours at Chellanam, Andhakaranazhy, Alappuzha and Thottappally (and other places acceptable for such activities). These locations may serve to a minimum degree as fishery harbours or could cater to small to medium sized vessels. These statements are promoted by the fact that, at a near future date the sustainability of the region will improve and thus cause the commencement of expanding the fishery potential as well as by the export of seafood-since economic gains can be well achieved by proper planning, development and management of the fishery sector. Though such ports and related fishery activity would contribute to massive economic prosperity, there are inherent negative impacts which require proper mitigating measures. Primarily the impacts could be on land and air but particularly in the water media. This is brought about by pollutional discharges, oil spills, dredging, constructional and operational damage. The industries located closed to the port may cause land pollution where as unchecked gaseous emissions could bring about air pollution. Some amount of restriction, legal or otherwise could help in improving the scenario but self control and proper management practises can alone help the up keep of environment cleanliness. The potential negative

impacts for a port/harbour region are as follows along with mitigation measures as applied to the region of study. The selection and siting of a location for port development would result in translocating people, disturbing the surroundings, affect the sensitive habitat and cause perturbations to the aquatic resources. EIA is most essential in such conditions and that the selection should never be or be adjacent to a sensitive habitat. The question of displacing people is to be tackled from a socio-political view point and this is economically significant too. The construction of a port should ensure that a reasonable equilibrium is fast ensured for the port vicinity, the channels and surrounding regions between erodable materials and sediment inputs. There is bound to be disturbance to the flora and fauna especially if dredging is introduced. In such cases a fixed area will be permanently lost (or stand allocated) for port operations and hopefully some (diverted) funds are available to strengthen the ecosystem elsewhere.

Marine traffic could cause possible embank destruction or damage to under water cables, pipelines and outfalls etc. This can be mitigated by properly identifying the peculiarities at each port and by modifying the harbour operations. Noise is another parameter of concern which requires personal and collective action to keep it at a lower acceptable level. In the water environment, turbidity often brings about large changes, even fish kills, thereby impacting aesthetic values. Use of silt curtains or coinciding with high ebb flows, the ill impacts of turbidity could be reduced marginally. In most harbours, natural or anthropogenic contamination brings about a reversal in water quality leading these areas to be declared as hotspots. This could be directly tackled. Extensive dredging apart from known negative impacts can also cause changes in river-nearshore circulation, biodiversity and salinity

intrusion patterns. The only way out here is modelling or conducting studies to assess the impacts beforehand and later progressing with attempts to minimise the impacts. In many instances there is a loss of shoreline integrity which can be possibly evaluated beforehand and necessary precautions can taken care of. From a human habitat view point, the presence of a port or harbour could bring about changes in social culture. Certain people do welcome changes but however that this should not affect the traditional practices or values. In many parts of the coastal region there may be archaeological sites and these could be avoided. A common sight in many ports of India is the occurrence of oil spills or petroleum products within the operational region and such instances will have to be strictly encountered upon. With the evolution of a port, surrounding areas will have to bear with saltwater intrusion into ground and surface waters. In quite grave situations, necessary modifications will have to be made for the water canals, divert away the tidal bore or augment the location with more river water. Dredging mainly impacts the bottom flora and fauna as well as the spoil may bring about uninhabitable conditions at the site of discharge. The only way out is prehand studies to assess the impacts and to choose a location where the spoil discharge has the minimum impact. Accidents could easily occur but under proper training and by use of safety devices, fire, spillage or such other accidents could be avoided. There is a tendency for people to discard small waste articles into the harbour waters. On accumulation, these have a telling negative effect on the system which should be avoided at all coasts. Heavy rail-road traffic or air cargo movements often upset the livelihood of local people. Some adjust quickly but on the whole the rest of the population could ask for time regulation as well as capacity regulation. Trained staff personnel have to be

deployed for mitigating the negative impacts and help maintain a healthy scenario around the existing or proposed ports so that the coastal zone may function in a better way.

4.15 Coastal Ocean Space – a Concern as well as Convenience

The discussion given hereunder pertains to the shoreline length of 82km from Fort Cochin to Thottappally and 20km towards offshore (adjacent to Ernakulam and Alappuzha districts). Only one permanent opening (at Cochin inlet – extreme north) and two seasonal openings, one at extreme south – the Thottappally spillway and the other is at Andhakaranazhy exists. The spillway at Thottappally is closed by a sand bar more or less naturally, which has to be cut open physically to drain the flood waters during southwest monsoon season (the spillway is then opened). Otherwise seawater will enter into the low lands of Kuttanad paddy fields. The scenario at Andhakaranazhy is similar but different. A natural bar is thrown offshore by the outflow of water from the hinterlands around this region when two sluice gates are kept open to drain rain water. This happens during monsoon period and later on, nature works around to close the inlet by moving sand inward (Ajith, 1996). Of course, there are a number of small openings along this coastal line which drain excess rain water to the sea. There are also a number of fish landing centres on the beach face depending upon road approaches to the beach but are mainly functioned by fish harvesting grounds in the nearshore.

The quantum of inland waters flushing out through the Cochin inlet is about 11×10^9 m^3 fresh water, annually. To this sewage and industrial wastes approximately 1.4×10^6 m^3 /day is added. Though no industry is directly discharging waste into the sea, the backwaters are made use of transporting the

waste to the coastal waters. In the harbour region maintenance dredging takes place during most of the months and at times capital dredging too is practised. The dredged spoil is disposed offshore within the study region or is made use of as reclamation material. The above activities are likely to bring about local and low intensity pollution problems in the coastal seas.

The common activities in the open ocean space are moderate to intense fishing, marine navigation, recreation (sometimes unauthorised), extraction of beach sands, coastal protection works and dredging of the approach channel to the Cochin port with the spoil after dredge, being disposed at offshore sites. Navy, at times, conduct defence exercises in this region. The activities may intensify during the occurrence of mudbanks which has been discussed in chapter-3.

A recently concluded study covering the area mentioned in thesis, by National Institute of Oceanography (NIO) – Regional Centre- Cochin for estimating the carrying capacity of the coastal waters have indicated seasonal bi-directional currents, semidiurnal tides, depositional and erosional tendencies along the beach, presence of well oxygenated coastal water, slightly excessive nutrients with a mild increase in trends but normal values for dissolved trace metals. The textural characteristics of sediments are variable but mostly clay dominates the region (70-75%) followed by silt (20%) and the balance is sand. The organic carbon content is around 10-15mg/g or even 25mg/g at times. Local pollution instances may crop-up from coconut husk retting wastes or dumping dredged spoil or faecal contamination on the coast. Oil pollution has been a potential concern though major tragedies have not yet occurred. According to the Central Water Pollution Control Board (CWPCB), the

Cochin area is classified as SW-IV which is designated as harbour use, but in fact, SW-I to SW-III can also be applied for regions where salt pans are present, shell fishing and mariculture are practised and it is an ecologically sensitive zone. Also bathing, water sports, commercial fishing, recreation and aesthetics are listed as designated uses. In the long run the nearshore waters of Cochin may figure as a "potential hotspot" because of continued built-up of nutrients and trace metals above the tolerance limit. In the present scenario, most parameters had indicated values within the prescribed limits of CWPCB (refer CWPCB report of Greater Cochin region, 2001). In light of above, the coastal waters have adequate health and scope for holding extensive marine activities which are conducive to development; however only those which do not degrade the marine environment is acceptable. These could be marine tourism, nearshore navigation, mariculture activity and engineering feats like beach restoration by means of beach savers. Better port facilities could be provided at Andhakaranazhy and Thottappally plus erstwhile Alappuzha port could be restored to its old glory. A number of small fishery harbours could also be located in this coastal stretch. Conceptually, in case of genuine need, a few locations may be serving as developing zones for "marine cities". The option to locate a few desalination plants are again acceptable. Fort Cochin, Arthunkal, Mararikkulam and Alappuzha are sites suited for beach recreation and development. The seaward region off Andhakaranazhy (or a site in the vicinity of Cochin inlet) is proposed for locating a SBM (Single Buoy Mooring) to berth oil tankers and to connect pipelines for sea to land transfer of crude oil. A modern facility should pose no environmental concern except for a major accidental oil spill/fire. In the absence of abundant sand deposits, any mining activity is probably not attracted to this region. In case new sand

resources could be located providing sustainable yields, this enterprise may take off with adequate protection measures.

There has been a long standing proposal for a Liquified Natural Gas (LNG) terminal just north of Cochin inlet, along side a thermal power plant another proposal speaks of a container terminal within a Cochin Port. These may develop in due course of time.

A management plan for the coastal open ocean space may address issues on coastal hygiene, better controls on waste discharge into inland waters which ultimately reach the open ocean space, control over deballasting activities and dumping of dredged spoil. New activities should be cleared only after a proper EIA study. Cochin Port and Coast Guard have often proclaimed their readiness to abate oil pollution – this may be reviewed to incorporate accidental chemical spillages too.

4.16 Coastal Zone and the Fisheries Sector

Certain other issues pertaining to the open ocean biological environment are over fishing, loss of nursery grounds, toxic algae blooms, use of inappropriate gears and allied activities. The dimensions of coastal fisheries (Government controls, community based fisheries, special habitats, trawling impacts, fishing vessels and their class, marketing strategies etc.) are far beyond the scope of this work, but in fact this particular sector can potentially serve to uplift the economy of the region and contribute successfully to a certain extent, the sustainable development of the region and state. To substantiate this statement, the annual marine fish landings have indicated consistent advancement in Alappuzha and Ernakulam districts over the past two decades

except a reversal during 1991-93 period. The export of marine products for Ernakulam district alone again shows an increasing trend.

From a management perspective, too many number of government institutions do not contribute substantially to the benefit of any sector. For the fishery sector nearly 18 organisations independently and jointly interact to promote fishing activity. To name them, they are as follows:

- Department /directorate of fisheries, Govt. of Kerala
- Matsyafed
- Agency for Development of Aquaculture, Kerala (ADAK)
- Harbour Engineering Department
- Fisheries Welfare Board
- Central Marine Fisheries Research Institute (ICAR), Cochin
- Central Institute of Fisheries Technology (CIFT), Cochin
- National Institute of Oceanography, Regional Centre, Cochin
- Marine Products Export Development Authority (MPEDA), Cochin
- Fishery Survey of India, Govt. of India
- Integrated Fisheries Project, Govt. of India
- Central Institute of Fisheries Nautical and Engineering Training (CIFNET)
- Central Institute of Brackish Water Aquaculture, Regional Centre, Alappuzha

- Fisheries College, Kerala Agricultural University, Cochin
- School of Industrial Fisheries, CUSAT
- School of Marine Sciences, CUSAT
- NABARD
- NGO's

On the whole, commendable advancement has been achieved but more needs to be done such as control on the excess number of motorised boats, use of appropriate nets, conflict(s) mitigation, improvement in stock holdings, legal interventions and so forth; these would address the issues on the ground. Further the fishery sector will benefit from addressing the following issues too.

1. Establishment of a superior authority to exclusively attend to the promotion of the fishery sector.
2. Attach importance to deep sea trawling, enhanced fish landings and proper conservation management measures.
3. Regulate the export market.
4. Avoidance of stagnation of fish catch against increasing efforts.
5. Promote traditional practices.
6. Involve fishermen to participate in management decision making
7. Proper estimation of potential yield and sustainable yield of coastal fisheries.
8. Continuing the ban on monsoon trawling for a fixed number of years to come; assess the impacts and further regulate the enforcement.

9. Evolve a clear mechanism to intervene and resolve conflicts between the mechanised and non-mechanised fishing sectors.

10 Expediate those schemes which have been evolved for improving the quality of life of fisherman.

11 Evolve a mechanism to link income –expenditure in fishing operations so as to regulate and decontrol government interventions

12 Regulate the use of gears depending on stock assessment

13 Address issues on mariculture, natural disasters and water pollution

14 Involve better scientific system on prediction of fishing grounds

15 Establish linkages between ecological, technological and social interventions so as to attain a justifiable balance in continuing and improving the existing systems

The specific problem in aquaculture for which management plans are yet to be formulated are intensive farming, fish diseases, pollution and ecological issues, and excessive use of antibiotics, production of healthy seeds and feeds, quality management and unhealthy practices. Many of these issues could be redressed if a holistic approach is adopted for a region as a whole.

Sustainability in the fishery sector should be addressed with more concerted efforts since most management and development over half a century has not yet yielded results – basically to alleviate the poverty of the fisherman. Specifically to this region selected for study and also common to other parts of the state of Kerala, fruitful ICZM can yield positive results only on improving

the condition of the local fishing community through participatory programs such that

a. A feel of social security is installed in the local community

b. Emphasis is laid on fisheries management

c. By adopting a policy on common resources, fish landings may not truly reflect the real cost of fishing, that is, in other words, the efforts pay less thereby a conviction rules the mind that fishing as such is "taken for granted" activity merely for survival purposes alone. Such an attitude should change

d. There should be a methodology for transfer of technological know how to the fast learning fisher folk.

e. It has been mooted that presence of coastal managers or even fishery managers will highly benefit the sector and thereby their CZM plans.

f. It is a need of time that professionals too work hand in hand with a pro – active sense to encourage the enterprises.

g. Fishing in fact has been more or less a part time occupation in this region. This concept probably has to change - the means to do so lie in intensive purpose – oriented fishing as well as culturing methods.

h. And lastly, integration of modern techniques with traditional (management) system will benefit this system.

4.17 Corrective Measures

To conclude, apart from available information and existing known policies, there are certain general non developmental approaches in coastal resource utilisation which do not favour continued implementation of CZM plans for SD. These are listed as

a. Lack of adequate data – environmental, habitat, climate, like wise.

b. Inadequacies in understanding coastal processes – path ways, transport mechanisms, geocycles, action – reaction and interaction patterns and like wise.

c. Lack of appropriate technology – ecosystems controls, abatement of pollution, hazard mitigation and like wise.

d. Financial constraints – investment, profits, capital and likewise.

e. Short–term planning – high profits, less intellectual inputs, disconcern of environmental reaction, impacts and like wise.

f. Weak organisational structure – fragmented thoughts, lack of motives, lack of commitment and like wise.

g. Inadequate legal measures - poorly formulated laws, poor implementation, absence of authority, delayed justice and like wise and

h. Strong traditional practices versus technology advancement – deep rooted sentiments, environmental bias, unawareness to emerging technology, misfit application and like wise.

It is proposed that the state council for coastal zone pay necessary attention to these points as definite regional/local development plans are evolved with people's participation and closer interaction.

Chapter 5

CONCLUSION

5.1 Introduction

The fact is obvious; roughly 60% of world's human population find their habitat in the coastal zone (Goldberg, 1994). Knowing the projected increase of human population and other species, the trends in urbanisation and industrialisation, the continuing exploitation of resources by the humans, day by day, the pressure on the coastal zone is increasing and impacting.

The coastal habitats have shown clear indications of degradation but at times hopeful signs of recovery (GESAMP, 1990, National Research Council, 1994).

5.2 The Major Issues in Coastal Zone and Impact Factor

Greater experience is mostly reported from developing nations especially of the tropics. The major problems in the world's coastal zones (Alongi, 1998) as applied to the central part of Kerala covered in this study, suitably modified to include the impact factors are presented below:

Sl. No.	Major Problems	Impact Factor(*)
1	Eutrophication	2
2	Coastal development including aquaculture	4
3	Habitat modification, destruction, alteration	5
4	Disruption of coastal hydrological cycles (including river discharge)	4
5	Point and non point source release of toxins and pathogens	3
6	Introduction of exotic species	2
7	Fouling by plastic litter	5
8	Build up of chlorinated hydrocarbons	3
9	Shoreline erosion / siltation (accelerated by deforestation, desertification) and other poor land use practices	5
10	Unsustainable, uncontrolled exploitation of resources	5
11	Global climate change and variability	4
12	Noise pollution	2

(*)Impact factor on a scale 1-5 with respect to ICZM for the region under study indicates

1	No Impacts
2	Mild Impacts
3	Moderate Impacts
4	Major Impacts
5	Highly Impacted

A detailed table is provided listing the domains, parameters of influence and impact factor on a scale 1-5 (as applied to the above table) with respect to ICZM for the region under study.

Domain	Parameter(s) of Influence	Impact factor
Modification of regime	Exotic flora/fauna	3
	Alteration of ground water hydrology	5
	Alteration of drainage	3
	River flow and flood control	3
	Weather modification	1
Land transformation and construction	Urbanisation	3
	Industries	2
	Airports	1
	Highways and bridges	4
	Rail-Railroads	2
	Transmission pipes, lines	3
	Barriers	4
	Dredging	3
	Canals	3
	Dams & Impoundments	2
	Off shore structures/Inshore/Bay structures	4
Resource Extraction	Surface Excavation	3
	Tube well and well drilling	5
	Dredging	3
	Fishing	3
Processing	Farming	2
	Grazing	2
	Feed Lots	2
	Dairying	2

	Mineral & Metallurgical	2
	Chemical Plants	2
	Oil refining	1
	Food processing	3
	Pulp and paper	1
Land Alteration	Erosion control and terracing	5
	Landscaping	5
	Harbour dredging	4
	Marsh fill and drainage	4
Resource renewal	Reforestation	3
	Wild-life stocking	2
	Aquatic habitat rebuilt	3
	Groundwater recharge	4
	Fertilisation application	3
	Waste recycling	3
Changes in Traffic	Railways	3
	Airways	1
	Automobiles	4
	Shipping	2
	Communication	3
	pipelines	3
Waste emplacement & treatment	Landfill	5
	Tank	4
	Solid waste	5
	Liquid-solid waste disposal	4
Accidents	Explosions	1
	Spills & leaks	3
	Operational failure	2
	Fire	2

Fisheries	Fish stock	3
	Methods of fishing	4
	Marketing	3
	Cold storage and ice plants	4
	Social security of fishermen	3
	Research and development	2
	Stagnation in fish catch	4
	Excess number of boats	4
	Loss of nursery grounds	3
	Pollution	3
	Fish diseases	3
	Seeds and feeds	3
Tourism	Scenic value	3
	Aesthetic sense	3
	Infrastructure	4
	Space	5
	Hotels	4
	Food	4
	Hygiene	2
	Culture	2
	Economics	3
	Safety	2
	Climate	2
	Accessibility	2
	Transport	1
	Hospitality	1
	Communication	1
	Privacy	1

Human habitat	Housing	5
	Food	3
	Water	4
	Air	2
	Land	5
	Population density	5
	Amenities	4
	Health and hygiene	3
	Sanitation	4
	Pattern and style of living	3

The above table provides an insight into the minor and major parameters influencing the processes in the coastal zone. Particularly, those indicating 4 and 5 impact factors are of greater concern to any planner or developer. In the domain of regimes and land changes, the alterations of the past twenty years are functionally important which impact further land use, water resource management and means to counter pollution. It is suggested that new plans and renewed efforts should be commenced to redeem this situation. Space, housing and sanitation could be systematically tackled while a boost in fisheries sector could bring about an overall economic uplift.

5.3 Coastal Zone Issues: Solutions and Suggestions

In this section, a threadbare analysis is performed to identify the issues in the coastal zone of the study area, state the confronting problems and come up with solutions and suggestions. The table is self-explanatory; this does not imply that all solutions and suggestions are practical (Jaison, 2000) and are those to be reckoned as direct problem solving remedies – the options are presented here so as to help evolve a plan for the coastal zone with sustainable

development in mind, by the concerned, when each domain or set of domains are selected for their issues and confronting problems. As with the gravity of issue at hand and read along with those governing parameters of influence, keeping the people's interest in the forefront, which are amenable to the promotion of the coastal environment, a set of alternatives are possible and an acceptable plan could be implemented.

ISSUES	CONFRONTING PROBLEMS	SOLUTIONS AND SUGGESTIONS
Agriculture	Small Size of land holdings	➢ Activate co-operative societies
	Salinity intrusion	➢ Take control measures
	Conversion of agricultural land to housing plots and other development lands	➢ Legal intervention ➢ Promote agricultural activities ➢ Locate new exclusive housing areas
Aquaculture	Paddy fields converted to full time prawn cultivation farms	➢ Practice paddy and prawn cultivations alternatively
	Non-scientific methods	➢ Educate in adopting scientific methods
	Virus diseases	➢ Curb practices

Awareness programmes	No agency to conduct	➢ Can be conducted by coastal authority fielding a "Coastal Managers". ➢ Improve public participation
Coastal protection	No methods are adopted to stabilize newly accreted areas	➢ Take protective measures ➢ Plan the use of land
	Seasonal erosion	➢ Construct groins at required sites ➢ Strengthen existing sea walls ➢ Use marine vegetative barriers ➢ Attempt use of beach savers
	Protective constructions are costly	➢ Develop and practice simple efficient methods ➢ Use locally available building materials
	Banks are not protected	➢ Protect with revetments

Depletion of resources	High pressure on resources	➢ Introduce proper management plans
	Alteration of ground water hydrology	➢ Prevent salinity intrusion ➢ Apply methods of recharge ground water ➢ Desalination plants ➢ Supply more amount of fresh water
	Cut down on vegetation	➢ Prohibit by law ➢ Promote cultivations
	Reclamation of land	➢ Inmediate stoppage – strong legal intervention ➢ Find new location for construction activities
Education	Quality of education in coastal zone	➢ Give special training to teachers / students ➢ Promote healthy teacher student relationship ➢ Improve parental support ➢ Establish and improve facilities like library and lab ➢ Occasions for extra curricular activities

	Poor economic conditions	➢ Give necessary financial support
	Lack of practical training	➢ Give training in fisheries and related sectors ➢ Provide work experience facilities
Energy	Voltage drop	➢ Periodic maintenance of transformers and connection lines ➢ Three-phase lines
	Non extraction of non-conventional energy sources	➢ Conduct awareness programmes ➢ Help people to make use alternate resources ➢ Supply necessary equipments ➢ Help people to construct biogas plants ➢ Exploit energy from waves solar radiation, currents etc
	High price for firewood	➢ Encourage people to plant trees
	Energy use are not efficient	➢ Hold awareness programmes ➢ Change methods to save energy

Health	Spread of water borne diseases and other epidemics	➢ Establish checking and control measures ➢ Provide necessary infrastructure and specialities to hospitals ➢ Control measures in water pollution and avoid stagnation ➢ Take special care during outbreaks
	Hygiene	➢ Awareness programme about importance of clean living surroundings ➢ Stop open dumping of human wastes ➢ Provide low cost sanitary conditions ➢ Public toilets in slum areas
Housing and human settlements	Slum habitats	➢ Construct flats – encourage vertical growth ➢ Introduce waste disposal Methods/sites

	Issues related to construction works in CZ	➢ Adapt CRZ, geo environmentally ➢ Use locally available materials for construction ➢ Prefer light construction ➢ Training to workers
	Poor sanitary conditions	➢ Awareness programs ➢ Financial support
Irrigation	No provision exists	➢ Form a irrigation plan ➢ Rain water can be stored and used
Land use	Land use pattern and development	➢ Conduct detailed survey ➢ Classify the region into different zones according to land use and land type and apply in the management plan
	Regulations	➢ Adopt long term strategic planning
Management authority	No authority	➢ Establish a coastal authority

	Fund problem	➢ Raise necessary funds from government local bodies and from eco tourism ➢ Licensing fees be levied
	Regulation and monitoring	➢ Activate coast guard and policing
Mangroves	Diminishing growth	➢ Promote replantation ➢ Create awareness
Manpower training	Lack of agents and institutions	➢ Give training in specialised fields pertaining to coastal zone management
Oceanographic venues	No ship accessibility	➢ Construct offshore harbour or port
	Maintenance of developmental activities	➢ Construct offshore marine cities ➢ Construct marine park ➢ Construct artificial beaches ➢ Construct offshore recreational sites ➢ Construction and maintenance of jetties piers, harbours etc.

Population	High population density (Underlying problem of all main issues)	➢ Short term measures to freeze the present number ➢ Diversify inhabitants to other areas ➢ Strengthen family planning measures and public awareness
Public participation in management programme	So far no attempts	➢ Use ICZM plan for study area ➢ Participate public in all stages of ICZM process for smooth running and effective implementation ➢ Coastal authority should take the initiative
Tourism and recreation	No cultural or archaeological sites	➢ Develop existing locations
	Hygiene problems	➢ Conduct awareness programs ➢ Stop open disposal of waste and sewages

	Facilities are limited	➢ Improve infrastructure and access to coastal zones ➢ Improve inland navigation ➢ Construct tourist resort ➢ Concentrate on back water tourism
	Developmental problems	➢ Activate Kerala Tourism Development Corporation (KTDC) and local eco-tourism groups ➢ Maintain and beautify beaches ➢ Artificial improvement of beaches ➢ Research on promotion of coastal tourism
Transportation	Over use and high vehicle density	➢ Improve road conditions - widen ➢ Network roads ➢ Restrict encroachment of road ➢ Conduct proper periodic maintenance work

	Inland boat services are limited	➢ Deepen canals and strengthen inland navigation ➢ Increase number of boats
	Water logging	➢ Organise canals and drainage network system ➢ Deepen canals ➢ Have bridges at selected locations ➢ Place pumping stations
	Bridges are weak and narrow	➢ Strengthen the bridges
	No protection of banks	➢ Construct protection walls and revetments
	Lack of coordination among different departments	➢ Coordinate work according to a plan ➢ A central authority to function
	Marine access	➢ Construct new ports ➢ New navigation scheme to be introduced
	Air access	➢ Introduce helicopter services

Water resources	Salinity intrusion	➢ Control drawl/attempt recharge
	No gravity flow	➢ Deepen canals ➢ Bank protection by revetments
	Pollution	➢ Reduce water logging ➢ Control disposal of wastes into the waters ➢ Cleaning of wells and ponds
	No storage or conservation of water	➢ Locate storage sites ➢ Desalination plants ➢ Adopt rain water storage and purification methods ➢ Ground water discharge
Wetlands	Conversion	➢ Legal intervention
	Degradation	➢ Adopt pollution control measures ➢ Locate new dumping grounds

5.4 The Coastal Zone and Hotspots

The concept of identifying hotspots is universal but mostly is linked with carrying capacity studies or when situations are demanding with regard to the serious consequences resulting from our deeds. By denoting an area as a hotspot, we attempt to highlight the environmental degradation or express our

anguish and experience on the itches of that site and thus project the needs to immediately mitigate the issues at large.

In this study too, a set of environments have been chosen with the idea to pin-point the concerns/sectors/pollutants to a specific geographical location or event occurring area which will invite special attempts by the concerned to address the issues in a more concerted and specific manner. The table below indicates coastal environmental concerns or hot spots in the study region (By name place or zones A-D, Fig. 7)

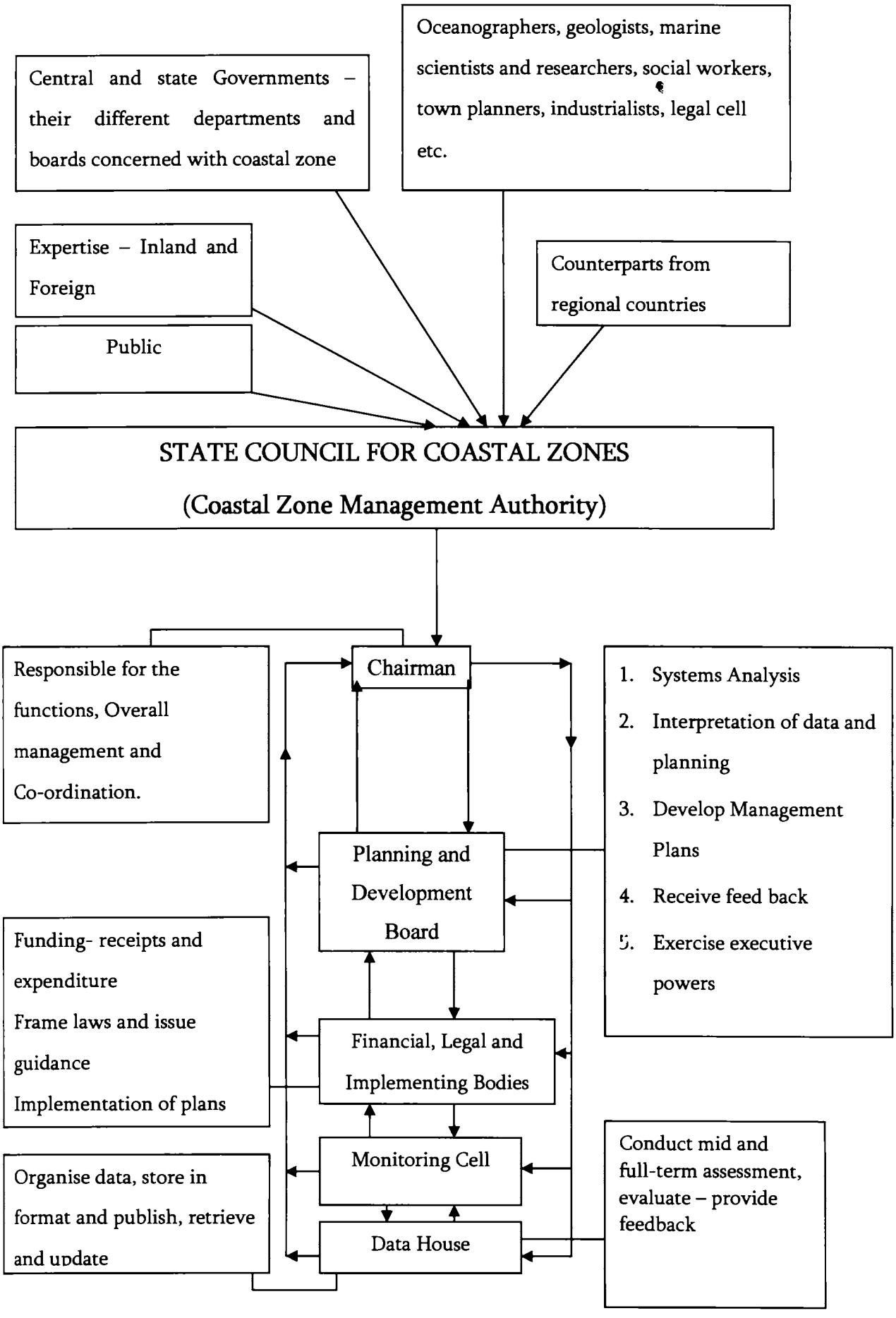
Environment	Concerns/sectors/ Pollutants	Location(s)
Land	Landscaping	Fort Cochin, Cherthala, Thottappally
	Water logging	Zone-A
	Erosion	Coastal regions of Zone-A
	Solid waste	Fort Cochin, Aroor, Cherthala. Alappuzha proper, Ambalappuzha
	Salinification	Coastal regions of Zone-A & B and seasonally at Zone-D
	Sea wall collapse	Zone-A
Air	Industrial sector	Aroor
	Urban to semi-urban areas	Fort Cochin and retting grounds in islands
	Fish landing areas	Seasonal along coastline
Water Surface water	Fresh water availability	Chellanam, Kumbalangy, Kumbalam, Perumbalam
	Salinity intrusion	Coastal regions of zones A and B and seasonally at zone D

	Flood management	Zone A & D
	Sewage and wastes	Entire shoreline, Cherthala and Alappuzha municipalities
		Coconut husk retting grounds
	Vector diseases	Whole of the study region
Ground water	Yield and recharge	Zone D
	Salinity intrusion	Regions close to the shore line
	Fluoride content	Patches in zone B
Biological		
Terrestrial ecosystem	Changes in cropping pattern, vegetative cover loss, mangrove depletion and bio-diversity	Whole of the study area in patches
	Degradation of	
Aquatic ecosystem	coastal eco habitats	Zone A
	Over fishing	
Fisheries	Degrading habitats and breeding grounds	Aquaculture fields of Chellanam to Cherthala
Marine (open ocean space)	Fish stock, potential yield and sustainable yield	Marine fisheries
	Mudbanks	Ecologically critical habitats at location of occurrence
	Sand mining and ecosystem	Selected locations
	Beach erosion	Zone A

5.5 The Framework for a Council

A major exercise in management related works is to propose a theoretical framework for conduct of business, in its absence, which is obviously true in this instance of attempting ICZM leading to sustainable development.

The chart diagram given below proposes the establishment of a Central Governing Authority or State Council for the coastal zone, which will evolve and govern the planning and development of our valued nearshore lands and seas. All concerned government departments will render full support and co-operation in addition to those from professional bodies and also seek participation from dedicated workers. Since coastal zone is (more) international in character, regional and foreign participants could play a fruitful role in ICZM. A Chairman will head the council with other functional cells and in this particular instance, more zonal diversity could be anticipated as each stretch or segment of the coastal zone has specific features and thence specific plans will have to be evolved. It is suggested that formulation of a council (already one exists in the state) with expressive powers and creative roles should pave the way rightly to serve the case of our coastal environments.


Central and state Governments – their different departments and boards concerned with coastal zone
Oceanographers, geologists, marine scientists and researchers, social workers, town planners, industrialists, legal cell etc.
Expertise – Inland and Foreign
Public
Counterparts from regional countries
STATE COUNCIL FOR COASTAL ZONES
(Coastal Zone Management Authority)
Responsible for the functions, Overall management and Co-ordination.
Chairman
1. Systems Analysis
2. Interpretation of data and planning
3. Develop Management Plans
4. Receive feed back
5. Exercise executive powers
Planning and Development Board
Funding- receipts and expenditure
Frame laws and issue guidance
Implementation of plans
Financial, Legal and Implementing Bodies
Monitoring Cell
Organise data, store in format and publish, retrieve and update
Data House
Conduct mid and full-term assessment, evaluate – provide feedback

5.6 Sustainable Development and Coastal Zone

Kerala State, known as "Gods' Own Country" is blessed by maritime climate, plenty of water and coastal seas. The people here have diversified taste and are professionally minded, hardworking, result oriented and they accept growth, selfishly. Powerful in dictating, often Governments keep changing so are policies. Once a path is identified, the benefits are derived by the people of the state and they welcome positive change. One such event has come and gone by – still lingers.

Since 1997, in the state of Kerala, a new Kerala model-highly decentralised with high levels of local participation was put into practice (Ramachandran *et al.*, 2002); the People's Participatory Programme commonly known as PPP was promulgated for people to decide for themselves their future on those crucial issues which involved habitat and infrastructure development, expansion in opportunities for employment, health and environment and so forth which are closely linked to achieving sustainability. As interpreted (Franke and Chasin, 1996) the Kerala model is viewed as a set of high material quality of life indicators, coinciding with low per capita income, a set of wealth and resource redistribution programme and high level of active mass participation in all democratic functions. The model has been hailed as a success when the society at large found ways to solve many of their inherent weaknesses but also advance in one way or other. This does not imply that there has been an overall shift in the day to day living pattern. With changes in political scenario the Kerala model has vaxed and vained. However, the model impact us in many ways – mainly consider the voluntary commitment on the part of local people to rise to the occasion when confronted with options to do self-planning, self-implementation and self-assessment. Around the world, as far as

issued connected to the coastal zone and to those who aspire of sustainable development, the above stated approach played a very dominant role. Similar opinion has been expressed by Linden, 1990, Polunin, 1990 and Dudgeon, 1992.

Thence the effective implementation of any CZM plans, apart from legal or technological interventions has to have the full backing of the local people, those professionals inducted within the system, socio-political members and other NGO organisations- all working together to bring about positive results so that their concerted efforts pave the way towards sustainable development. The above concept can also be visualised from another angle; applying a broader conceptual theme (Franke and Chasin, 1996). Any developmental activity in the coastal zone to remain sustainable so as to yield sustainable results will address some of the following points.

1. Attempts to redeem the existing anomalies and substantially improve the quality of life and the coastal environment.
2. Reasons the proposed set of planning parameters and plan implementation to reduce the social and economic disparities.
3. Finds a slot for people to express themselves freely thereby affording their continued interest in the development of their habitat and the adjoining coastal zone.
4. Ensures, equitable distribution and helps maintain the productive cycles of most resources on land and water.
5. The working order will maintain a certain standard of democratic practices which respect individual or collective rights in the coastal zones.

6. In the coastal zone such activities stand promoted which promotes economic security and affords adequate opportunities for a decent life.
7. Specifically for the coastal zone, all plans will encomprise not only the ecological sense of sustainability but incorporate subjects from a wider range of multitudinal environmental parameters.

As with progress achieved in deciding and designing the benefits of a welfare nation, India too has set examples in managing her valued coastal zones and in the longer run those healthier practices adequately addressed in this work may find useful opportunities for application in the realm of integrated management for sustainable development of the coastal zones.

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