Identifications of coastal geomorphology features using ASTER data and GIS in Thoothukudi coast, Tamil Nadu, India

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Abstract- *The attempt is to identify the coastal morphological features using GIS technology along Thoothukudi coast, with proper understanding of costal processes operating in Thoothukudi coast, which helps to management plan to safeguard the region from the coastal threats. The study region is represented by different coastal features like beach, beach ridges, coastal plain, dune complex, lagoon, mud flat, shallow food plain, shallow alluvial plain, shallow buried plain, salt flat, swale and coral reef island, etc. Coastal geomorphological features are identified using ASTER data and GIS analysis to evaluate changes and to bring out reliable information in large landscape mapping of morphologic features.*

Keywords- Coastal geomorphology, ASTER data, GIS and Thoothukudi Coast.

I. INTRODUCTION

Coastal geomorphological studies are to focus on identifying the morphological development and evaluations of coastal features. It explores the relationship between the coastal landform and related process from climatology, oceanography, fluid mechanics, sedimentation and geography [7]. Distinctive coastal features may varied by large-scale geological factors, local geological setting, surface process and relative changes in hydrodynamic pattern. These dynamic environment of the coast are directed towards static equilibrium and to balanced and equalized as coastal features. Generally, coastal features categorized as three reacts i.e. depositional, erosional and special features [15,4]. The depositional features are Beaches, Spits, Bars, Dune, Barrier island and Palaeo delta, formed through the influence of accretionary process of sediments. [9]. Erosional features are beach platform, cliff and shore etc. Finally, the special features are Estuaries, Kayaks, Lakes, Lagoon, Mud flats, Tidal flats, Marshes and Mangroves etc.

Many researchers has discussed on coastal geomorphology of India. In south east India, narrow sand dunes, coastal dunes and beach ridges of coastal features are observed by [3]. Coastal region east coast is differing from west coast in nature of geomorphological feature and evolutions [5]. East coast of India is classified into three distinct depositional environments namely marine, fluvial and Aeolian features [19]. Spit formation and its process of development along Thoothukudi coast was discussed by [22,10]. Salient features and Tombolo was observed by [13].

Thoothukudi coast is represented by many coastal features such as, beach, beach ridges, coastal plain, dune complex, lagoon, mud flat, shallow flood plain, shallow alluvial plain, shallow buried plain, salt flat, swale and coral reef island [1,17]. The Main objective of the present study is to highlight and to map surficial features of coastal geomorphological distribution along Thoothukudi coast by GIS based analysis. It provides a proper understanding of costal processes operating in Thoothukudi coast and thus helps to suggest a protective technique for this costal region.

II. REGIONAL DESCRIPTIONS

Thoothukudi coast is located in the south east portion of the Tamil Nadu between 8°41’49” N and 9°22’20”N latitudes and 78°3’56” E and 79°26’6” E longitudes, which includes Tuticorin group of islands (Van island, Koswari island, Karriyashulli island and Vilangushulli island) and Vembar group of islands (Upputhanni island, Pulluvinichalli island and Nallathanni island) of Marine National Park of Gulf of Mannar. Gulf of Mannar along the region is scattered with 21 islands distributed as fringing reefs on shallow shore stretching 170 nautical miles from north of Mandapam to south of Thoothukudi [8,2]. Different types of reef forms such as shore platform, patch, coral pinnacles and atoll type are also observed in the Gulf of Mannar (Fig.1)

III. METHODOLOGY

Remote sensing and Geographical Information System (GIS) have been employed in coastal geomorphological research in past few years [20,11,21]. Surficial features of coastal geomorphology are also highlighted by visual interpretation of GIS based analysis. The primary data for the present study were acquired from

topographic map from Survey of India's index map no 58K/4,8 and 12 and 58L/1 and 5 and cloud free data of 2016 ASTER (Advanced Space borne Thermal Emission and Reflection Radiometer) image from open sources of Earth Explorer server.

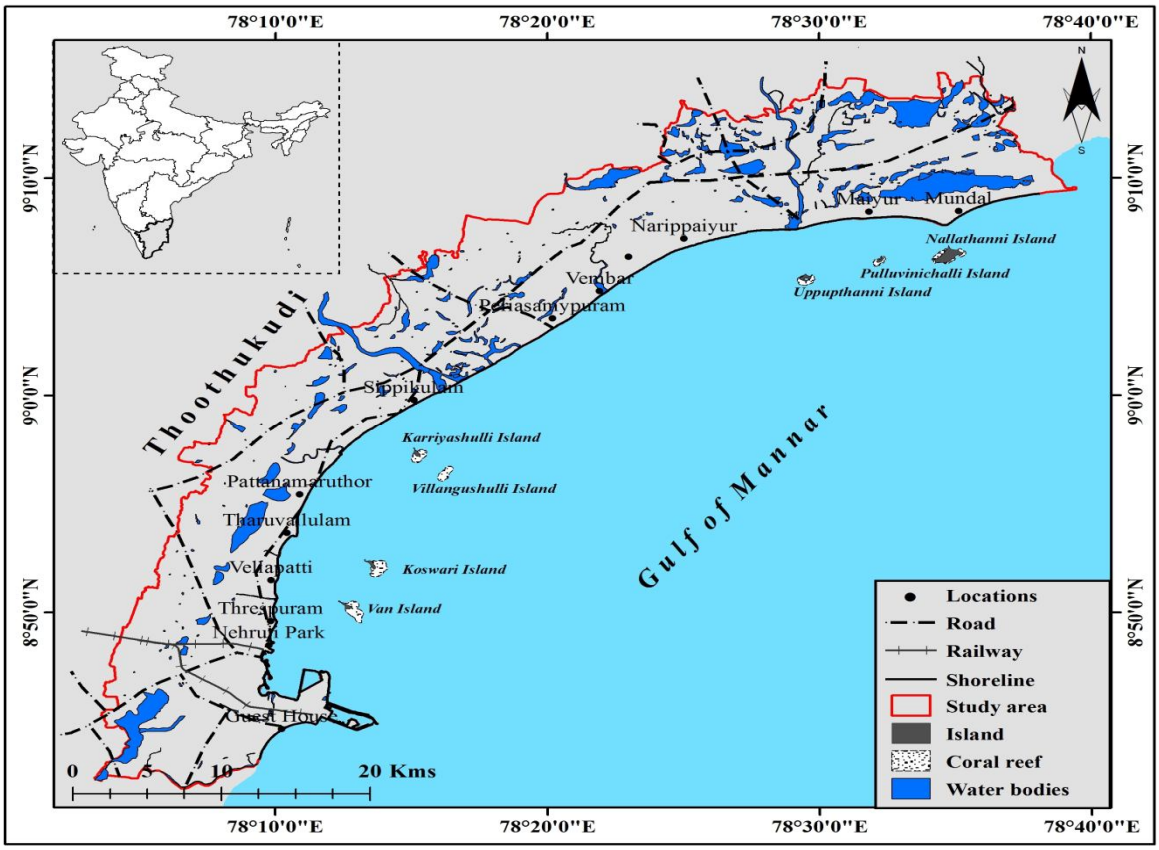

Figure 1. Study area map of Thoothukudi coast

This surficial coastal features are observed from False Colour Composition of VNIR bands, 15 meter resolution of ASTER data projected into UTM 43 Northern hemisphere datum. Further, it has been enforced to radiometric correction, atmospheric correction and mosaicked to preferred visual interpretations. Before, Interpretations of coastal features field investigations conducted using Magellan GPS (Global Positioning System) to improve accuracy of digitization.

IV. RESULT AND DISCUSSION

Coastal geomorphology features identified in Thoothukudi coastal region and adjacent group of island are Beach, Beach Ridges, Coastal plain, dune complex, lagoon, mudflat, shallow food plain, shallow alluvial plain, shallow buried plain, salt flat, swale and coral reef island (Fig.2). The recognized coastal geomorphological features are described as follow,

Salient had widened the shoreline due to either submerged or emerged offshore barrier. Certain parameter of Thoothukudi harbour to Tharuvaikulam with length of 0.26km, 0.24km, 1.01km and 0.12 km respectively. salient were spotted along Thoothukudi coast at the place of Threspuram, Tharvaikulam and Mundal. These seaward projection are formed by offshore barriers of coral reef island, diffracted and reflected of wave approaching shadow zone along mainland [13].

Breakwater, Coastal structures such as jetties, groins, detached breakwater and sea wall are constructed to protect the coast from the natural hazards [18]. This coastal structure positioned in seaward direction of the surf zone, to minimize the shoreline erosion and to promote widening beach are initiated by sediment deposition, which modified the nearshore currents. Along Thoothukudi coast six artificial breakwaters are constructed. Based on the analysis one of the two breakwaters were identified in new harbour to open sea with length of 4 km. The length of the northern and southern breakwater was 4098m and 3873m correspondingly. Remaining four breakers was constructed in between

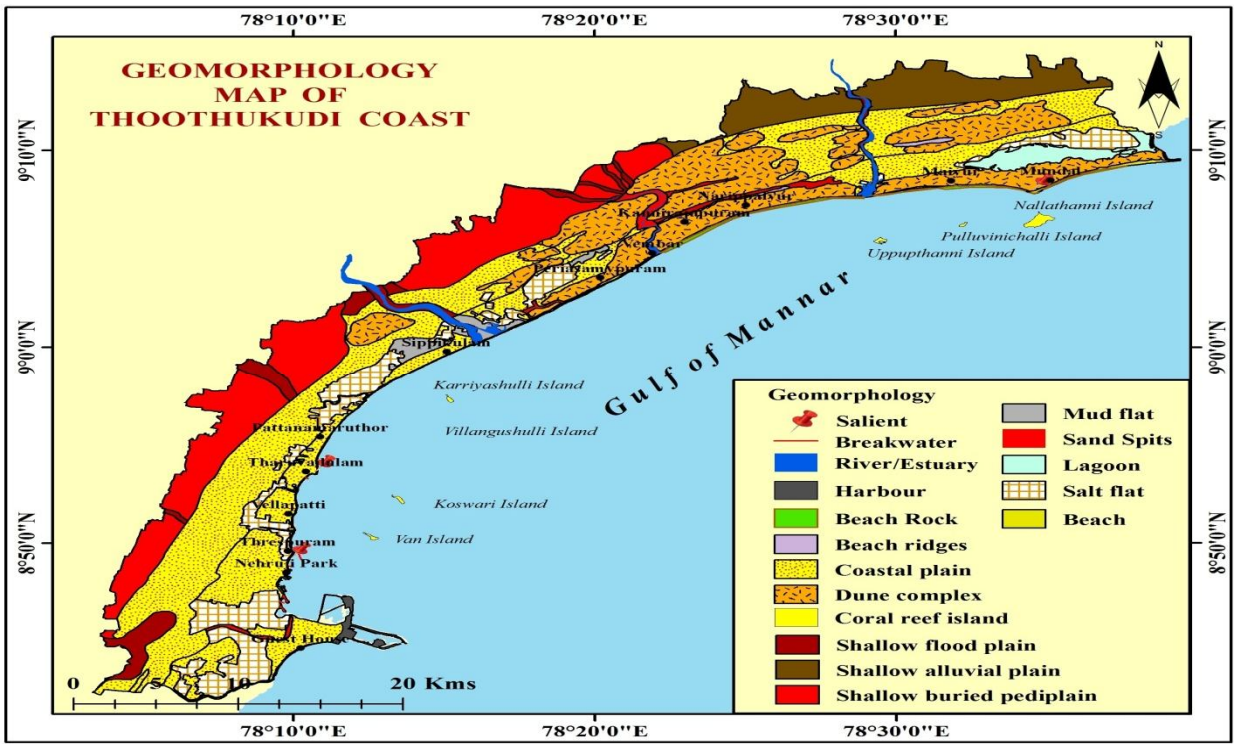

Figure 2. Map showing coastal geomorphological features of study region

Estuary, four estuarine of river mouth were located in Kallar, Vaippar, Vembar and Gundar River were huge amount of heavy minerals from the source with fine sand materials are deposited.

Harbour, In Thoothukudi region has two manmade harbours one at old port (fishing Harbour) and other is commercial harbor named V.O. Chidambarnar port, which is very near to major international are routes. The new harbor constructed in the sea which covers exactly 3.29sq.km and old port cover 1.89sq.km.

Beach Rock, is common geomorphological features of warm tropical and subtropical shore. In Thoothukudi coast estimated about 0.59sq.km of beach rock were found in Vembar to Mundal beach shore, which is formed during earlier phase of late Holocene transgression. These beach rocks are formed by coastal sediment and carbonate shell fragments cemented together to precipitate the calcium carbonate in beach shore [16].

Beach Ridges, wave or wind deposits of ridges running parallel to the shoreline were spread over 2.56sq.km in northern side of the Thoothukudi coast between Vembar to Mundal.

Coastal plain, is a flat low-lying land adjacent to seashore, which is estimated as 281sq.km in southern part of the study area, which extent downward to east directions form the study region.

Dune complex, are extensive of small sand dunes formed by the blowing of wind. In study region dunes run parallel to flow directions of wind. These dunes are mostly situated in central part of study area and covers 164.36sq.km.

Coral reef island, are scattered around the Thoothukudi coast and distributed with submerged fringing reefs in Gulf of Mannar. Each islands measures about 5-6 km2 in area and characterised by reefs with marked zonation of patch reef, offshore patches and coral pinnacles [14]. Study area has seven coral reef barrier island system of Tuticorin group of island which includes Van Island (2.72sq.km), Koswari Island (10.66sq.km), Karryashulli Island (8.33sq.km) and Vilangushulli island and Vembar group of island compiled of Upputhanni Island (21.03sq.km), Pulluvinichalli Island (8.48sq.km) and Nallathanni Island (109.70sq.km). These uninhabited Islands are the first Marine Biosphere Reserve in South & Southeast Asia and one of the biologically richest coastal regions in India. These islands dominant corals species are Pocillopora damicornis, Acropora, Montipora and Turbinaria and reef building organism of Calcareous algae is rich in around the study region [12].

Shallow flood plain are formed in the area adjacent by force of river driven land during the flood time, which are experiencing heavy discharge of water. In this region 12.11sq.km of shallow flood plain were identified near Vaippar, Kallar, and Gundar Rivers.

Shallow alluvial plain, is a large body of flat landform formed by deposition of sediments in shallow level. This characteristics features was observed in north western part of the study region, which cover about 64.16sq.km.

Mudflat, is a coastal wetland contains fully mud deposits from tidal action or river derived sediments. This feature largely found in and around Thoothukudi harbour and near Sippikullam area measuring approximate 11.99sq.km.

Sand spits, are identified very close to Thoothukudi harbour, which cover 0.39sq.km, these small long narrow feature formed by near shore processes and littoral transport, which built a small quantity of land in shoreline towards seaward.

Lagoon, a body of water separate from sea due to large deposition of sediment barriers. These usual morphological features enclosed by salient in Mundal, which around 14.33sq.km.

Salt flats, extensive salt layer formed naturally in temperately a body of saline water. In Thoothukudi coast experienced salt flat largely by artificial and naturally manufacturing of salt from salt pan for about 96sq.km.

Beach, Thoothukudi coast contain eighty six percentage of reflective, nine percentage of Intermediate and five percentages of dissipative beaches [6]. These beaches cover 4.81sq.km, and contain loose sediments range from silt to pebble size of sand, from low tide line to vegetation line.

V. CONCLUSION

In Thoothukudi coastal region detail investigations are carried out to determine the surficial coastal geomorphological mapping through visual interpretations of 2016 acquired ASTER data. These remote sensing and GIS techniques provide accurate and reliable information in large landscape mapping. This present work confirmed the mature stage of costal features such as salient, breakwaters, estuaries, harbour, beach rock, beach ridges, coastal plain, dune complex, coral reef islands, shallow-flood plain, alluvial plain, mudflat, sand spit, lagoon, salt flat and beach. Identifications of geomorphological features provide relevant information behind coastal process.

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REFERENCES

[1] A. Parthasarathy, and U. Natesan, -Coastal vulnerability assessment: a case study on erosion and coastal change along Tuticorin, Gulf of Mannar. Natural Hazards, 75(2), 2015 pp.1713-1729.

[2] A.K. Kumaraguru -Project title: Ecology of ornamental fishes of export value in the Gulf of Mannar. Project report for the period ending, 1997. pp.31-1.

[3] Alexander kunz, Manfred Frechen, Ramachandran Ramesh and Brigitte Urban -Luminescence dating of late Holocene dunes showing remnants of early settlement in Cuddalore and evidence of monsoon activity in south east India. Quaternary International, Elsevier, 2009 pp.1-15.

[4] C.A. King, -Feedback relationships in geomorphology. Geografiska Annaler. Series A. Physical Geography, 1970 pp.147-159.

[5] E. Ahmad, -Coastal geomorphology of India. Book 1972 p. 375.

[6] H.M. Sabeen, . -A comparative study of beach sediments in the east and west coasts of India between Tuticorin and Quilon.unpublished Ph.D., thesis in Manonmaniam Sundaranar University,Trinelveli 2015 335p

[7] J.L. Davies, -Geographical variation in coastal development (Vol. 1522168). K. M. Clayton (Ed.). London: Longman 1980.

[8] K. Krishnamurthy, A. Choudhury, and A.G. Untawale, -Status report–Mangroves in India. Ministry of Environment and Forests, Government of India, New Delhi,1987. p150.

[9] L.D. Wright, and B.G. Thom, -Coastal depositional landforms: a morphodynamic approach. Progress in Physical Geography, 1(3), 1977, pp.412-459.

[10] M. Chockalingam, -Coastal geomorphological studies of the region subtended between Mandapam and Devipattinam, Tamilnadu. Unpublished Ph. D. thesis) Tamil University, Thanjavur, 1993 pp117-127.

[11] M.G. Shaikh, S. Nayak, P.N. Shah, and B.B Jambusaria, -Coastal landform mapping around the Gulf of Khambhat

using Landsat TM data. Journal of the Indian Society of Remote Sensing, 17(1), 1989, pp.41-48.

[12] M.V. Mukesh, -Sedimentology of the coral reef ecosystem in and around the barrier islands of Chidabaranar district Tamilnadu. Unpublished Ph. D. thesis) Manonmaniam Sundaranar University,Trinelveli 1997.

[13] N. Ramanujam and R. Sudarsan, -A study of coastal transformation at Tuticorin as a result of emerged and submerged natural breakwaters of Van Island, Gulf of Mannar. Environmental Geology, 43(5), 2003, pp.521-525.

[14] N. Ramanujum, M.V. Mukesh, and N.B. Preeja,. -Calcium carbonate accretion, Mechanical properties and adaptive significance of the coral Acropora cervicornis in the windward side of Karriyashulli Island, Gulf of Mannar, Jou. Ind. Assoc. Sedi. 11, 1992, pp.89-94.

[15] P.D. Komar -Beach processes and sedimentation. Prentice-hall eaglewood. Cliffs. New Jersey, 1976, 324p.

[16] P.J. Thomas, -Luminescence dating of beachrock in the Southeast Coast of India—potential for Holocene shoreline reconstruction. Journal of Coastal Research, 2009 pp.1-7.

[17] R. Muthukumarasamy, M.V. Mukesh, M. Tamilsevi, and A. Chandrasekarn -Identification of geomorphological and geological features in between Valinokkam and Thoothukudi coast using remote sensing and GIS technology.International journal of current Research, 5(9), 2013 pp. 2676-2678.

[18] R.G. Dean, and R.A Dalrymple, -Coastal processes with engineering applications. Cambridge University Press 2004 p.489. .

[19] S. Prasad, K. Pandarinath and S.K. Gupta -Geomorphology, tectonism and sedimentation in the Nal region, western India. Geomorphology, 25(3), 1998 pp.207-223.

[20] S.R. Nayak, and B. Sahai, -Coastal geomorphology of the Gulf of Khambhat. Proc. Sym. Quat. India. MSU Baroda, 1985. 87p.

[21] V. Klemas -Airborne remote sensing of coastal features and processes: An overview. Journal of Coastal Research, 29(2), 2012, pp.239-255

[22] V.J. Loveson, G.V. Rajamanickam, S. Bhan, and V. Jha, -Coastal geomorphology of the south-ern Tamilnadu, India. Remote Sensing in Land Transformation Management. Hyderabad, India, 1987 pp.115-12