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Studies on Remote Sensing and GIS Applications on Coastal Geomorphological Landforms Between Thondi and Muthupettai, Tamil Nadu, India

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Abstract: The aim of this study is to bring out coastal geomorphological landforms from Thondi to Muthupettai area using remote sensing, GIS and field information. It is in the survey of India toposheets No. 58 0/1 and 58 0/2, 58 N/4 and 58 N/8, 58 N/7 in a scale of 1:50,000, 1:250,000. The study area contains three types of coastal geomorphologic landforms; they are depositional, erosional and other features. The depositional features like, beach, sand dune, beach ridges, spit, lagoon and mudflats. The erosional features like sea cliffs and other features like, salt pan, backwaters and mangroves, creeks and deltas. Extensive fieldwork has been undertaken to confirm the presence of different geomorphic landforms which are identified from earth observation system. From the analysis, it has been found that the satellite data is very useful and effective for getting the results of temporal changes. The present study exhibits the potency of GIS in representing the spatial distribution of various coastal geomorphological landforms. A GIS database was developed and updated in order to provide access for future use and computer analysis. These coastal landforms are indicating that the study area had the emerging types of the coastline.

Key words: Costal geomorphology, landforms, remote sensing, GIS, toposheets

INTRODUCTION

Geographical Information System (GIS) is a synergism of various disciplines. It includes spatial information systems, computerized databases, computer graphics, cartography, statistics, remote sensing, etc. (Ganesh, 2008). Remote sensing as the words imply is the method of observation of earth scape by a device some distance away from it. According, to the physics of remote sensing, different surface objects return different amount of energy in different wavelength of the electromagnetic spectrum. Detection and measurement of these spectral signatures enable identification of surface objects both from the airborne platforms and from space borne platforms. Now a days, the world scientific community is focusing their attention towards the coastal areas of their settlements. About >60% of the populations are found to occupy the coastal areas in the developed nations (Rajamanickam and Loveson, 1998).

Geomorphology as a science developed much later than geology although several aspects of geomorphology are embedded in geological processes. Geomorphology deals with the genesis of relief forms of the surface of the earth's crust. Certain natural processes are responsible for the forms of the surface of the earth. Although, understanding of various processes leading to landforms is necessary to understand the environment in which researchers live (Rao, 2006). The study of coastal landforms is one of the most interesting areas of geomorphological research. The study is important as the tides, waves and currents provide energy that is constantly working to change the landforms (Shaikh *et al*., 1989). The presence of strandlines away from the present shoreline, submerged beaches and paleo beach ridges are found as indications of the quaternary transgression and regression (Vasudevan *et al*., 2004). Systematic geographical studies which can help to understand the coastal evolution and subsequently to use in the coastal zone management has been proposed (Rajamanickam and Loveson, 1998). Karikalan *et al*. (2001) studied the coastal geomorphology of the Porto-Novo region, South Arcot district, Tamil Nadu. The present

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investigation is mainly focusing on the coastal geomorphological landform between Thondi and Muthupettai with the help of remote sensing application like GIS packages.

MATERIALS AND METHODS

Study area: The study area extends from Thondi to Muthupettai along the Palk Strait of Bay of Bengal, Tamil Nadu, over a length about 120 km. Palk Strait is the darling of the Indian coasts is the only strait available, so close to the Indian shores. The latitude of the study area is 9°44'-10°23'N and longitude is 079°02'-079°32'E (Fig. 1). It is in the survey of India toposheets of No. 58 0/1 and 58 0/2, 58 N/4 and 58 N/8, 58 N/7 in a scale of 1:50,000, 1:250,000.

To study the coastal geomorphologic landforms, the current imagery of IRS 1 D was used. Base maps were digitized by using the Arc GIS 3.2 and 9.1 Software which were then attributed. Satellite data were Geo-referenced to a common projection by using the ERDAS Software. Satellite imagery in the digital forms was visually interpreted. The variation in the image characteristic like tone, texture, pattern, etc. was used to identify various landforms. The information obtained from the imagery was transformed to base map prepared from survey of India topographical map.

In designing the database study areas boundaries were marked from the topographic maps. Spatial data were digitized using a digitizer table in the Arc GIS 3.2 and 9.1 Software. Errors were edited which include are table more

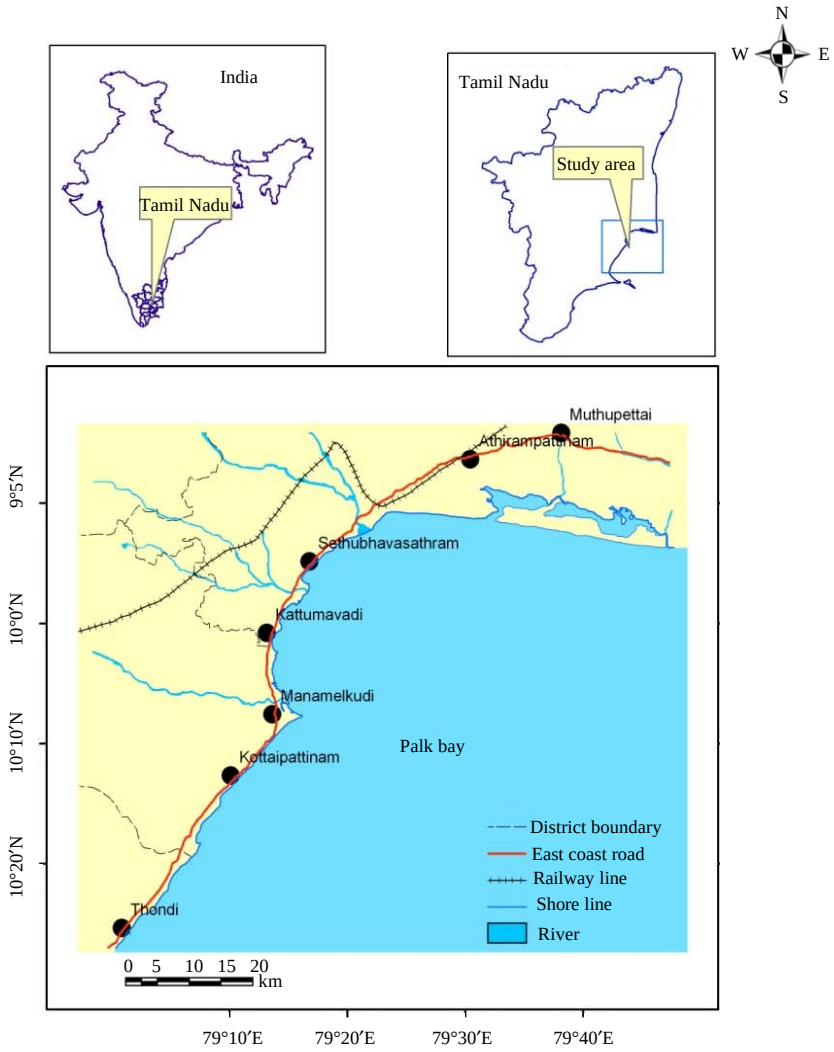

Fig. 1: Map showing the study area

and interest. Ground truth verification is one of the important components in the field of remote sensing and GIS application. The validation of the information derived from the remote sensing data is essential for checking their accuracy. In this study, the coastal geomorphologiacal landfrom maps were prepared after incorporating the necessary corrections that are obtained during the ground truth check.

RESULTS AND DISCUSSION

The first geomorphological map prepared in the year 1914 but the main demand for the maps came cover form planner and agronomists after World War II. However, a formal mapping system was designed only during 1950s. Many systems were developed by European countries like France, Poland and Russia. The International Geographical Union's sub-commission on geomorphological mapping was set up in 1960 to standardize legends for mapping. However, specific consensus was arrived at a modified legend. A geomorphological map must give information about morphology (appearance), morphometry (dimensions and slope values), morphogen (origin/genesis) and morphochronology (the age) of each form. The representation of these details is an involved and complicated matter on a single map (Rao, 2002).

The term landform as used by geoscientific modelers to denote a portion of the earth that unites the qualities of homogeneous and continuous relief due to the action of common geological and geomorphological processes (Bolongaro-Crevenna *et al*., 2005). Geomorphology deals with surficial features their form, size and materials in association with other factors, over which can rely upon directly or indirectly for many basic necessities (Rajus and Vaidyanadhan, 1978). Coastal geomorphology is the study of the evolution of landforms in relation to contemporary process and morphologic changes that are presently taking place. Geomorphology of the coastal landforms consists of three major types. Such as Aeolian landforms, fluvial landforms and coastal landforms. Aeolian landforms deals with inland sand dunes while the fluvial landforms to cusp, beach, coast, ridges, estuary, delta, at with vegetarian, tidal creek and mangroves. The coastal geomorphologies of the study area are classified into three types namely depositional, erosional and other features.

Depositional features: The eroded materials are deposited in a particular place. Due to deposition the places are emerging to a specific size. This type of features is called as depositional features. Depositional features of the present study area include beach, sand dune, beach ridges, spits, lagoon and mudflats. The beach is temporary or short lined deposits on the shore (Fig. 2). It covers the seashore between the high and low water level of the tides. There are two kinds of beaches are observed in the study area. There are sandy beaches and muddy beaches. The sandy beaches noted in Manamelkudi, VadakkuAmmapattinam, Pudhupattianm, Vattanam and Thondi. In this area, the beach is composed of fine and medium sand. The muddy beaches noticed from Kattumavadi to Sethubavasathram and Kilathottam to Muthupettai. Dunes are identified in aerial photography by very light tone. In the study, area dunes are scarcely distributed. The sand dunes are noticed in the Pudhukudi, Mimisal, Kumarappavayal, Villinivayal and Chinnamunai. The dune length varies from 2-5 m and height fluctuates from 1-2 m (Fig. 3). From the aerial photos, beach ridges are identified by medium gray line with medium text line. The beach ridges are noticed in the present study area in Sembai pattinam. The height of the ridge is 1-3 m (Fig. 4). The length is 1-2 km. These ridges patterns are indicating their recent origin.

Fig. 2: Beach at Pudhupattinam

Fig. 3: Sand dune at Sembaipatttinam

Fig. 4: Beach ridges at Sembaipattianam

Fig. 5: Spit at Pudhupattinam

The spit growth is noticed in Kottai Pattinam, Muthukuda, Manamelkudi, Pudhupattinam and Kilathottam. The spit length varies from place to place. For example, the highest length of the spit is noticed in Kilathottam, more or less 200-500 m (Fig. 5). In the high tide region behind mangroves around the sand spit, mud flats are noticed. Rajamanickam and Loveson (1998) described well-developed hooked nature of spit bending towards S-E direction and having a line with mainland is S-W direction. The shallow stretch of seawater behind the barrier is called a lagoon (Fig. 6). The coastal lagoons are noticed in Ponnagaram, Palakudi, Vadakku Ammapattinam and Munpalaipattinam. Mudflat is identified by dark gray tone with smooth and irregular texture and shape, respectively from the imagery. Mud flats are noticed in Vattanam and Pudhupattiam (Fig. 7).

Erosional features: Due to severe wind and waves the material from the surface are eroded from one place and it deposited to the others. The features that are formed due to erosion are called erosional features. Sea cliff is a deep rock face rising from flat ground or from a side of a mountain (Fig. 8). The cliffs are noticed in Sundarapaduiyapattianm, Pudhupattianm, Manamelkudi and Muthupettai.

Fig. 6: Lagoon at Muthupettai

Other features: The other features include the saltpan, backwaters, creek, delta, mangrove and mangroves. The saltpan is defined an untrained usually small and shallow rectangular man made depression on hollow in which saline water accumulates leaving a salt deposits. The saltpan is noticed in Kattumavadi, Vattanam and Kottaipattinam (Fig. 9). Backwaters are noticed only in the Muthupettai area. The total area of backwater is 119 km^2 (Fig. 10). Tidal creeks are inlets through which water flows to and form a lagoon or other backwater during high and low tides, respectively (Fig. 11). The creeks are noticed in Kattumavadi, Manamelkudi and Adiramapattinam. The deltas are identified by deep red line in the imagery (Fig. 7 and 9). The deltas are noticed in Vattanam, Manamelkudi, Sembaipattinam and Kilathottam. In the aerial photographs, mangroves are seen in dark and gray tone with irregular surface. The mangroves are noticed in Vattanam, Palakudi, Muthukuda, Adiramapattinam (Fig. 12). The well-developed mangroves noticed Muthupettai area only.

Mapping of natural resources and natural hazards as well as assessment of land surface resistance to denudational processes are important in guiding planning and may be very useful for example in developing countries or areas with expansion of population and infrastructure as a result of economic growth. Maps giving this information are especially important in densely populated high mountain regions where relief and geomorphological processes control or have influence upon nearly all natural and artificially features such as slope stability, vegetation, glacial processes, hydrography as well as settlement and communication pattern. Other areas where problems occur are areas with crustal movement and frequent seismic activity causing development of increasingly steep and unstable terrain or low areas close to rivers or the sea or areas with seismic or volcanic activity. In all cases, geomorphological

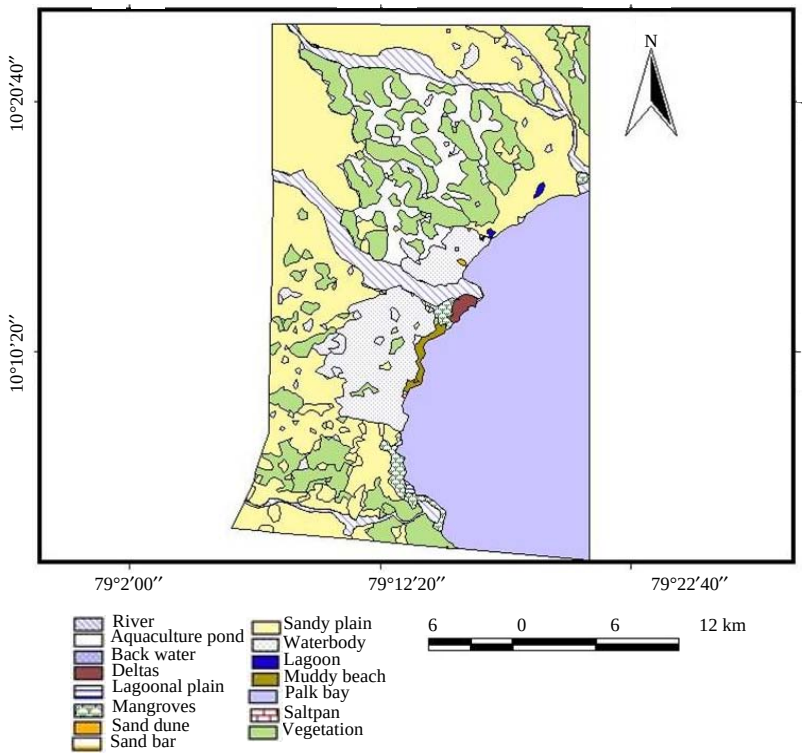

Fig. 7: Coastal geomorphological landforms from Manamelkudi to Adirampattinam

Fig. 8: Sea cliff at Pudhupattinam

mapping at different scales is a useful approach in landscape planning and natural hazard classification. The technological advances during the last two decades have facilitated this research since it enables the use of digital remote sensing together with Geographic Information Systems (GIS) and the use of detailed Digital Elevation Models (DEM). Although, many advantages such as low costs, easy aerial coverage and easy processing and classing of data, remote-sensing techniques can only give coarse indications of small features or sub-surface processes in the landscape and during detailed mapping such techniques must be combined with mapping in the field. Further, despite this technical development geomorphological maps still have their limitations in describing the landscape especially in the sub-surface features due to lack of detail and to the researchers subjectivity (Barsch *et al*., 1987; Petley, 1998; Bocco *et al*., 2001; Etzelmuller *et al*., 2001).

The earliest geomorphological maps described features such as river valleys and terraces. Other maps showed some slope forms, karst landforms, landslides and rock falls or concentrated on landform groups created by similar processes such as fluvial or glacial features. For a long time these maps which actually should be called thematic rather than geomorphological were used for illustrating only certain chosen, characteristic or even fashionable landforms. In these maps neither a detailed classification of the landforms was given nor did the maps give a complete description of all the landforms in the landscape (Rudberg, 1979; Klimaszewski, 1982, 1990; Elvhage, 1983). The concept of producing geomorphological maps describing a limited amount of information is still common. A now a days common example of this is simple morphogenetic maps commonly used in field studies of glacial features (Evans, 1990).

Ramasamy and Karikalan (2010) reported the distribution and percentage of heavy minerals in coastal

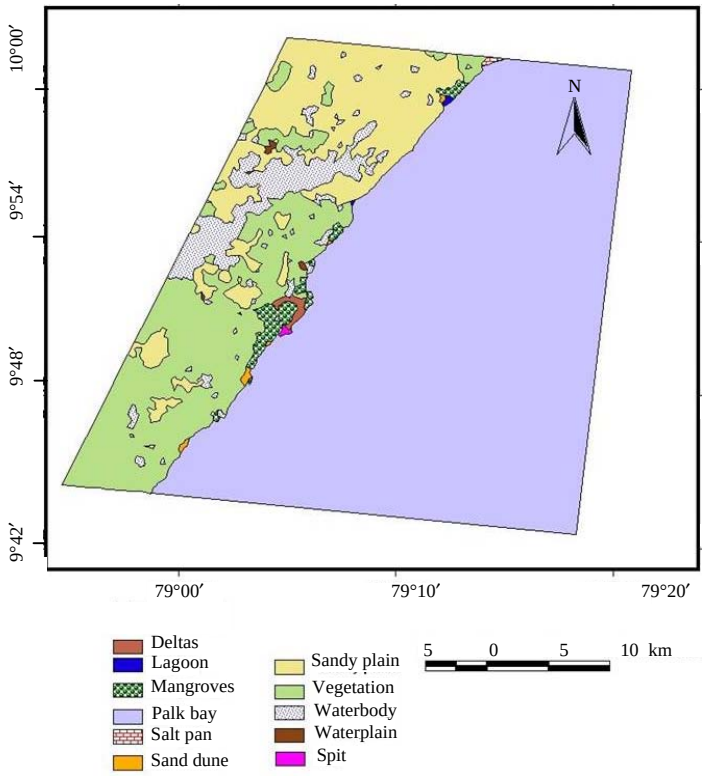

Fig. 9: Coastal geomorphological landforms from Thondi to Manamelkudi

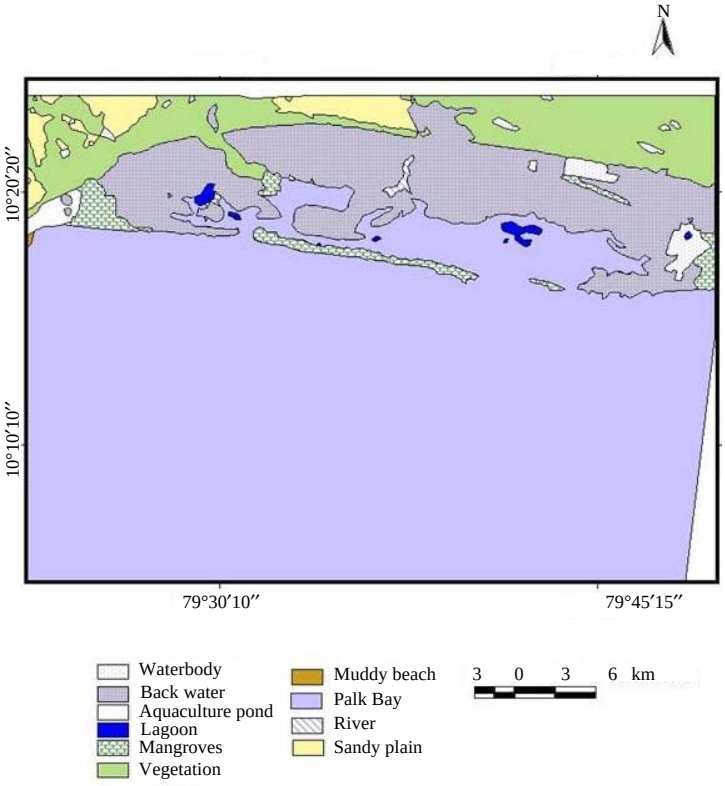

Fig. 10: Coastal geomorphological landforms from Adirampattinam to Muthupettai

Fig. 11: Creek at Kattumavadi

Fig. 12: Mangroves at Muthupettai

geomorphologial landforms in Palk Strait. Five different coastal geomorphological landforms such as berm, beach, spit, sand dune and lagoon were reported from Thondi to Manamelkudi in the Palk Strait, Bay of Bengal. In the present investigation described the three major types of coastal geomorphological landforms (Fig. 1-9, 11 and 12). Such as aeolian landforms deals with inland sand dunes while the fluvial landforms such as beach, coastal dunes, ridges, estuary, delta, mud flat with vegetation, tidal creeks and mangroves. The coastal geomorphology of the study area is classified into three types namely depositional, erosional and other features. The coastal landforms are beach, sand dune, beach ridges, spit, lagoon, mudflat, creeks, deltas, sea cliffs, saltpan, backwaters and mangroves.

CONCLUSION

The study has revealed that the satellite has the unique capability to detect the coastal geomorphologic landforms quickly and accurately. In the study, it has been identified that the input derived from the satellite data would contribute to the regional efforts to access and monitor the coastal landforms as well as to formulate the policies and measures to mitigate the undesirable effects. From the analysis, it has been found that the satellite data is very useful and effective for getting the results of temporal changes. The present study exhibits the potency of GIS in representing the spatial distribution of various coastal geomorphological landforms. Applications of remote sensing and GIS have provided new insights to the beach topography and coastal geomorphological landforms of Palk Strait in the Bay of Bengal. This has also provided a data analysis tools and methods to evaluate the geospatial patterns in short and long term change. Beach fore dune is also retreating due to anthropogenic and geogenic processes. The geospatial analysis illustrates the significance of land cover/land use including variation in shoreline position and sediment budget has characterized the geomorphological vulnerability in the coastal region of the southern Tamil Nadu coast.

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