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RESEARCH ARTICLE

A STUDY ON DISSIPATION OF COASTAL GEOMORPHOLOGICAL FEATURES IN PART OF EAST COAST FROM CUDDALORE TO CHIDAMBARAM, TAMIL NADU USING REMOTE SENSING & GIS TECHNIQUES.

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Abstract

The coastal zone of India has been affected by many natural hazards like storms, cyclones, floods and tsunami. The present study covers the area from Cuddalore to Chidambaram of Cuddalore district, which is part of the southeast coast of India and focuses on the coastal geomorphological changes by the help of LANDSAT ETM data & IRS P6 data for 2000 and 2012 respectively. The area of interest is located on the east coast of Tamil Nadu from Cuddalore to Chidambaram. Based on the 2000 data, the scale variable for each geomorphological feature was optimized by comparing manually digitized training samples with automatically recognized image objects. Classification rule sets were developed to extract the feature types of interest. The classification settings were then applied to both IRSP6 LISS III & LANDSAT ETM, which allowed the detection of geomorphological features to change between 2000 and 2012. From 2000 to 2012, changes of geomorphological features were calculated from two attributed table and changes, which were derived from the subtracted overlay map.

The geomorphic units under different heads namely, features formed by present day wave action, features formed due to sea level oscillations; land and sea water interaction have been presented. The influence of sea level oscillations, land and sea interaction forms a diverse coastal geomorphology along the coastal area of interest. The details of features such as beach, sandy dune, flood plain, water logged area, mangrove area, back water, lake, river and coast plain have been recorded and the formation as well as significance of their occurrence is presented. The coastal geomorphology of the study area clearly established not only the sea level oscillations but also variations in climatic conditions in this part of the coast. The present study shows that remote sensing and GIS techniques can play an important role for making better planning and rational use of natural resources in the future.

Introduction:-

Geomorphology deals with the genesis of relief forms on the surface of the earth's crust. Certain natural processes are responsible for the forms on the surface of the earth. A thorough understanding of various processes leading to landforms is necessary to understand the environment in which we live (Rao, 2002). Coastal zones are high biological productive regions and important components of the global bio system. Coastal areas are very important for human beings since the beginning of time. Most of the big cities around the world are situated at coastal areas. Due to abundant natural resources and urbanization, population rapidly has increasd on coastal areas. More than world's half population lives within 60km of the coast and would rise to almost three quarters by 2020 (Jayanthi, 2009).

As coastal zones are facing intensified natural and anthropogenic disturbances including sea level rise, coastal erosion, over exploitation of resources among others, various studies are made in the coastal areas, which place great pressure on it, leading to diverse coastal hazards like sea erosion, seawater intrusion, coral bleaching, shoreline change; etc. Coastal landforms are highly dynamic in nature. They are continuously modified by natural and other man made processes (Kumaravel, 2013). More than three hundred million people, or nearly 26 % of the total population, live in the coastal zone of India. Considerable variation occurs in the frequency, magnitude and seasonality of these events. While the west coast of India is affected by the seasonal tropical cyclones during the southwest monsoon (June–September), the east coast is affected by the northeast monsoon (October– December) and is highly vulnerable to storm surge events (Saxena, 2011). The December 2004 Tsunami has severely affected the coastal zone of Tamil Nadu which distorted the geomorphology of the coast where the extent of inundations shows the vulnerability of the southern region of Tamil Nadu coast due to the flat topography compared to the northern region (Rahul,2006).

Remote sensing technique is the best suited for regional studies of temporal variations of a feature; it is certified and used universally. Therefore, remote sensing method is adopted in the present study to get information on geomorphological features changes in part of East coast from Cuddalore to Chidambaram (Sathyanarayan, 2012). The modern scientific technologies of remote sensing and digital image processing are extremely useful in periodic assessment of the coastal changes and to formulate better management (Santhiya, Lakshumanan and Muthukumar, 2010). This is incorporated by the use of GIS tool for working of maps, in addition to Geographic Information System which is very useful in integrating, modeling, visualizing and interpreting different types of data.

Information about geomorphology change is necessary to update geomorphology maps for effective management and planning of the resources for sustainable development. The district is emphasized by various geological formations ranging in age from the oldest Archaean rocks to recent sediments. Specifically the study area, is covered by Quaternary formations consisting of Marine sedimentary plain, fluvial flood plains and fluvio marine plains between marine and fluvial flood plains. The rest is covered by tertiary formation consisting of Cuddalore formation. Generally, the Quaternary landforms of East coast of India generally denote features of emergence characteristics, while that of west coast are mostly dominated by features of submergence characteristics (Ramesh, 2006).

According to the Geomorphology of Cuddalore District**;** the entire district can be broadly divided into following 3 zones. Western pediplains of entire area are covered by Mangalur and Nallur blocks. This part is occupied by denudational landforms like shallow buried pediment, deep buried pediment and pediments. Central part of the district is characterized by sedimentary high grounds, elevation >80 m of Cuddalore sandstone of Tertiary age (Dinagaran, 2009). This zone occupies part of Virudhachalam, Kammapuram, Kurinjipadi, Cuddalore and Kattumannarkoil taluks. Rest of the area in the district is covered by eastern coastal plain, which is predominantly occupied by the flood plain of fluvial origin formed under the influence of Penniyar, Vellar and Coleroon river systems.

Marine sedimentary plain is noted all along the eastern coastal region. In between the marine sedimentary plain and fluvial flood plains, fluvio marine deposits are noted, which consist of sand dunes and back swamp areas (Dinagaran, 2009). Remote sensing satellite data provides a synoptic view of the coastal zones (Green et al); these modern scientific technologies of remote sensing and digital image processing are extremely useful in periodic assessment of the coastal geomorphological feature changes and in formulating better management.

The work has been taken up with the following objectives.

1. To map the coastal geomorphological features in the part of Tamil Nadu East coast Cuddalore to Chidambaram Coast.
2. To evaluate the changes of geomorphological features and processes that influenced their production and the comprehension of coastal geomorphological changes for its management.

Study area and methodology:-

Study area:-

The study area (Fig.1) lies in the coastal belts and parts of Cuddalore and Chidambaram Taluk of Cuddalore district, Tamil Nadu, India. It is bounded to the north by Pondicherry Union Territory, south by Nagapattinam district, east by bay of Bengal and west by Panruti and Virudhachalam Taluks of Cuddalore District. It lies between 11°20'00"N and 11°45'0" N latitudes, and 79°30'00" and 80°00'00" E longitudes. The coastal stretch of study area has a total length of 34 km **(Fig. 3)** along the Bay of Bengal. Geologically, the study area is covered by Quaternary Marine sedimentary plain, Cuddalore formation, fluvial flood plains. Therefore, in between the marine sedimentary plain and fluvial flood plains, fluvio marine deposits are noted (Fig 1). The study has three major rivers: Gadilam, Uppanar and Vellar.

Generally, the eastern part of the district represents a flat plain and the western part slightly hilly area. The slope varies from 8° to 4° towards east and in the west, and in the coastal plains it is less than 1 (Kuldeep et al., 2013).A number of surface water bodies are found within this region, of which; Perumal Eri (Lake) in the western side is connected to the river and thermal power plant effluent finds its way into the river through this water body. Viranam lake is located 14 km (8. 7 mi) SSW of Chidambaram taluk, is one of the water reservoirs from where water is planned to be supplied to Chennai.

Methodology:-

The satellite data are geometrically corrected and geo referenced with Survey of India toposheet Map NO58M on scale of 1:250, 000 surveyed in the year of 1975 for Pondicherry, Tamil Nadu, India, using ground control point (UTM projection and WGS 84 datum). Visual interpretation is still one of the most widely used methods for detecting, identifying and characterizing the spatial features on an image since human brain is a good interpreter of images (Santhiya, Lakshumanan and Muthukumar, 2010).The satellite data are interpreted based on the visual interpretation keys and changes are identified for the geomorphology and finally verified with the field check using GPS for the doubtful areas and change detection analysis using Arc GIS 9.1 software

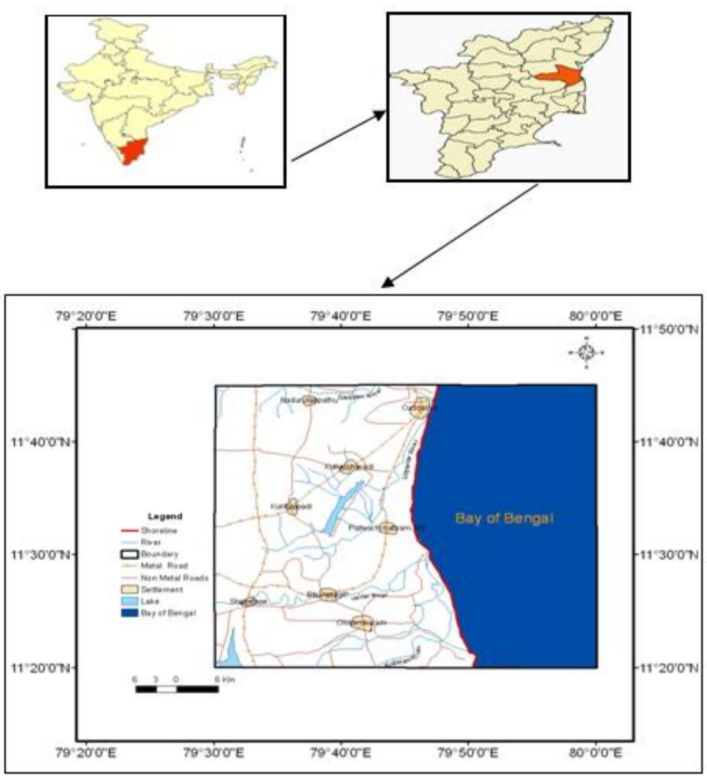

Figure 1: Base map of the study area

From the satellite data, the various thematic data bases were generated with special reference to study area. From the same, all data sets were digitized in Arc GIS 9. 1 software. Then, the coastal geomorphologic features were mapped in the same way using Landsat ETM Data for 2000 downloaded freely from http://landsatlook.usgs.gov/ and IRS P6 for 2012 satellite data acquired from National Remote Sensing agency (NRSA). In this study, the geometric and radiometric errors were rectified through image preprocessing techniques. LANDSAT image is not geometrically corrected and it also contains striping effect. So the radiometric correction was done for getting the de-striping images. Geometric correction by is done creating ground control points in image as well as in toposheet by the help of image to image registration process.

The IRS 2007 image was registered to the previously registered ETM 2000 base year image with UTM Zone, Datum WGS84. After the rectification process an area of interest was selected and the FCC was generated and enhanced through the histogram equalization method to distinguish the geomorphological features. Then, the two thematic data have been overlaid using GIS overlay function of Arc GIS to display coastal geomorphology changes. Finally, quantitative study of all thematic data for coast geomorphology is constructed. The constant changes is detected by field check to propose the rate of changes for the past twelve years. The change deduction by human and natural process from 2000 to 2012 is prepared and displayed.

Results and discussions:-

Confirmation of mapped geomorphic features in the field itself was a way of reassessing the accuracy of interpretation. The data generated during the field check is an important database, in addition to remote sensing data.

Flood water at Cinnakaramedu Sandy Dunes slope length measurement

Figure 2: Flood Plain and Sandy Dunes slope length measurement.

Back water at Kodiyampalayam Bridge Beach width measurement (Samyarpettai)

Figure 3: Back water and Beach width measurement.

Ground data is, generally an Amalgamation of collection, verification and measurement of landforms. Ground truth accuracy depends upon the extent of doubtful areas, the number of areas verified, the accessibility to the study region and accuracy requirements. The field traverse is made to cover maximum doubtful area.

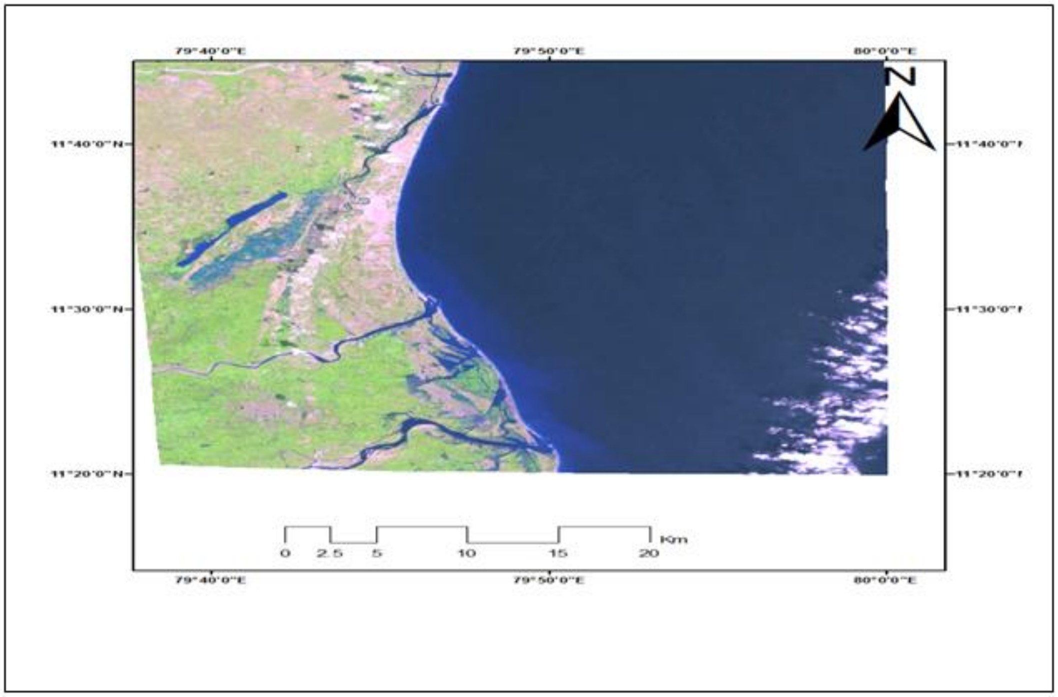

Figure 4: AOI of Landsat image of 2000

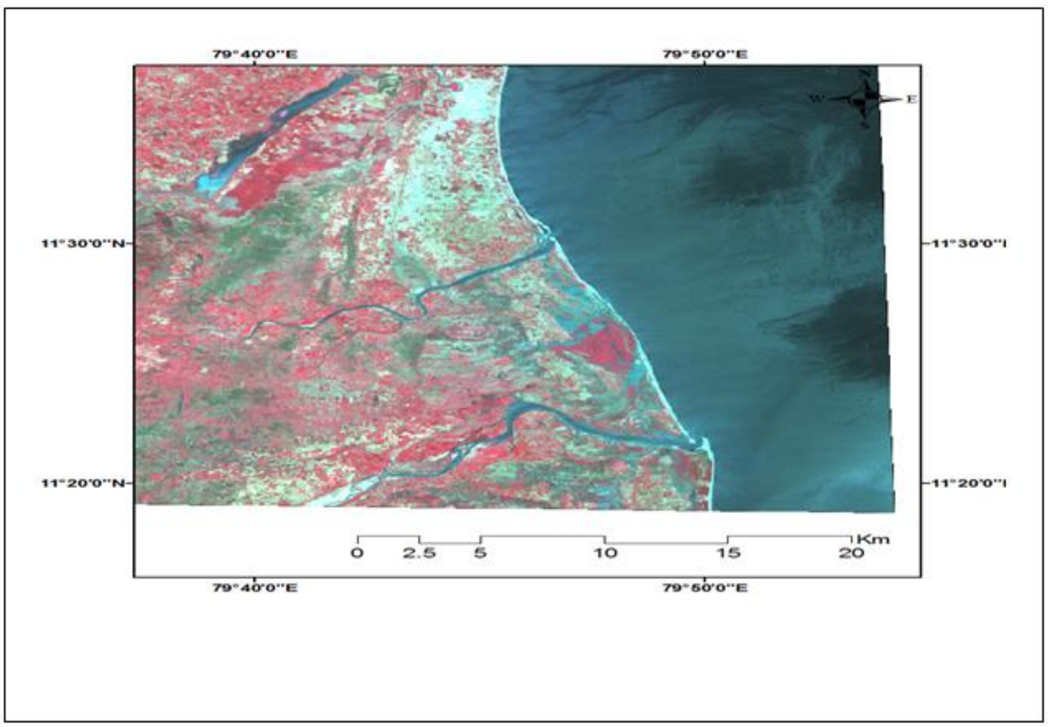

Figure 4: AOI of IRS P6 of 2012

The field equipments like measuring tape, camera, field note, pen, pencil, eraser, study area toposheets and primary geomorphology maps are taken to the field. All the doubtful areas are marked in maps to know their geographical locations and accessibility by Global Positioning System readings taken.

While traversing along the beaches, the width of beaches and height of sandy dunes has been measured, the nature and type coastal features are taken note of. The post ground truth corrections and modifications are done to preliminary maps to produce 2000 and 2012 final maps. The maps represent the coastal geomorphologic features of the study area. The maps have been updated with field information with utmost precaution, to ensure maximum accuracy and reliable information after repeated rechecking and cross checking. In these maps, the different features are delineated and classified and details of legend are shown in figs. 4, 5 and 6.

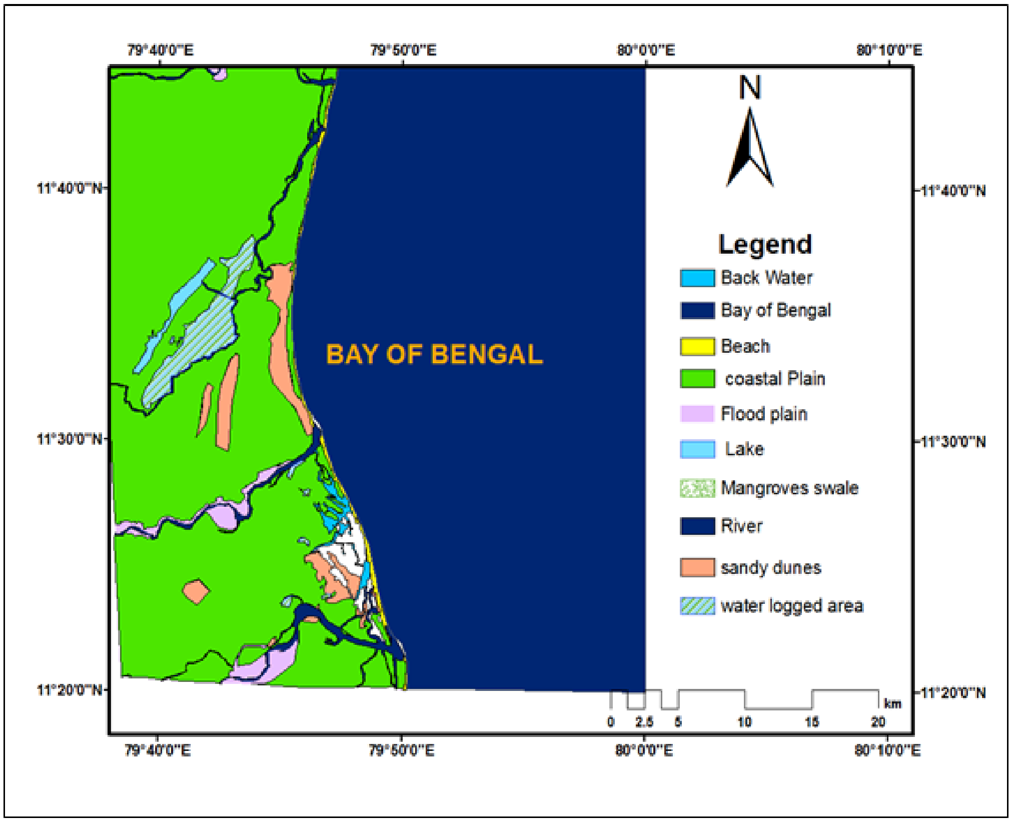

Figure 6: Geomorphological feature map during the year 2000

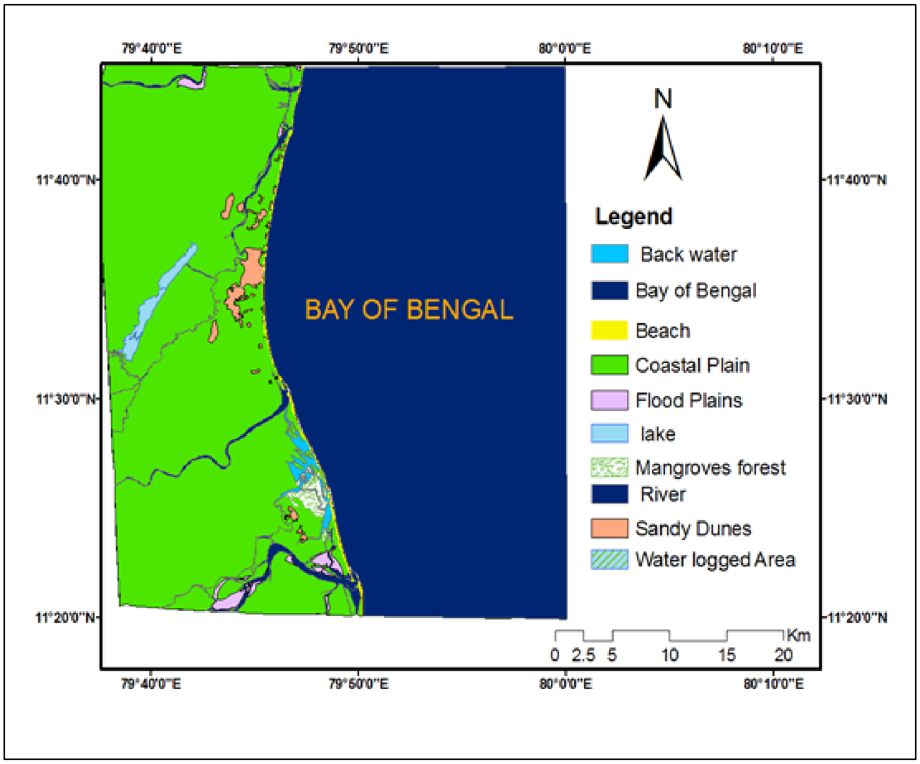

Figure 7: Geomorphological feature map during the year 2012

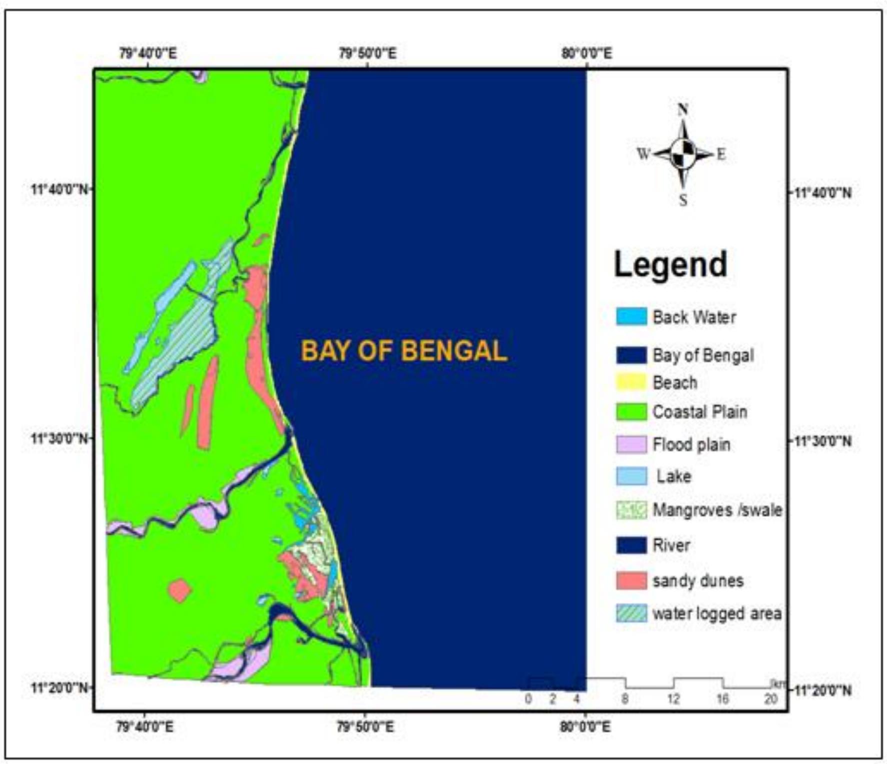

Figure 8: Showing geomorphological changes between 2000-2012

Table1: Classification of coastal Geomorphological features.

Coast Geomorphology Classification of Study Area (2000 - 2012)				
Landsat Data (2000)			IRS P6 (2012)	
Classes	**Area (Sq.km) in 2000**	**Percentage (%)**	**Area (Sq.km) in 2012**	**Percentage (%)**
Back water	6.4	0. 8	8	1. 0
Beach	8. 9	1. 2	10. 2	1. 3
Coastal plain	636. 4	81. 9	584.3	75.6
Flood Plain	17. 1	2. 2	20. 5	2.6
Lake	6. 4	0. 8	9	1.2
Mangrove area	12	1. 5	11	1.4
River	29. 9	3. 8	33. 0	4. 2
Sandy Dunes	34.5	4. 5	14	1.8
Water logged Area	25. 5	3. 3	82	10.6
Total	**777.1**	**100**	**772**	**100**

Table 2: Changes of coastal geomorphology features.

Classes	Area (Sq.km) in 2000	Area (Sq.km) in 2012	Difference
Back water	6.4	8	1.6
Beach	8. 9	10. 2	+1. 3
Coastal plain	636. 4	584.3	-52.1
Flood Plain	17. 1	20. 5	+3. 4
Lake	6. 4	9	2.6
Mangrove area	12	11	-1
River	29. 9	33. 0	+3. 1
Sandy Dunes	34.5	14	-20.5
Water logged Area	25. 5	82	56.5
Total	**777.1**	**772**	

The change in study is the process of identifying differences in the state of an object or phenomenon by observing it at different times. Change study is an important process in monitoring and managing natural resources and urban development because it provides quantitative assessment of the spatial distribution of natural features. This study is making an increasingly common application of remotely sensed data. Change study is useful in such diverse applications as coastal geomorphology change, land cover change, land use change, monitoring shifting cultivation, assessment of deforestation, study of changes in vegetation phenomenology, seasonal changes in pasture production, damage assessment, crop stress detection, disaster monitoring, day/night analysis of thermal characteristics as well as other environmental changes.

In the present study area of interest (AOI) of Landsat TM Data & IRS P6 occupied nearly 777.1sq.km and 772.0 sq. km respectively. In 2000, study area is mainly covered with coastal plain (636. 4sq.km), river (12sq.km), water logged area (25.5 sq.km) and sandy dunes (34 sq.km) that have shown changes in 2012 (Table 1 & 2). Based on the photo elements the visual interpretation was done using Landsat multidated satellite data. The study area falls under major geomorphic features such as coastal plains, river, sandy dunes, water logged area, back water, beach, mangrove area and flood plains, which are shown in the table. In both 2000 and 2012 satellite data, the dominant feature is coastal plain that has undergone changes from 636. 4 (sq.km) in 2000 to 584.3 (sq.km) in 2012. The great change has been shown by water logged area from 25. 8 sq.km to 82.0 sq.km.

Back Water:-

A backwater is a part of a river in which there is little or no current. It refers either to a branch of a main river, which lies alongside it and then rejoins it or to a body of water in a main river, which is backed up by an obstruction such as the tide or a dam. The back water is greatly found in south east of the study area and covers 6.4(sq. km) and 8.0 (sq. km) in 2000 and 2012 respectively (Table 1& 2), this increment is due to the impact of Tsunami.

Beach:-

Around 55% of Indian coastline is beach fringed. The beaches in the region are invariably sandy and have a gentle slope gradient (Wagle, 1991**)**. Sandy beaches are found at bay heads, along straight shores, on the Seaward side of sand bars and between two promontories; it is found that most of stable beaches are backed by dunes or by narrow littoral terraces, which are in turn at places backed by abandoned cliffs. Beaches are the product of waves interacting with a sandy beach at the shoreline.

The sandy beaches are extensively developed along the entire coast of study area. It trends in north-south direction. The sediment in motion along the shore is the beach (Avatharam, 2001)**.** The sand removed from the berm tends to move offshore and alongshore. The beaches in study area have increased from 8. 9 (sq.km) to 10.2 (sq. km) in2000 and 2012 (Table 1 &2) respectively due to the depositional process in respect of mean sea level changes. Besides, in the study area, the width of beach ranges from 17m to 36m that may be due to ocean currents wind climate, wave climate and rainfall and run off.

Coast plain:-

The topography of the coastal plain is a terraced landscapes that stair-step down to the coast and to the major rivers. A coastal plain is a flat, low-lying piece of land next to the ocean. Coastal plains are separated from the rest of the interior by nearby landforms, such as mountains. A coastal plain can also develop when river currents carry rock, soil and other sedimentary material into the ocean. Layers of this deposited sediment build up over time, creating a flat or gently sloping landscape. In the study area, the coastal plains have been decreased from 636. 4 (sq. km) to 584.3 (sq. km) in 2000 and 2012 respectively (Table 1 & 2), this is due to the depositional and erosional activities along the coast.

Flood Plain:-

Flood plain is an area of land adjacent to a stream or river that stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high discharge. It includes the floodway, which consists of the stream channel and adjacent areas that actively carry flood flows downstream and the flood fringe, which are areas inundated by the flood, but which do not experience a strong current. In other words, a floodplain is an area near a river or a stream when the water level reaches flood level. Coastal flooding occurs, normally in dry, low-lying land in which, the extent of coastal flooding is a function of elevation were inland flood waters penetrated and is controlled by the topography of the coastal land exposed to flooding. In the study area, the floods plains have been changed from 17. 1 (sq. km) to 20. 5(sq. km) in 2000 and 2012 respectively (Table 1 & 2), this is increment is due to the natural calamities of like floods and tsunami that affected the east coast of Tamil Nadu (Arunachalam, 2011). It has been observed that food line is landward (Saxena, 2011).

Lake:-

The Perumal Lake with north east direction covers 6. 4 (sq. km) and 9.0 (sq. km) in 2000 and 2012 respectively (Table 1 & 2). The Lake is connected to the river that increases water in the lake during flooding due to sea level oscillations and seasonal changes.

Mangrove area:-

Mangroves are various types of trees up to medium height and shrubs that grow in saline coastal sediment habitats in the tropics and subtropics – mainly between latitudes 25° N and 25° S. Trees of different species and of several families, which grow only where they can come into permanent contact with either seawater or brackish water. They occur at the edges of the tropical or sub-tropical seas, in bays, lagoon and estuarine regions.

Mangroves help in the production of detrital organic matter, recycling of nutrients and this enrich the coastal waters and support benthos population of sea. In the study area, Mangroves area covers 12.0 (sq. km) and 11.0 (sq. km) in 2000 and 2012 respectively (Table 1 & 2) located at Pitchavaram, this decrease is due to the impact of Tsunami that has affected the study area. Mangroves are also degraded and destroyed due to conversion of these areas for agriculture, aquaculture on the East Coast (Shailesh Nayak, 1990**).**

River:-
The length of Tamil Nadu coastline is 1076 km long (tn.gov.in 2014). About 46 rivers with 171,000(sq km) discharge water into the ocean. These rivers bring considerable sediments, as they traverse long distance, affecting the shore processes very significantly (Shailesh, 1990).

Rivers in the study area covers nearly 29.9(sq.km) in 2000 and 33.0 (sq.km) in 2012 respectively (Table1). This increment is due to global warming (Table 4). All rivers carry floods during monsoons. The constant increase in river area may be due to the influence of Tsunami waves towards land area during 2001 event when altered the Tamil Nadu coast geomorphology.

Sandy Dune:-
Sandy dunes are important coastal geomorphic units comprising of active and loose sediment heaps with negligible amount of vegetation (Wagle, 1991). In this zone, Series of sand dunes that vary in size and degrees of stability occur parallel to the coast and are mainly located close to the beaches and rise to the slope length of about 4. 5 to 6. 9 m. They are mainly devoid of vegetation or have only a very thin veneer of vegetation. Aeolian activity and Tsunami have been reportedly high resulting in migration and eroding the sandy dunes from 2000 to 2012 that result in change in their shapes and the coverage. It indicates the age of late Pleistocene to Recent. The material for the formation of these dunes is essentially derived from the present day beach extending from foreshore to backshore.
The dunes that are much inland are more vegetated than those near the sea. The vegetation is mainly of grassy variety. It has an important effect in helping to bind together the sand by their complex root system and thus help to protect the dunes from erosion. If the vegetation by any reason is removed, sand is exposed to the wind and blown away causing further erosion and migration of dunes. At most places dunes get stabilized by the vegetation. Along the coast different types of coastal dunes are observed, where extensive dune formation is observed covering 34.5 (sq.km) and 14.0 (sq. km) in 2000 and 2012 respectively (Table 1 & 2). All the dunes especially that are adjacent to the beach are characterized by the presence of ripples formed by the alternate white and black sand layers. The ripple formation can be ascribed due to the oscillatory flow of wind. Well developed coastal dunes are observed along the coast of Cuddalore to Pitchavaram. .

Water logged area:-
This area is a soft and watery land, which is so filled with water as to be heavy or unmanageable. The water logged area occupies 25. 5(sq. km) and 82.0 (sq. km) in 2000 and 2012 respectively (Table 1 & 2). The temporal extend is due to the flooding and tsunami in the coast of the study. The water logging extends along the upper river that may be the origin through flooding during monsoons. This usually occurs in area of poor drainage, where water does not penetrate deeply. Air spaces in the soil are filled with water, and plant roots suffocate. Consequently, waterlogged conditions adversely affect crop yields.

Conclusion
The attempt to determine the coastal geomorphology changes from Cuddalore to Chidambaram by using Landsat ETM and IRS P6 data for the past twelve years is estimated and represented. The present study shows that satellite remote sensing based coast geomorphological features mapping is very useful and very effective for getting results of temporal changes of coastal geomorphology. The study has been conducted with Landsat ETM Data & IRS P6 data; the study area falling in the coastal region of the Tamil nadu shows major changes in coast geomorphological features for the periods from 2000 to 2012.

There is an increase in Back water, Beach, Flood plains, river and water logged area and there is decrease in mangrove area, sandy dunes, lake and coastal plain. It has been found that coast geomorphology changes have been mostly caused by tsunami and global warming. It may be concluded that the Landsat TM Data & IRS P6 scene for mapping coast geomorphology changes in the Cuddalore- Chidambaram Coast area provided a satisfactory result. However, it is recommended to derive coastal geomorphology on regular interval so, that the information can be updated through time. Hence, this is an essential tool for future planning and management of coastal regions through identification of regionally significant areas and features in the coastal environment that should be protected providing an overview of the significant resource management issues in the region relating to coastal development. A suitable management plan is proposed to protect the coastal geomorphology of the study area, which is often affected by natural calamity.

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