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GEOMORPHOLOGY AND RESOURCE MAPPING OF TUTICORIN COAST, INDIA: A REMOTE SENSING AND GIS PERSPECTIVE

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ABSTRACT

Coastal areas are facing serious threats from both manmade and natural disturbances; coastal erosion, sealevel variation, and cyclones are the major factors that alter the coastal topography and coastal resources of the island ecosystems. The impact of natural disturbances can be reduced by protecting the coast by green shielding. The present study was carried out to understand the coastal geomorphology and coastal resources of Tuticorin coast, India, using satellite image and to find suitable areas for bio shielding of this coast using mangroves and casuarinas. The study found satellite imageries, along with field survey, will be useful tools for delineating the coastal geomorphology and coastal resources and finding suitable areas for bio shielding.

Keywords: Coastal geomorphology, Coastal Resources, Bio shielding, Gulf of mannar, Tuticorin

INTRODUCTION

The Indian coast is bestowed with a wide range of coastal ecosystems like mangroves, coral reefs, sea grasses, and salt marshes and geomorphologic features like lagoons, back waters, and estuaries. In many areas, the coastal topography formed over the years provides significant protection from natural disturbances like cyclones and tsunamis. But these natural barriers could diminish or even be lost if they are not managed properly. Pressure on the coastal environment arising from all kinds of human activities is generally high because of this high population density; i.e., about 60% of the world's human population lives in the coastal areas alone. The natural and socioeconomic processes in coastal zones are complex and inter related to one another. Coastal topographic slope and Absence of vegetation are some of the factors that determine potential option to reduce coastal vulnerability to natural hazards; realizing this importance only, the concept of ''bioshields''has evolved. This recently coined word depicts how naturally occurring plants and trees in coastal areas shield a region from the ferocity of. Conversion of coastal sand dunes and plantations has intensified dramatically after the tsunami, driven largely by the belief that bioshields mitigated tsunami inundation (Bhalla, 2007). Understanding of the coastal geomorphology helps the afforestation of the coastal areas using mangroves (Baskaranet al., 2003). Even, coral reefs act as a barrier against wave action along the coastal areas and prevent coastal erosion. In addition, coral reefs protect mangroves and sea grass beds along the shore(Thanickachalam and Ramachandran, 2003). Chatenoux and Peduzzi (2007) reported that the areas covered by sea grasses were less affected by tsunami waves.

Coastal afforestation with casuarinas, screw pines, palms, bamboos, and mangroves can protect the coast from erosion and indeed protect other natural ecosystems (Gopalakrishnan, 2007). The long coastline of India, which runs more than 8085 km, consists of different island ecosystems in the Arabian Sea and Bay of Bengal. The coastal zone in India is receiving increasing importance in view of its higher productivity and is under tremendous pressure due its increasing exploitation. One of the important factors needed for proper coastal zone

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management is information on existing resources and coastal geomorphology.

Aim and objective

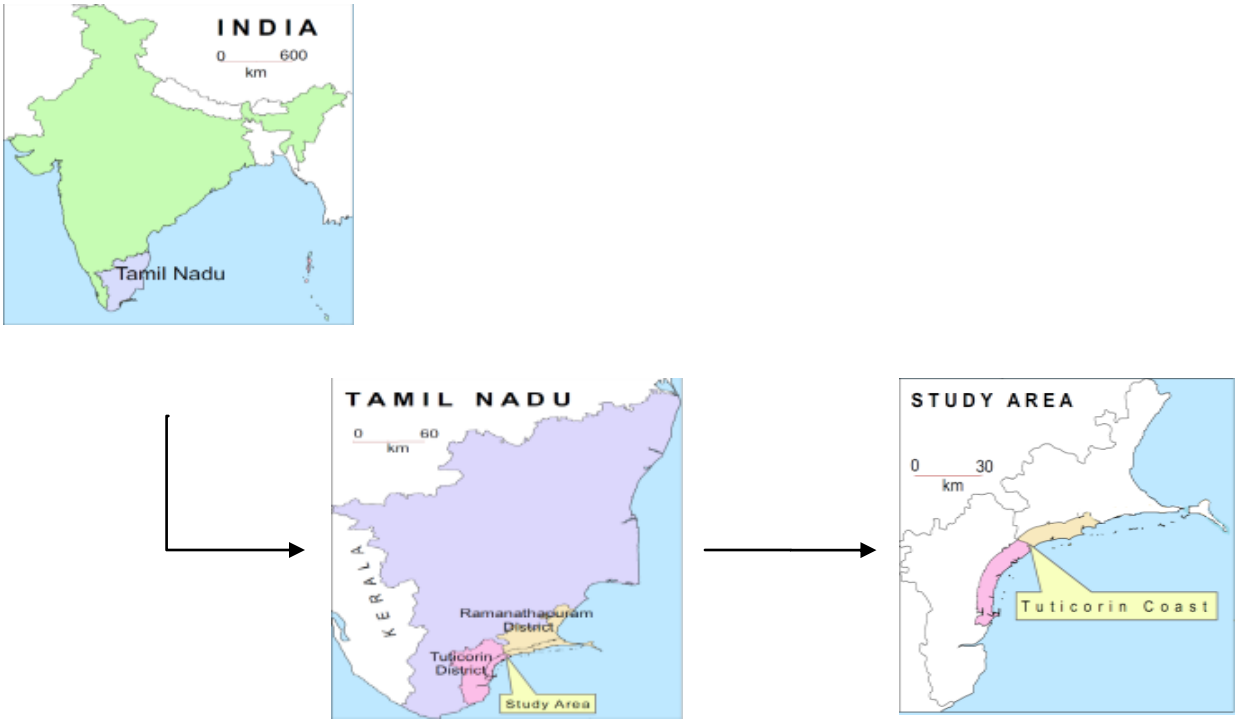
This project work is aimed to understand coastal geomorphology of Tuticorin coast and to find suitable siting for bio shielding using remote sensing and gis

- To map the coastal geomorphology of the Tuticorin coast
- To identify various coastal resources present in Tuticorin coast
- To find the suitable siting for bio shielding

STUDY AREA

The study area chosen for the present study is a Tuticorin district coastal area in Tamilnadu, India has a coastline of about 7,500 km. Gulf of Mannar extends from rameswaram to Tuticorin coast in the SW-NE direction, lies between 78º5' & 79º30' E longitudes and 8º47' & 9º15' N latitudes, to a length of about 140 km. Gulf of Mannar is endowed with a rich variety of marine organisms because its biosphere includes ecosystems of coral reefs, rocky shores, sandy beaches, mud flats, estuaries, mangrove forests, seaweed stretches and sea grass beds. A port town Tuticorin with several industries and saltpan activity, its population is around 0.4 million. The coastline of Tuticorin has a length of about 163.5 km – 25 km wide. Major Industries such as Southern Petrochemical Industrial Corporation, Thermal Power Plant, Tuticorin Alkali Chemicals and Heavy Water Plant are also present in this area. Due to the accelerated development activities the coastal area experience significant changes.

Location of study area



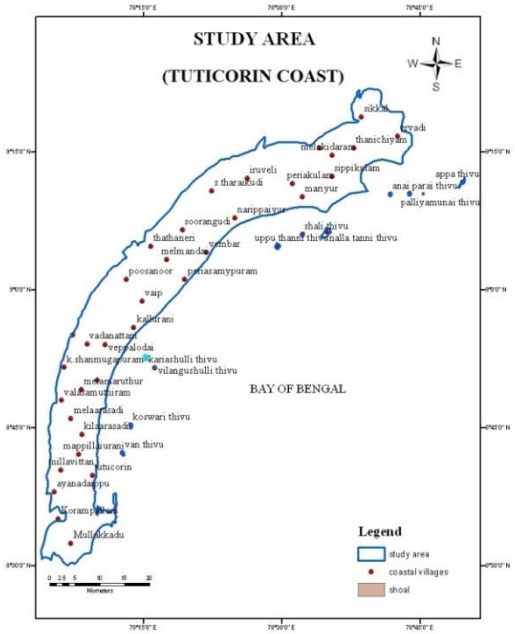


Fig 2.1 study area

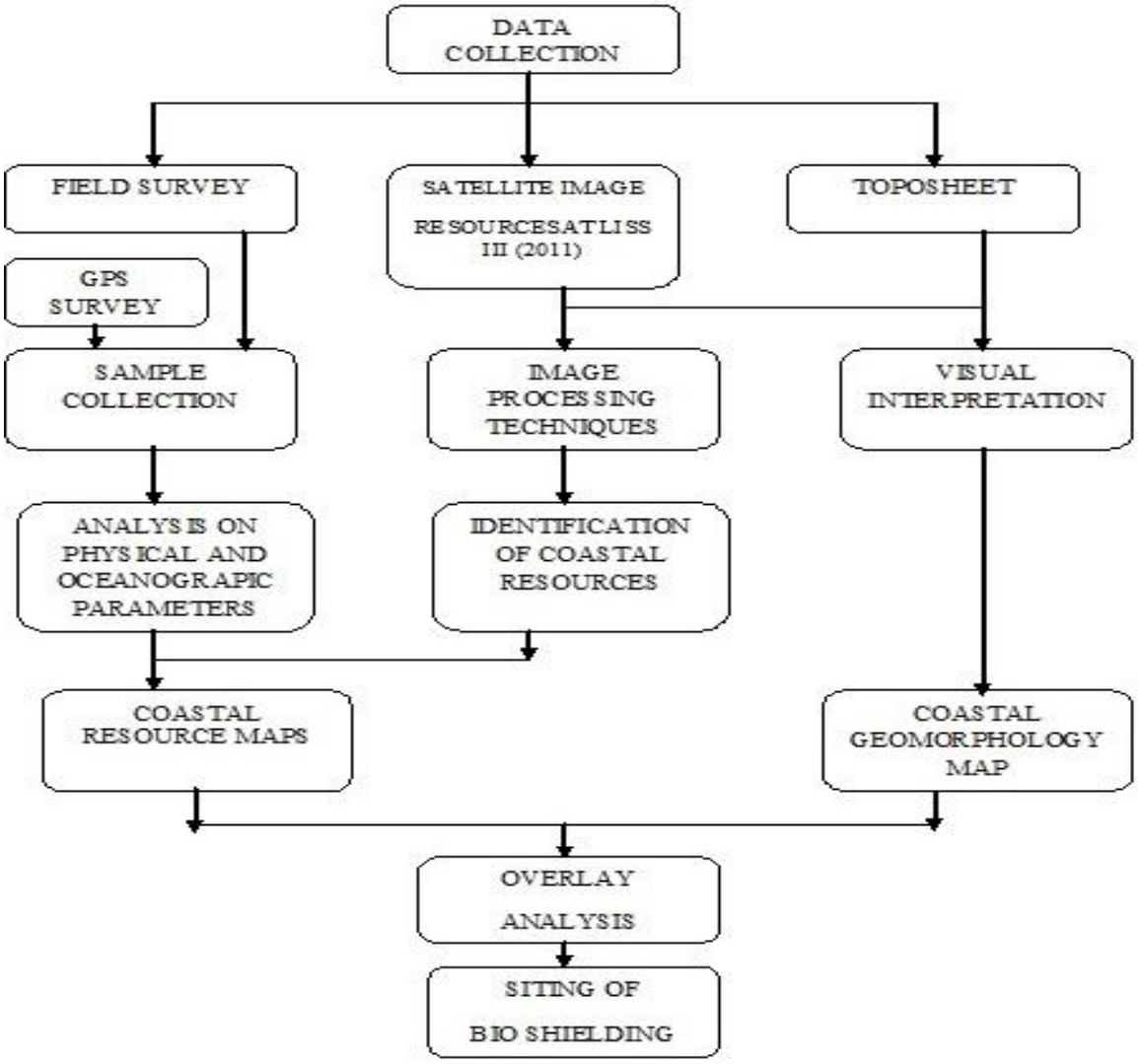
Data and techniques

The study on Geomorphology has been dealt by many researchers by using different remotely sensed data products. For all mapping of the study area has been prepared from the topographic sheets (58K/4, 8, 11, 12, 15, and 16; and 58O/3, 4, 7 and 8; and 58L/1and5), published by the Survey of India (SOI) on 1:50,000 scales. The present study also used remotely sensed data of RESOURCESAT (LISS III) 2011 FCC images By using Arc GIS software environment is help to various analysis part of this study which arc tools such as geo referencing, overlay, buffering and linear referencing tool with WGS 84 UTM 44 grid polyconic projected coordinate system. After having set up the objectives of the study, primary and secondary base line data have been collected from the field survey ,published and unpublished reports/data of different departments and analyzed in order to understand the existing climate condition of the study area in detail.

Resource sat describsion

Parameters	Range
Scanning technique	Pushbroom
Spatial resolution	23.5m
Temporal resolution	24 days
Swath width	142 km
Sensors	TM/HRV
Path and row	143/53,54

Block diagram



Coastal geomorpholgy

Tuticoirn coastal zone has been classified into major landforms like Fluvial, Fluvio-Marine and Marine origin based on theoretical explanations and image interpretation elements. The features were checked with existing literatures, topographical sheets and field checks. These features were considered as geomorphology of the study area (Fig.2.2,Fig 2.3), the observed geomorphic features identification, description and distribution are explained in the following paragraphs.

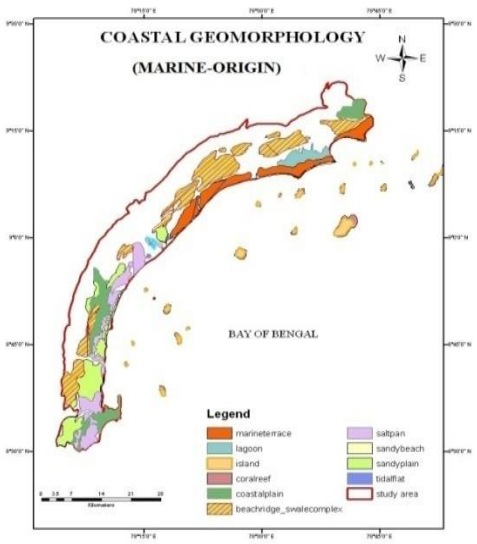


Fig 2.2 marine origin

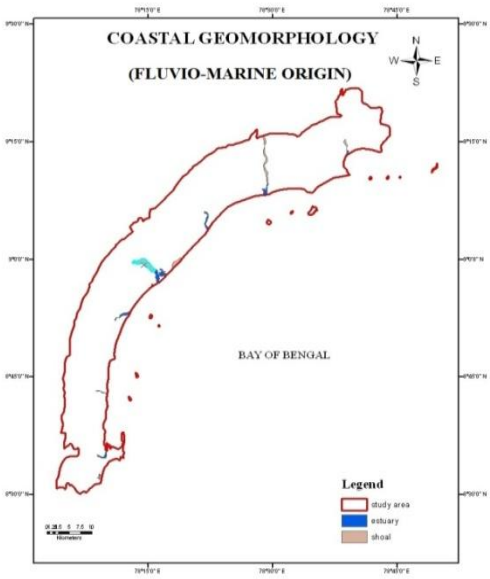


Fig 2.3 fluvio –marine origin

Fluvio-marine origin

The fluvio-marine landforms are the landforms which are made by the combined action both by fluvial and marine process. Such landforms identified in the study area are estuary and shoal. They are described as follows:

Estuary ecosystem

The term estuary, derived from the Latin 'aestus' meaning tide, refers to a tongue of the sea reaching inland. A definition that is widely used describes an estuary as 'a semi-enclosed coastal body of water having a free connection with the open sea and within which sea water is measurably diluted with freshwater derived from land drainage' (Cameron and Pritchard, 1963). The upstream limit of an estuary can be defined in terms of the limit of saline water penetration, or the uppermost point at which tidal oscillation of water level is discernible. The term 'ria', which is

Spanish for estuary, was used by Von Richthofen (1886) to refer to mountainous sided estuaries. Estuaries have been observed in Karampallam, Vembar, GundarPalar, Kottagudi They cover an area of 874ha or 0.58 percent of the total study area.

Shoal ecosystem

The term shoal refers to an area of shallow water in the coastal area especially to a submerged sand bank that is visible only during the low tide. In the study area shoals occur at the river mouths of Kottagudi, palar, Gundar, Vaippar and KorampallamOdai which covers an area of 265ha or 0.18 per cent.

Marine origin

The marine landforms are those which have been formed predominantly due to the action of sea waves. They are 10 marine landforms in the study area. They are sandy plain, coastal plain, beach ridge-swale complex, sandy beach, marine terrace, spit, salt flat, mud flat, tidal flat/tidal inlet, island, lagoon/paleo lagoon, and coral reef. The following section described them detail.

Sandy plain ecosystem

Coastal sandy plains are generally appeared an extensive area of lowland, with a level or sloping. They formed due to the marine deposition. It occupies an area of 17832ha which accounts for 11.88 per cent of the total area of the Tuticorin coastal zone. They are distributed for larger extent in the western portion of Tuticorin coast followed by the coastal margin of the northern part, Tuticorin coast, south east of KarampallamOdai and adjacent to on either siding of Vaippar Estuary.

Coastal plain ecosystem

Coastal plains are generally an extensive area of lowland, with a level or gently undulating surface. These formed due to the marine deposition. The Tuticorin Coastal zone occupies and area about 14614ha or 11.88per cent. The major coastal plains are seen the southwest ofTirupullani, the northeast and along the northeastern part of the coastline, the north and south of Tuticorin.

Beach ridge & swale complex ecosystem

Beach ridges are moderately undulating terrain features of marine depositional type. They formed during Pleistocene to Recent age. The areas between Sikkal and west of Tiruppulani are covered by well-developed beach ridges. There are nine major beach ridges observed in the coastal zone, which are the ancient shore line. Almost all beach ridges in the coastal zone are parallel to each other and trend from east to west and northeast to southwest direction. The complex swales are seen to be a part of the coastal plains of Tiruppulani of Vaigai river delta. They are branched and arranged in linear patterns. They lie almost parallel to the present coastline. The swale complexes are predominant between kottangudiar and palar. Swales are depressions, located normally between beach ridges. Swales are comprised of silt, clay and sand. During monsoon periods, Swales are flooded with the water and water stagnation persists for some time. It covers an area of 27,453ha which accounts for 18.42 per cent of the total area of the Tuticorin coastal zone.

Marine terrace ecosystem

It is a known fact that the marine terraces are one of the indicators of sea level variations. Some of the marine terraces are observed at places such as the Vembar to Killakarai coastal tract. The vertical sequence of marine terrace is formed 6 metres below the level. It also indirectly indicates hard rock regions. About 6718ha of land is under the terrace which accounts for 4.65 percent of the total area of the study area.A salt covered the surface that is formed when a lake in an area of internal drainage in an arid area dried up. In the present study area a major salt flat lie in and around the Tuticorin and Valinokkam and distributed for 6902ha or 4.63per cent of the total area under salt production.

Island ecosystem

There are 11 emerged islands in the Gulf of Mannar near the coast between Tuticorin and vaippar These islands named in vernacular such as, Van Tivu, KoswariTivu, VilangushuliTivu, KariyashuliTivu, UppuTanniTivu, shalliTivu, NallaTanniTivu, AnaipariTivu, PalliyarmunaiTivu, Puvaransan putti Tivu, AppaTivu,. These islands

are sedimentary rock types of landforms. It noticed that fringing reef along the windward side of the islands protects the islands from direct wave action. Morphology of sandy islands is very dynamic. The morphological variations of islands are Due to natural and anthropogenic agents. The natural agents include erosion, accretion, wave, current, sea level variation etc. The Islands erosion and accretion are caused mainly by the action of wave and wave-induced current and longshore current along the shores of islands. Due to the cyclonic winds are in the northeast and southwest direction is similar to that of wave direction. The erosion has been identified along the northern side of the islands (landward side). Evidences of submerged trees and sharp edged coasts are found along the northern shores of these islands. This is because of the long shore current and tidal current flows towards the south, along the northern shore of islands erode the coast and these eroded materials are transported and deposited on seaward side of the coast. While high velocity waves are moving towards northern shores of islands with the littoral sediments and coming across the coral reefs, these sediments are dropped on the coral reefs

Coral reef ecosystem

Coral reefs tend to occur in warm, tropical, shallow waters. Coral reefs form natural offshore, backwater and so play an important role in the coast from waves and reefs are particularly susceptible to environmental impacts. Many problems relating to the reefs are due to the impacts of tourism (Middleten, 1995). Coral belongs to the phylam coelenterate and classes of Anthozoa are the major species of the study area. A total 137 such coral species are found in this area (Tamil Nadu Forest Department, 2002). Some general characteristics of the coral reefs are follows;

1. Coral is a colony of tiny sea anemone like Polyps living together in thousands and secreting calcareous skeleton of calcium corbonate (CaCO3), they have different colours and shapes.
2. Coral reef provides an ideal habitat and feeding ground for various marine animals.Coral reef protects the islands from coastal erosion.

GEOLOGY

The study area comprises of rocks and unconsolidated sediments ranging in age from Archaean to Recent, unconsolidated sediments deposited during Recent to late Pleistocene epochs to occur over most part of the study area. About 83.5 percent unconsoliodated sediments are formed. They have been classified as fluvial, fluvio-marine and marine and they areal extent for 275km (19.3 per cent), 763sq.km (53.5 per cent) and 153sq.km (10.7 per cent) respectively. The fluvio-marine sediments on the other hand are confined only to the southern and central part of the study area. They lie along a narrow stretch between Kuliyankarisal in TuticorinTaluk to Gundar River and parallel to the marine sediments on the island side. Fluvial sediments that lie along the western margin adjacent to the fluvio-marine sediment on the island side continuously from the area near KottagudiAr in the northeast up to the areajust north of K.Thangamalpuram in the south. These sediments have been deposited by the rivers such as Gundar, Palar and Kottgudiar. Apart from these unconsolidated sediments, laterites of Quaternary period are also found along a narrow stretch between the KottagudiAr in the northeast and Palar in the southwest and the northeast of Kadugusandai. Further down southwest between the villages S.Tharaikudi and Narippaiyur of KadaladiTaluk .Calcareous gritty sand stone and clay are (5.34 sq.kms, 0.31 per cent) confined to the northern rim of Tuticorin coast. Hornblende-biotite gneiss rock is (136sqkms, 9.54 per cent) restricted to the southwestern part towards the west lying on either side of the Vaippar River.

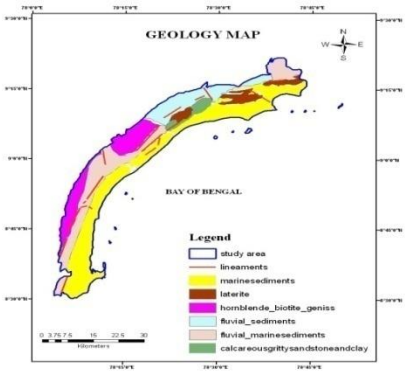


Fig 2.4 geology map

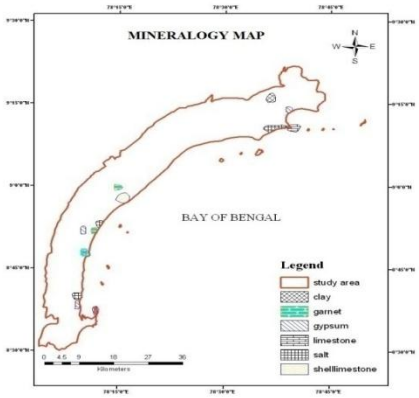


Fig 2.5 mineralogy map

SOIL AND THEIR DISTRIBUTION

Information regarding the soils of the study area was obtained from the Soil Survey and Land Use Organisation, Department of Agriculture, Government of TamilNadu State. There are four soil orders (*viz, Entisol, Vertisol, Inceptisol, and Alfisol*) based on USDA Classification with 16 soil series found in the study area (*Figure2.6*). The characteristics of these soil series and their distribution in the Tuticorin Coast are described as follows:

Entisol (Recent soil)

Entisols are those soils which are developed recently. Soils belonging to this order are found on steep actively eroding slopes or on flood plains that receive new deposits of alluvium at frequent intervals. Alluvial flood plains, deltas, shorelines bordering, lagoons and estuaries usually have these soils. In the study area, these soils have been drained mainly from the depositional process by the rivers. Within this soil order, three soil types are found and they include recent soils, recent sandy soil, and red sandy soil. Each of this soil types can be further subdivided into a number of soil series.

Vertisol (Black soil)

Vertisols are commonly referred to as black soils. They are subjected to cracking during summer season, mostly *montmorillenite*that shrink and swell over the rainy seasons. They have wide deep cracks during moisture deficient periods.Alkaline reaction is common to the various parent materials like calcareous sedimentary rocks, basic igneous rocks and alluvial deposits. They are usually formed over gentle slopes.

Inceptisol (Immature soil)

Inceptisols are imperfectly or very poorly developed soils with indistinct tprofile features that retain close resemblance to the parent material

Alfisol (Reddish Brown soil)

Alfisol are associated with moisture less continental climatic zones than the mollisols. They are the most extensive soils found in the study area having mineral content and usually moist. They have either an argillic or a nitric horizon. The vase saturation is more than 50 per cent below top.

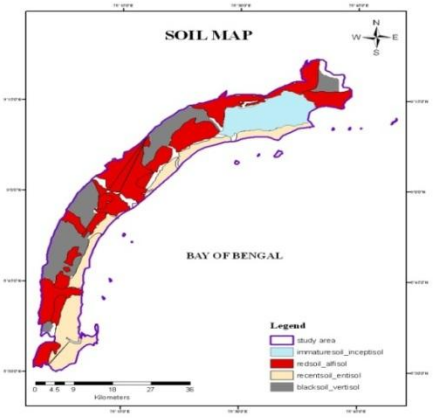


Fig 2.6 soil map

GENERAL LAND USE/ LAND COVER

The spatial distribution of land use/ land cover has been brought out *(RESOURCESAT 2011LISS-III FCC image)* as it the result of permanent adjustment between constraining properties and socio-economic attributes of the study area (*Figure 2.13*). The total area of the coast zone is 14,8865 ha. It could be brought out under six major land use (Level I) categories. They are Built up lands covering an area of 6,824 ha or 4.6 per cent, Agricultural lands 72,436 ha or 48.7 percent, Forests 9,601 ha or 6.4 per cent, Wastelands 45,611 ha or 30.6 per cent and water bodies 1, 0054 ha or 6.8 per cent, and others 4,339 ha or 2.9 per cent of the total study area. The predominant class of agricultural lands is followed by the wastelands.These wastelands are in the central part and along the coast line of the eastern margins of the study area. However, the wastelands along the coastline can be utilized if proper conservation measures or alternatives are taken. They are suitable for scrub forest.

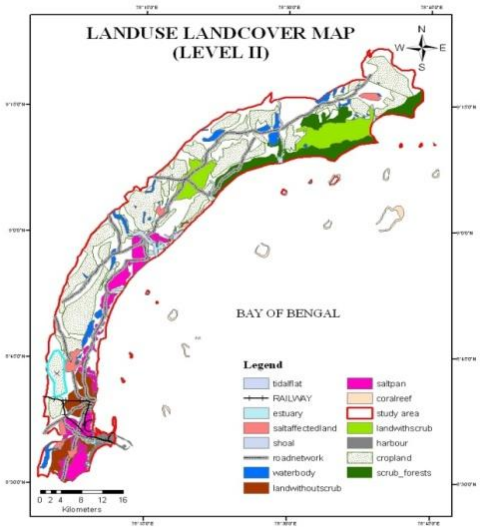


Fig 2.7 landuse land cover map

RELIEF

The relief (*Figure 2.3*) of the study area was deduced from the Survey of India topographic sheets of 1:50,000 scale and the field survey by using GPS (*GARMIANPalm tap*). The contours at two meters interval were generated to understand the topography. Accordingly, two small packets of elevated lands are found near K.Shanmugapuramvillage of OttapidaramTaluk and Thathaneri Village of VilathikulamTaluk. The rest of the study area is relatively plain. The maximum elevation of 28.7m, above MSL is foundnearK.Shanmukapuram. In general, the slope gradually decreases towards the east from highlands. No island has perceptible relief variation except the central part which is having a slight elevation.

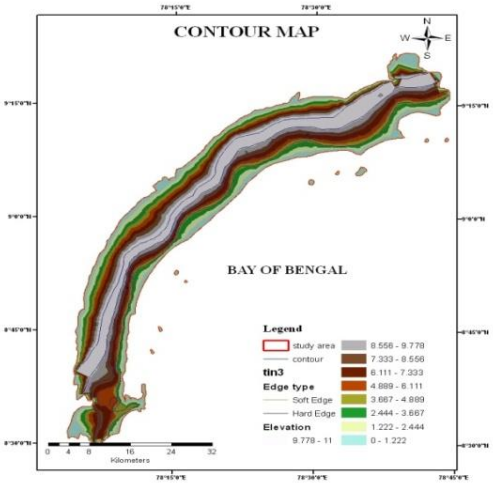


Fig2.8 contour map

RESULTS AND DISCUSSION

Utilization of aerial photos and satellite imageries for the geomorphology and coastal resource studies was emphasized by several researchers (Baskaran*et al.*, 2003; Deshmukh*etal.*, 2005; Dinesh Kumar *et al.*, 2007; Navalgund, 2005; Thangaradjou*et al.*, 2008). The coastal areas of tuticorin coast have various geomorphic units with different configurations and settings. Mapping of the coastal geomorphologic and resource features was carried out using resource sat imagery. The result indicated the presence of coastal ecosystems like sea grasses and patches of coral reefs in Tuticorin coast (Figure 2.3). Buffer zones (500 m) were created to identify the areas requiring more attention and areas for the afforestation along the coasts (Figure 2.9). Beaches are extensively developed along the southern and northern coasts of Tuticorin coast. When compared to northern side, southern coast has wider beaches,. Most portions of these sandy beaches were characterized by sharp slopes with uneven substratum.

Geomorphology was considered an important factor for identifying sites for mangrove or any other coastal plantation. Replanting of mangroves is generally most successful in relatively sheltered areas but is also carried out in more exposed areas, where the main aim is to control soil erosion (Stevenson, 1997). Partly because of the ease with which propagules can be replanted, many mangrove restoration schemes have been undertaken, often as a forestry production initiative. Replanting schemes in many parts of the world have been successful (Kairo*et al.*, 2001. Understanding of the sediment nature of Tuticorin coast is required before largescale mangrove afforestation activity in this part of the coast. At tuticorin coast, the tide is the

main factor for the transportation of sediment and the flooding of lagoons, so more research is needed to identify a species suitable for afforestation.

Buffer zones (500 m) created during the present study from the shoreline toward both the seaward and the landward sides represent the highly sensitive areas There should be a regulating mechanism to protect this valuable resource from anthropogenic stress. For this, the buffer zone area on the landward side should be managed carefully, especially the north and southwestern coasts, which can be considered for effective green belting using casuarinas and coconut trees where natural dune formation occur. The estuaries present in tuticorin coast may be considered for mangrove restoration, where natural lagoon formation is occurring and providing a suitable geomorphological location for mangrove plantation. The area from the shoreline to the end of the buffer zone can be considered for implementing restoration programs for sea grasses and coral reefs; such seagrass restoration activity was implemented successfully in the Gulf of Mannar.

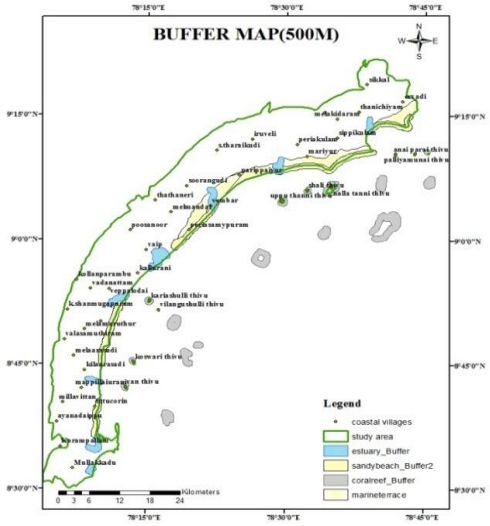


Fig 2.9 buffer map

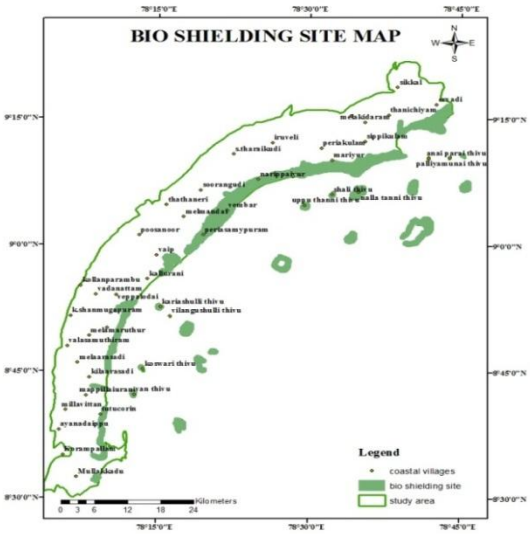


Fig 2.10 bioshielding map

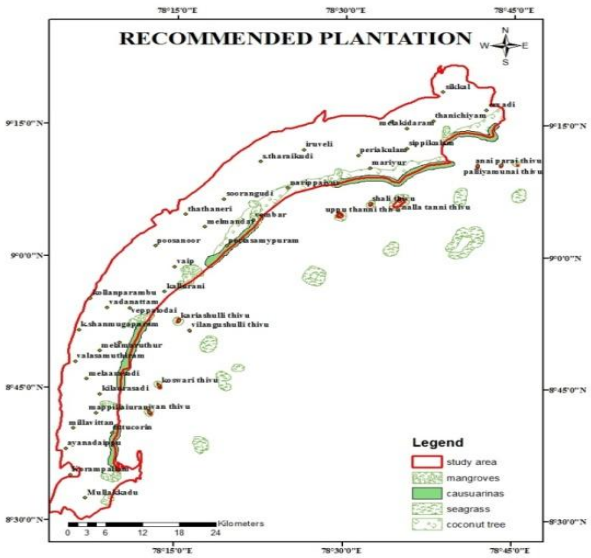


Fig 2.11 recommended plantation

The present coastal vegetation is not sufficient to protect the coastal people from natural calamities. The run level due to the recent tsunami in many places indicated the need for finding safe locations for settlement (Ramanamurthy*et al.*, 2005). In cases of non availability of land for human settlements, the low-lying areas can be made available for settlements only after ensuring the proper safe guards, which may be attained by bio shielding. The coastal ecosystem in the vicinity of tuticorin coast can be declared a protected area considering its importance.

PLANTATION	GEOMORPHIC FEATURES	PLACES
Sea grass	Coral reef	Island present in the study area
Coconut tree	Marine terrace Sea shore	Thaniciyam,ervadi, Narripayur,melmandai mariyur
casuarinas	entisoil,sea shore	Periasamypuram ,sippikulam Melaarasaradi,kilaarasaradi
mangrooves	estuaries	Sippikulam ,vembarveppalodai,kallurani,narripaiyurkorampallam

CONCLUSION

Tuticorin coast is one of the most ecologically sensitive coastal ecosystems of India because it is surrounded by both Palk Bay and the Gulf of Mannar and subjected to varied water current and seasonal behavior throughout the year. These regions are noted for their valuable diversity of corals, sea grasses, and other coastal resources. To protect the coast from any natural hazard, green shielding of the coastal areas is required. Rather than using artificial constructions, natural barriers can provide safety and are eco-friendly in nature. The areas bounding tidal pools can be considered for the afforestation of mangroves, where as the dunes and beaches can be considered for casuarinas, coconut, and pine plantations. This would ensure the coast some sort of protection from sea level variation and natural disasters in the near future. Above all, an integrated management

plan for the coastal zone of Tuticorin is of greatest need today to curtailthe impact of natural disasters against the backdrop of increasing coastal tourism in this coast.

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