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ORIGINAL ARTICLE

Application of Geospatial Techniques to Determine Coastal Erosion and Accretion along the Ramanathapuram Shore, Tamil Nadu, India

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ABSTRACT

The coastal region is one of the most sensitive areas on earth. This region has a diversified ecosystem. Erosion and accretion are common natural phenomena that can be seen in this region. In some circumstances, these changes become hazardous to the coastal ecosystem. Natural processes such as rainfall, flood, cyclone, longshore drift, and tectonic shifts can trigger irregular coastal changes. Similarly, anthropogenic factors such as urbanization, unscientific land usage, mining, etc., enhance coastal dynamics and make larger changes. Hence identification of such region has great importance. Geospatial technology has brought various advanced methods for shoreline change studies. It has decreased the huge effort for getting an accurate result for a larger area. Landsat satellite imageries with 30 m spatial resolution have been used for studying the changes in the shoreline of Ramanathapuram for the years 2000, 2005, 2010, 2015 and 2020. In Geographic Information System (GIS) software, the Digital Shoreline Analysis System (DSAS) tool is added for shoreline change analysis. DSAS will build the baseline transects. The rate of shoreline change was calculated using the MATLAB feature runtime function for ArcGIS. Based on the DSAS output, the region of high erosion, low erosion, stable, and low accretion, high accretion zones have been identified on the shore. The results reveal that 5.1% of the shoreline, around 9.3 km is under high erosion, 11.5% of the shoreline, which is around 20.8 km, is under low erosion, 71% of the shoreline, around 128 km, is a stable region, 6.7% of shorelines, around 12 km, have low accretion, and 5.6% of shorelines, around 10.1 km, have high accretion. The coastal villages, namely, Mayakulam, Keelakakrai, Periapattinam, Mandapam, West-Pamban, and East-Rameswaram, have a high erosion with a maximum rate of change between 2.29 to 5.11 m/y. The coastal villages Ervadi, Kalimankund, Sattankonvalsai, South-Pamban and South-Rameswaram have high accretion with a maximum rate of change between 2.34 to 5.24 m/y.

INTRODUCTION

The shoreline is a highly significant and complex area where the land, air, and sea unite. It is sensitive to external disturbance (Vousdoukas et al. 2020; Laegdsgaard et al.2006). Longshore drift and constructive waves will cause coastal alterations (Ashton et al., 2001). The coastal region will also be subject to change by the wind forces, wave action and sediment movement. Similarly, the rapid urbanization, uncontrolled usage of marine resources and other anthropogenic factors contribute to the destruction of the coastal environment (Bougherira et al., 2020; Joevivek et al., 2014; Nobi et al., 2010; Boateng et al., 2012; Kawakubo et al., 2011; Yoo et al., 2016; Sanil Kumar et al., 2002).Morphological changes over the coastal region makes variation on coastal ecosystem and communities (He et al., 2021; Velsamy et al., 2020; Mentaschi et al., 2018). The changes in such sensitive coastal regions impact various physical, climatic, and biological aspects (Nithu Raj et al., 2019; Appeaning-Addo et al.,2013). The coastal region influences the economy and, more importantly, social well-being (Saxena et al., 2013; Mandych et al., 1992). In this concern, coastal studies have become crucial to analyzing the decadal seaside changes.

Shoreline change analysis is a well-defined and widely used method for assessing changes in the shoreline position through time (Valderrama-Landeros etal.2020; Burningham et al.2017; Murali et al.2015). For the study, geospatial technology is used to identify the areas of erosion, accretion on a long-term interval. Recent development in remote sensing technology and spatial data products and their integration with GIS software has increased the capability of identification and demarcation of land features (Abualtayef, M et al.2021; Ghafourian, S et al.2021; Stevens et al.2011; Turer Baskaya et al.2015; Boateng et al.2012; Kwarteng et al., 2009; Szlafsztein, C et al.2017). The data quality and availability are also improved several-fold during the period between 2000-2020, which are suitable for observing the coastal region's historical development (McCarthye et al., 2017; Van Zuidam et al.1998; Brian Baily et al., 1996). ArcGIS 10.2 have been well implemented in this study to extract the multiyear shoreline boundary. DSAS is a highly supportive tool for shoreline change studies (Karima Remmache et al.2021; Mageswaran et al.2021; Baig et al.2020; Glitson et al.2020; Mohanty et al. 2017; Sreenivasulu et al. 2016; Oyedotun et al. 2009). This method is very effective while assessing a long-term change (Baral, R et al., 2018; Bheeroo et al.2016; Kuleli et al.2010; Dawson et al., 2009). DSAS will create the transects from the digitized baseline to measure the horizontal shoreline movement (Mullick et al.2020; Mahmud et al.2020; Umit Duru et al.2017; Sheeja et al. 2016). This research helps to understand the village-level shoreline changes for controlling the erosion risk and serves as a foundation for evaluating the coastal villages in the study area.

STUDY AREA

The coastal region of Ramanathapuram district, Tamil Nadu, India has taken up for the research work. It is between the geographic coordinates of 78°45' E to 79°20' E longitude, and 9°05' N to 9°30' N latitude with an average altitude of 2 m above mean sea level. The north part of the study area constitute the coast of Palk bay, and the southern part is represented by the Gulf of Mannar coast. For shoreline change analysis, the study area has split into two zones. Zone-I is along the Ramanathapuram coast, and zone-II is Rameswaram Island which is offshore. The 25 coastal villages namely, Ervadi, Mayakulam, Keelakarai, Kanjirangudi, Tiruppulani, Kalimankund, Periapattinam, Karan, Rettaiyurani, Pudumadam, Nochiyurani, Sattakonvalsai, Mandapam, Pirappanvalsai, Enmanamkondan, Nagachi, Attangarai, Alagankulam, Terbhogi, Athyuthu, Chitrakkottai, Devipattinam, Pathanendal, falling in zone-I and the villages namely, Pamban, and Rameswaram are in zone-II are studied to observe the shoreline dynamics (Fig. 1).

This region is very complex towards the consolidated impacts of subsidence and extraordinary occasions, like a storm, floods (Behera, R et al., 2019; Aucelli et al., 2018; Jeanson et al. 2014; Sheik Mujabaret al.2013). The area has been listed in a moderate zone of cyclone affecting region and high drought zone by the National Disaster Management Authority (NDMA) of the Government of India. There has been one significant cyclone during the study period, and the name given to this west-southwestward wind was cyclone Gaja in 2018. The average annual rainfall of Ramanathapuram is 827 millimetres, with the highest concentration in Pamban and along the shore and decreasing inland (Directorate of Geology and Mining, 2016). The average temperature in the area is around 28° C; the maximum

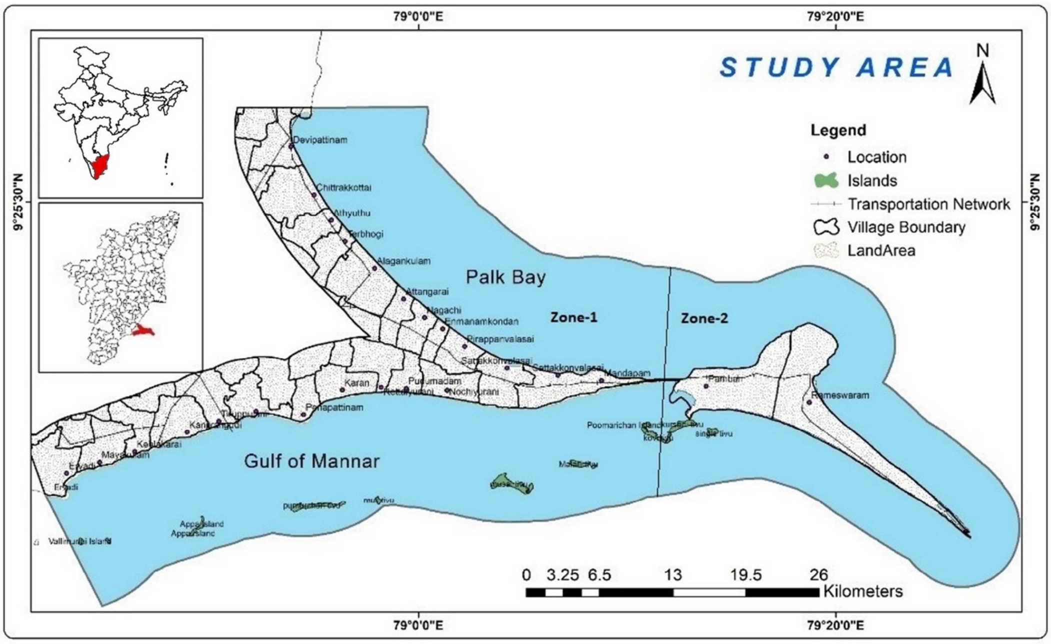


Fig. 1. Study Area

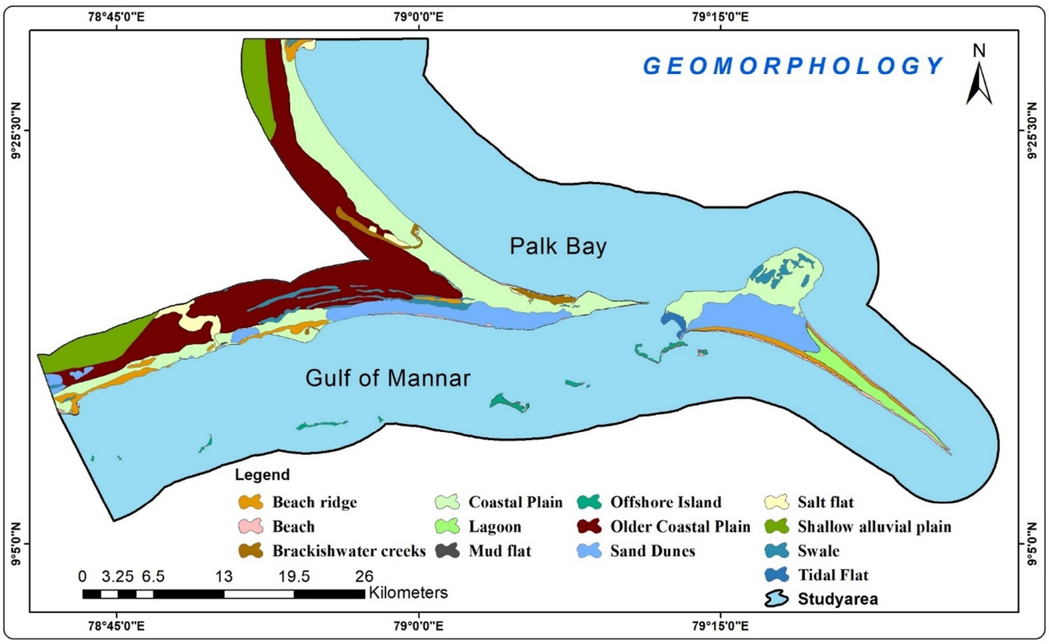


Fig. 2. Geomorphology map of Study Area

temperature shoots up to 31.3° C and the minimum of about 21° C. The distribution of beach ridges and additive inventory of sediments from the neighbouring rivers along the coastline demonstrates that the shoreline has a path towards the ocean (Natesan et al., 2015). Beaches in the study area are sloping with an inclination of 2° to 6°, with a width of 10 to 50 m. The nearshore depth varies from 2 meters to a maximum of about 20 meters. The study area covers unconsolidated quaternary sediments composed of coastal alluvium, fluvial deposits, laterite, and fluvio marine Deposits of Quaternary age (GSI, 1998). Thirteen major coastal landforms were noticed in the study area viz., beach, beach ridges, brackish water creek, coastal plain, older coastal plain, mudflat, offshore island, older Mudflat, paleo-beach ridge, salt flat, sand dunes, shallow alluvial plain and swale/swamp (Fig. 2). These have been formed by the erosional and depositional action over the coastal region.

MATERIALS AND METHODS

Data collection is the logical way to identify and evaluate the zone of interest. For the present study, Landsat-5 satellite data of 2000, 2005, 2010 and Landsat -8 satellite data of 2015 and 2020 was used. To identify the exact position of the shoreline, each data has enhanced using a band composition tool and turned it into the false colour composite image. Hence the shorelines were digitized from these satellite data using ArcGIS software. These shorelines have been used to identify and extract the variations along the coast. A list of the data used in the study is given in (Table 1).

The digital shoreline analysis system (DSAS), an extension software tool that works with ArcGIS, was used to observe the changes in the shoreline over a 21-year duration. For this study, a baseline is plotted on the land, which is 500 m away from the recent shoreline position. The user is the one who determines the baseline, which acts as the initial point for transect generation. The location of the reference baseline is not limited; it might be drawn entirely to one side of the coastline data. After creating the baseline, transects with 50 meters of equal distance were constructed perpendicular to the baseline. These transects pass over the mutilated shorelines, which are used for the Statistical calculation of EPR and LRR. In this analysis, EPR estimates the distance between the oldest and youngest shoreline position (Bheeroo et al., 2016; Kaliraj et al., 2014). The MATLAB runtime monitor calculates the End Point Rate (EPR) by dividing the total distance between the oldest and youngest shorelines by the total period. The linear square regression rate (LRR) has determined the shoreline location on the transect as time (Daud et al., 2021; Manik Mahapatra et al., 2014; Thieler et al., 2009). The DSAS outcome ranges in between negative to positive values. The negative value of EPR and LRR indicates that the shoreline is moving landward, whereas the positive value indicates that the shoreline is moving seaward (Emam et al., 2020; Immanuvel David et al., 2016; Kermani et al., 2016). In the study, statistical outcomes of EPR and LRR are classified into five categories viz., high erosion (-5 m to -2 /yr), low erosion (-2 to -1 m/yr), stable (-1 to 1 m/yr), low accretion (1 to 2 m/yr) and high accretion (2 to 5 m/yr).

Table 1. Data details

Sl. No.	Name of Data	Details of Data	Date	Output
1	Landsat 8	Multispectral and Thermal	April 2020, 2015	Shoreline Change Studies
2	Landsat 5	Multispectral and Thermal	May 2010, 2005, 2000	

RESULT

Shoreline Change Rate

Coastal Zone - I

Dynamic coastline changes were occurring in some coastal villages of Ramanathapuram district. The total length of the shoreline taken is 180 km. The DSAS results reveal that 5.1% of shoreline, around 9.3 km is under high erosion, 11.5% of the shoreline, which is around 20.8 km, is under low erosion, 71% of the shoreline, around 128 km, is a stable region, 6.7% of shorelines, around 12 km, have low accretion, and 5.6 % of shorelines, around 10.1 km, have high accretion. The graphical representation of shoreline change is shown in (Fig. 3).

In the study, transects from 1 to 95 is the coastal village Ervadi (Fig. 4 A and 5 A). The shoreline length of the region is 4.7 km, oriented in S-SW direction. As per the result obtained from DSAS, 1.8 kilometres of shoreline is stable (-0.9 to -0.20 m/year) at the western end of the coast. High erosion occurs along a 1.2 km coastal zone at

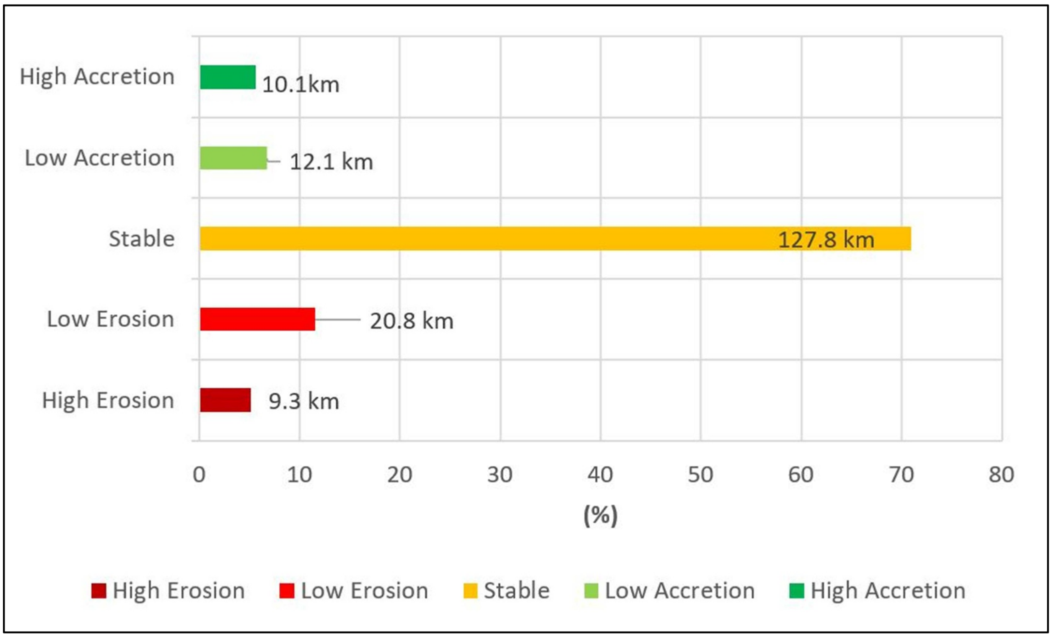


Fig. 3. Graphical representation of shoreline change

Table 2. Statistical Report of Shoreline Changes

Zone ID	Transect ID	Coastal Village	High Erosion			Low Erosion			Stable			Low Accretion			High Accretion		
			Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
1	1 to 95	Ervadi	-2.05	-3.44	-2.8	-1.9	-1.01	-1.37	-0.98	0.88	-0.20	1.03	2.01	1.29	3.43	5.24	5.60
	96 to 187	Mayakulam	.2.0	-2.29	-2.13	-1.83	-1.16	-1.54	-0.73	0.83	0.19	1.03	1.67	1.32	-	-	-
	188 to 238	Keelakarai	-	-	-	-1.82	-1.26	-1.61	-0.96	0.43	-0.19	-	-	-	-	-	-
	239 to 350	Kanjirangudi	-	-	-	-1.16	-1	-1.10	-0.97	0.78	-0.23	1.04	1.16	1.10	-	-	-
	351 to 409	Tiruppulani	-	-	-	-1.57	-1.01	-1.15	-0.91	0.88	-0.49	-	-	-	-	-	-
	410 to 502	Kalimankund	-2.12	-3.16	-2.7	-1.85	-1.01	-1.37	-0.95	0.93	-0.02	1	1.81	1.36	2.05	2.34	2.23
	503 to 569	Periapattinam	-	-	-	-1.8	-1	-1.29	-0.99	0	-0.50	-	-	-	-	-	-
	570 to 670	Karan	-	-	-	-1.74	-1	-1.22	-0.98	0	-0.10	-	-	-	-	-	-
	671 to 687	Rettaiyurani	-	-	-	-	-	-	0	1	0.33	-	-	-	-	-	-
	688 to 748	Pudumadam	-	-	-	-	-	-	-0.67	0.31	-0.07	-	-	-	-	-	-
	749 to 851	Nochiyurani	-	-	-	-	-	-	-0.18	0.94	0.18	1.01	1.23	1.13	-	-	-
	852 to 926	Sattakonvalsai				-1.87	-1.1	-1.46	-0.97	0.99	0.28	1.02	1.83	1.45	2.26	3.76	3.14
	927 to 1434	Mandapam	-2	-3.74	-2.9	-1.97	-1	-1.42	-0.99	1	0.0	1.02	2	1.4	-	-	-
	1505 - 1580	Pirappanvalsai	-	-	-	-	-	-	0	0	0	-	-	-	-	-	-
	1581 to 1605	Enmanamkondan	-	-	-	-	-	-	0	0	0	-	-	-	-	-	-
	1606 to 1660	Nagachi	-	-	-	-	-	-	-0.67	0	-0.01	-	-	-	-	-	-
	1661 to 1698	Attangarai	-	-	-	-1.22	-1.16	-1.19	-0.98	0	-0.10	-	-	-	-	-	-
	1699 to 1805	Alagankulam	-	-	-	-1.35	-1	-1.1	-0.99	0.66	-0.23	-	-	-	-	-	-
	1806 to 1843	Terbhogi	-	-	-	-1.1	-1.05	-1.07	-0.98	0	-0.50	-	-	-	-	-	-
	1844 to 1877	Athyuthu	-	-	-	-	-	-	-0.51	0	-0.14	-	-	-	-	-	-
	1878 to 1968	Chitrakkottai	-	-	-	-	-	-	-0.71	0.77	-0.02	-	-	-	-	-	-
	1970 to 2059	Devipattinam	-	-	-	-1.4	-1.01	-1.19	-0.94	-0.94	-0.16	-	-	-	-	-	-
	2060 to 2117	Pathanendal	-	-	-	-	-	-	-0.15	0.92	0.09	-	-	-	-	-	-
2	395 to 872	Pamban	-2.03	-4.02	-3.46	-1.97	-1.01	-1.35	-0.99	1	0.07	1.03	1.99	1.48	2.01	4.84	3.08
	1 to 1434	Rameswaram	-2	-5.11	-2.57	-1.99	-1	-1.4	-0.99	0.99	-0.07	1.01	2	1.47	2.02	4.37	2.79

the southern end of the coast, with a rate of change between -2.05 to -2.8 m/year. Low erosion occurs along 0.73 km of the coastal region, with rates ranging from -1.9 to -1.37 m/y. Low accretion is found in 0.16 km of the coastal area, having a change rate of 1.03 to 1.29 m/y, and 0.84 km of this shoreline is experiencing high accretion at a rate of 3.43 to 5.60 m/y. The village dominates the sandspit region, where sand accumulation is more by the longshore drift. A detailed report of changes is shown in Table 2.

Mayakulam coastal village has a shoreline length of 4.5 km, and it is trending towards the NW direction. Transects from 96 to 187 are plotted for this village, shown in (Fig. 4 B and 5 B). The results show that the northern region has a stable distance of 3.4 km of shoreline (-0.73 to 0.19 m/y). High erosion occurs along 0.05 km coastal zone, with a rate of change between -2.0 to -2.13 m/y in the western region. Low erosion occurs along 0.55 km of the coastal region, with a rate of changes ranging from -1.83 to -1.54 m/y at the west end. Low accretion is found in 0.45 km of the coastal region, at a rate of 1.03 to 1.32 m/y. There is no high accretion noticed along this coast.

Transects from 188 to 238 show the shoreline change of keelakkarai. The shoreline length of this village is 2.5 kilometres, trending towards the W-NW direction. 2.2 km of shoreline is stable (-0.96 to -0.19 m/y) at the northern and western ends. Low erosion occurs along 0.25 km of shoreline, with rates ranging from -1.82 to -1.61 m/y at the middle region of the shore. On this shore, there is no appreciable accretion or high erosion. The changes are shown in Fig. 4 C and Fig.5 C

The shoreline length of Kanjiragudi is 5.6 kilometres, oriented in NW direction. Its transect number is given from 239 to 350 (Fig. 4 D and Fig.5 D). 5.3 km of shoreline is stable (-0.97 to -0.23 m/y) at the northern and western ends. The village has low erosion along 0.32 km of shoreline, with an average rate of -1.16 to -1.10 m/y in the middle region. There was no other noticeable shoreline change that occurred along the shore.

Transects from 351 to 409 (Fig. 4 E and Fig.5 E) denoting tiruppulani, the coastal length of this village is 2.8 kilometres, which is trending towards W-NW direction. 2.1 km of shoreline is stable (-0.91 to -0.49m/year) at the western end of this village. Low erosion occurs in a 0.76 km coastal zone in the eastern region, with rates ranging from -1.57 to -1.15 m/y. There was no accretion, or high erosion noticed on this shore.

The coastal length of Kalimankund village is 4.8 kilometres trending E-SE direction. Its transect numbers range from 410 to 502. (Fig. 4 F and Fig.5 F). 3.2 km of shoreline is stable (-0.95 to -0.02 m/y) at the eastern end of this region. High erosion was noticed along 0.24 km at the coastline zone's southern curvy region (Fig. 6-C), with rates ranging from -2.12 to -2.7 m/year. Low erosion occurs along a 0.82 km at a western region along the coastal area, with rates ranging from -1.85 to -1.37 m/y. 0.34 kilometres of coastline with Low accretion, its rate of change between 1 to 1.36 m/y, and 0.15 km of this shoreline is experiencing high accretion, with rates ranging from 2.05 to 2.23 m/y.

Periapattinam coastal length is 3.2 km, trending in the SW direction. Given the transect numbers from 503 to 569 (Fig. 4 G and Fig.5 G). 2.4 kilometres of shoreline is stable (-0.99 to -0.50 m/year) at the southern and western end of the coast. Low erosion occurs along 0.74 km in the middle coastal region, with the rate of change between -1.8 to -1.29 m/y. This shore has no noticeable accretion of high erosion.

The Karan village coastline length is 5 kilometres which trending in N-NW. Its transect number ranges from 570 to 670. (Fig. 4 H and Fig.5 H). The shoreline is stable (-0.98 to -0.10 m/y) for 4.7 kilometres in the western region. Low erosion was noticed along 0.28 km of coastline, with a rate of change between -1.74 to -1.22 m/y. This shore has not been observed with accretion or high erosion.

The coastal length of Rettaiyurani village is 0.91 km trending towards SW direction, with transect numbers ranging from 671 to

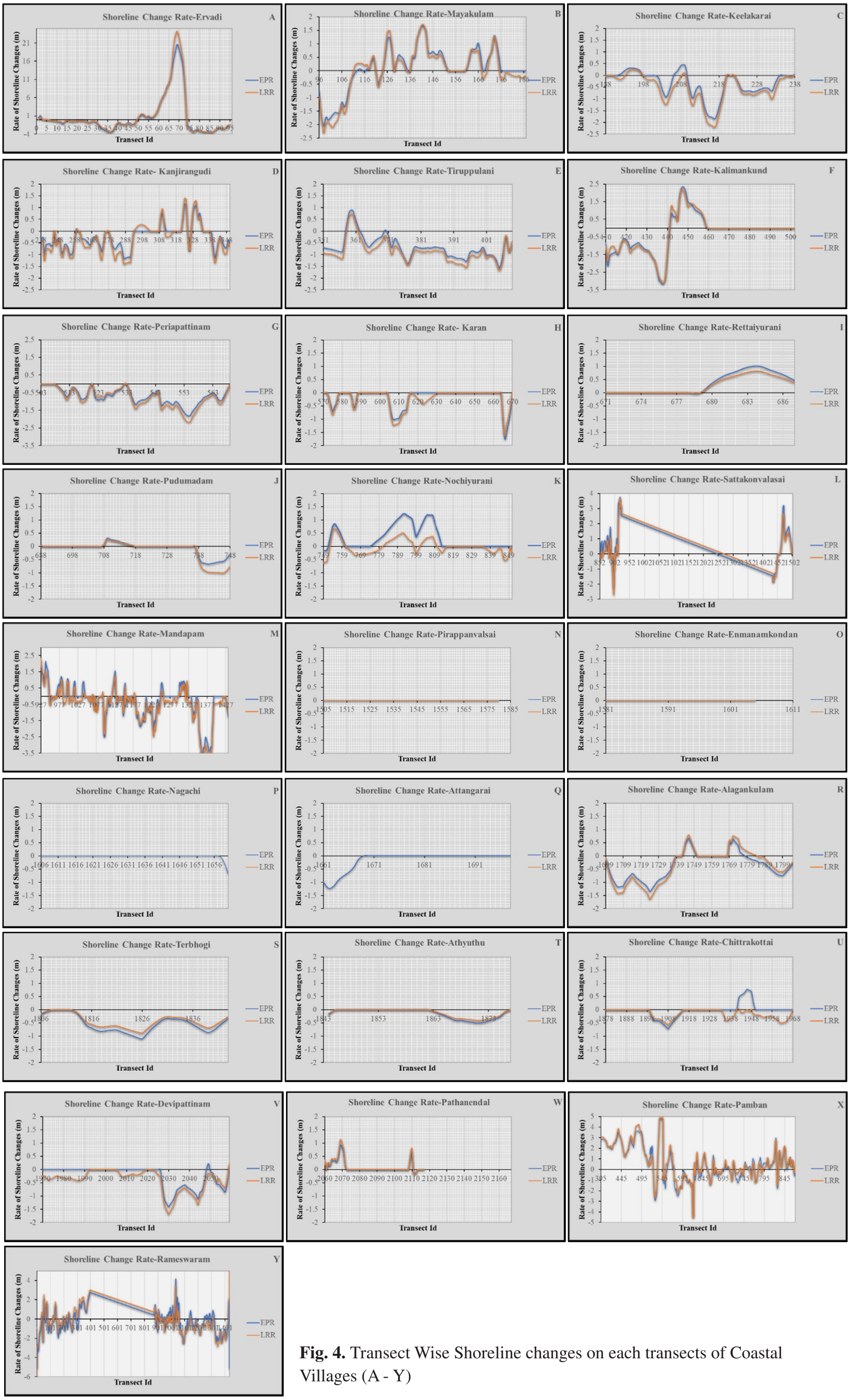
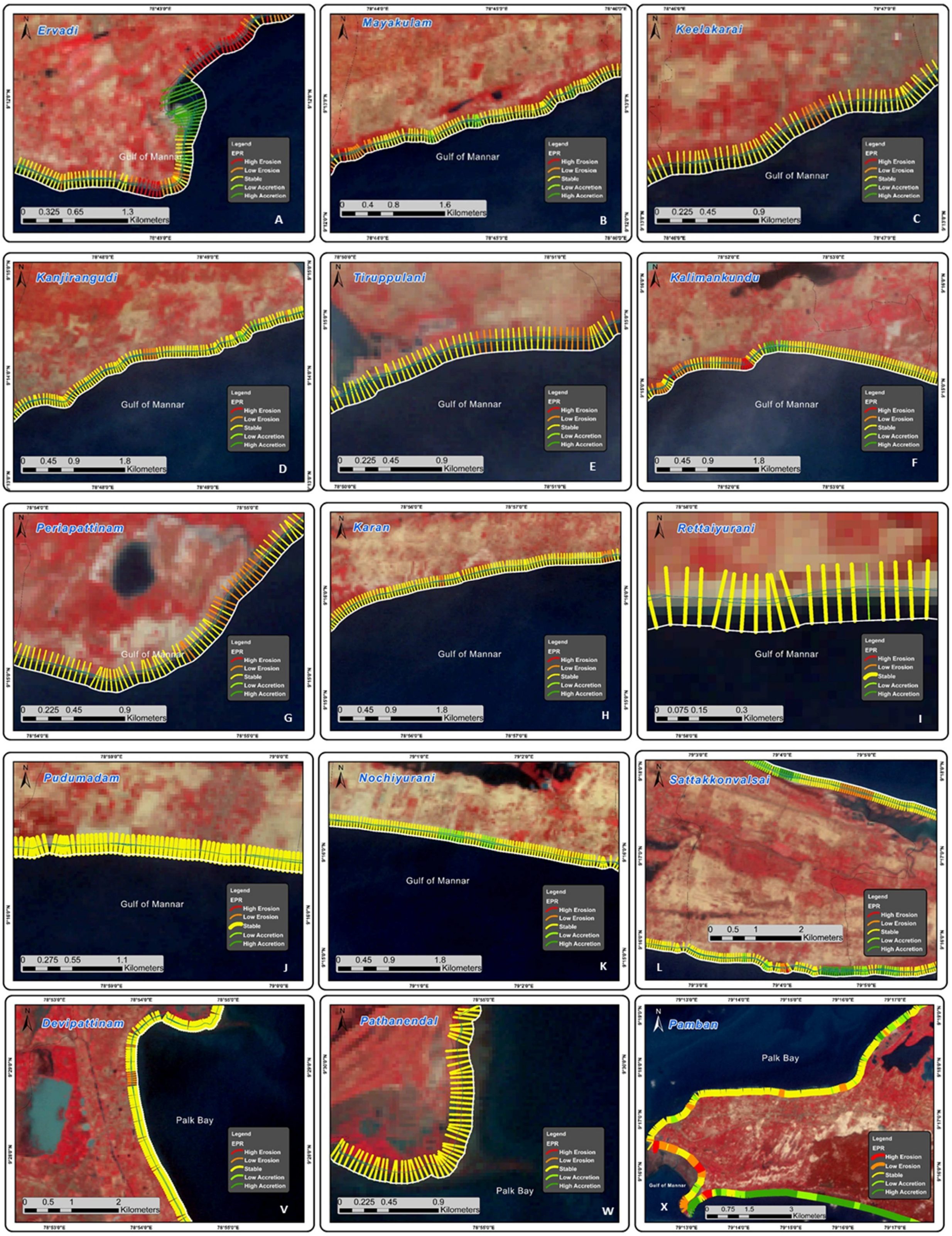


Fig. 4. Transect Wise Shoreline changes on each transects of Coastal Villages (A - Y)



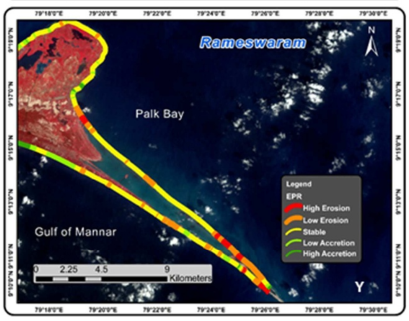


Fig. 5. Multiyear of shorelines and transect lines in Villages A-Ervadi, B-Mayakulam, C- Keelakarai, D- Kanjiragudi, E-Tiruppulani, F-Kalimankundu, G- Periapattinam, H- Karan, I- Rettaiyurani, J- Pudumadam, K- Nochiyurani, L-Sattakkonvalsai, M-Mandapam, N- Pirappanvalsai, O- Enmanamkondan, P- Nagachi, Q- Attangarai, R-Alagankulam, S- Terbhogi, T- Athyuthu, U- Chittrakkottai, V-Devipattianam, W-Pathanendal, X-Pamban, Y- Rameswaram.

687. (Fig. 4 I and Fig.5 I). The shoreline is stable for 0.91 kilometres (0 to 0.33m/y). This coast has not experienced any accretional or erosional changes.

The coastal length of Pudumadam village is 3.1 km trending towards the east, with transect numbers 688 to 748 (Fig. 4 J and Fig.5 J). For 3.1 kilometres, the shoreline is stable (-0.67 to -0.07 m/y). There was no accretional or erosional changes were noticed on this coast. The minor variation is the result of tidal fluctuation during low and high tide.

The village Nochiyurani's coastal length is 4.4 km, trending N-NE direction. Its transect numbers are from 749 to 851 (Fig. 4 K and Fig.5 K). The shoreline is stable (-0.18 to 0.18m/y) for 4.4 kilometres. There was no accretional or erosional changes were noticed on this coast.

Sattankonvalsai village has a shoreline length of 6.8 km trending towards the East direction. Its transect number is given from 852 to 926 (Fig. 4 L and Fig.5 L). The shoreline is stable (-0.97 to 0.28 m/y) for 3.6 km in the western portion. Low erosion occurs along 0.85 kilometres of coastline, with rates ranging from -1.87 to -1.46 m/y (Fig. 6-D). 1.4 km of coastline is under low accretion at the eastern region, with a rate of 1.02 to 1.45 m/year, and 0.90 km of this shoreline is experiencing high accretion at a rate of 2.26 to 3.14 m/y.

Mandapam village coastal length is 25 km trending towards the SW direction. Given the transect numbers from 927 to 1504 (Fig. 4 M and Fig.5 M). This narrow region is in the eastern tip of the Rameswaram mainland, where the roadways and railways line connects to the Rameswaram island. Here shoreline is stable (-0.99 to 0.0 m/year) for 19.1 kilometres in the southern region. 2 km stretch of the coastline region is undergoing high erosion in the western part ((Fig. 6-A), with a rate ranging from -2 to -2.9 m/year. Low erosion occurs in the mandapam tip, along a 2.3 km stretch of coastline, with rates ranging from -1.97 to -1.42 m/y. 1.4 km of shoreline is in low accretion with the rate of change between 1.02 to 1.4 m/y. High accretion has not been observed in this village.

The shoreline length of Pirappanvalsai village is 3.9 km, showing the trending in SW direction, with the transect numbers from 1505 to 1580 (Fig. 4 N and Fig.5 N). 3.9 km of shoreline is stable. The was no appreciable changes observed along this coast.

The village Enmanamkondan has a shoreline length of 1.2 km, trending in SW direction. The transects from 1581 to 1605 denote the particular region (Fig. 4 O and Fig.5 O). There were no changes in the shoreline position, so the whole area is stable.

The coastal village Nagachi has a length of 2.7 km, which trending in the SW direction. The transect number starts from 1606 to 1660 (Fig. 4 P and Fig.5 P). 2.7 km of shoreline is stable. The rate of shoreline change is between -0.67 to -0.01m/y. There was no accretional or erosional changes were noticed on this coast.

Attangarai's coastal length is 1.8 km, trending in the SW direction, with the transect numbers from 1661 to 1698 (Fig. 4 Q and Fig.5 Q). 1.7 kilometres of shoreline is stable (-0.98 to -0.10 m/year). Low erosion occurs in 0.81 km of the coastal zone, with rates ranging from -1.22 to -1.19 m/year. This shore has no accretion and high erosion.

The coastal length of Alagankulam is 5.3 kilometres trending in the SW direction, with transect numbers from 1699 to 1805 (Fig. 4 R and Fig 5 R). 4.6 kilometres of shoreline is stable (-0.99 to-0.23 m/year). This shore has only noticed low erosion in 0.73 km with a rate between -1.35 to -1.1 m/y.

The coastal length of Terbhogi is 1.9 kilometres, trending in SW direction. Its transect number was given from 1806 to 1843 (Fig. 4 S and Fig.5 S). The shoreline is stable for 1.8 kilometres. (-0.98 to -0.50m/year). Only low erosion was noticed in 0.10 km of the shore, with rates ranging from -1.1 to -1.07 m/y.

The coastal length of Athyuthu is 1.7 km, trending in the SW direction, with transect numbers ranging from 1844 to 1877. (Fig.4 T and 5 T). The shoreline is stable for 1.7 km (-0.51 to -0.14 m/y). There was no accretional or erosional changes were noticed on this coast. This coast has not experienced any accretional or erosional changes.

Chitrakkotai's coastal length is 4.5 km trending towards the W-SW direction, with the transect numbers from 1878 to 1968 (Fig.4 U

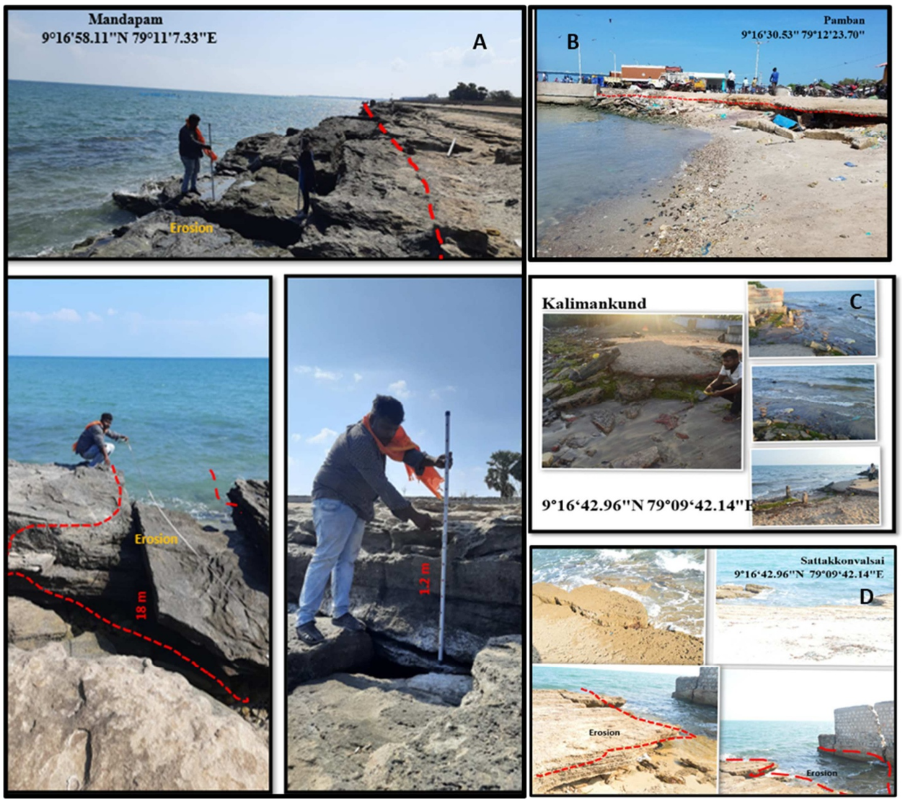


Fig. 6. Erosion in: **A**- Mandapam, **B**- Pamban, **C**- Kalimankund, **D**- Sattakonvalsai.

and Fig.5 U). 4.5 km of shoreline is stable (-0.71 to -0.02 m/y). This coast has not experienced any accretional or erosional changes.

Devipattinam's coastal length is 4.6 km trending towards the west, with the transect numbers from 1970 to 2059 (Fig. 4 V and Fig.5 V). The shoreline along 4.2 kilometres is stable (-0.94 to -0.16 m/y). Low erosion occurs along a 0.35 km stretch of coastline, with rates ranging from -1.4 to -1.19 meters per year. This shore has no noticeable accretion or high erosion.

The coastal length of Pathengal is 2.8 kilometres, which is trending towards the S-SW direction. Its transect number is from 2060 to 2117 (Fig.4 W and Fig.5 W). The whole region is stable with a minor variation of -0.15 to 0.09 m/y.

Coastal Zone -II

Pamban coastal length is 25 km, which s trending towards the W-SW direction. The transect numbers range from 394 to 873 (Fig. 4 X and Fig.5 X). This coast has 12.3 kilometres of stable shoreline (-0.99 to 0.07 m/y). 0.90 km of the coastal region is undergoing high erosion at the western end (Fig. 6-B), with rates ranging from -2.03 to 3.46 m/year. Low erosion occurs along 2.6 km of coastline, with rates ranging from -1.97 to -1.35 m/year. This region is on the western tip of the offshore Rameswaram island, where the roadways and railway lines from the mainland join with the island. 3.4 kilometres of coastline with Low accretion, ranging from 1.03 to 1.48 m/year, and This coast has a high rate of accretion of 2.02 to 3.08 m/year for 5.6 kilometres.

Rameswaram's coastal length is 50.8 km. which shows the SE trending. The transect numbers range from 1 to 393 and 874 to 1434 (Fig. 4 Y and 5 Y). The shoreline is stable for 29.4 kilometres (-0.99 to -0.07 m/year). High erosion is present along 4.6 kilometres of the coast, with rates ranging from -2 to -2.57 meters per year. Low erosion occurs along 9.4 kilometres of coastline, with rates ranging from -1.99 to -1.4 meters per year. Low accretion with a rate of 1.01 to 1.47 m/year along 4.8 km of coastline, and This coast has a high accretion rate of 2.02 to 2.79 meters per year around 2.6 kilometres.

DISCUSSION

The study was carried out to analyse the coastline alteration in the Ramanathapuram coastal area. When noticing erosion and deposition in the study area's 25 villages, it is clear that erosion is highly influencing in Mayakulam, Keelakakrai, Periapattinam, Mandapam, West-Pamban, and East-Rameswaram villages, and the process of accretion has become more active in Ervadi, Kalimankund, Sattankonvalsai, South-Pamban and South-Rameswaram villages.

The coastline of Tamil Nadu has been affected by many natural hazards, including southeast and northeast seasonal tropical cyclones (Vissa et al., 2013). The marine and aeolian activities prevailed in this area, and the region has been subjected to various disasters like cyclones, storm surges and erosion over the past (Nobi et al., 2010). Wind, waves, tides, sediment supply, changes in relative sea level, and human interventions also impact the shoreline, and these activities cause the coast to alter over time. This region has a severe threat of sea-level variations (Mohan et al., 2000). The coastal area has been subject to erosion by various processes (Baskaranet al., 2003; Loveson et al., 1987; Lovesonet al., 1990). The region comprises deltaic formations with a maximum erosion rate of -6.9 and accretion of 17.8 m/year (Usha et al., 2015).

The coastal tract of Ramanathapuram district has diverse topographies. The major coastal part of the district is covered by fluvial, fluvio-marine, aeolian and marine sediments of the Quaternary period with medium to coarse-grained sandstone and claystone (Rajagopal, et al., 2012). This coastal region includes all sensitive landforms like coastal dunes, ridges, mudflats, sand, bays, lagoon, delta plain, back swamps and mangroves plantation (Venkateswaran et al.,2017).

Understanding the processes of erosion, deposition, sediment transport, flooding, and sea-level changes that alter the shoreline is critical for coastal protection planning (Armenio et al., 2019; Murali et al., 2013). Regarding infrastructure development and tourism, the present study has significance in the planning and development activities of coastal villages in the Ramanathapuram district. This study also is helpful to identify and evaluate the coastal dynamics on a regional scale.

CONCLUSIONS

- This study verified that geospatial techniques are extremely useful in determining coastal erosion and accretion changes.
- The study shows that the average erosion rate in the study area is 2.29 to 5.11 m/y, and the accretion rate is 2.34 to 5.24 m/y.
- Out of 180 km of coastal length, 9.3 km is subjected to high erosion, 20.8 km, is undergone low erosion. 12 km, region have low accretion, 10.1 km occurring high accretion—nearly 128 km coastal region has shown minute or no change.
- The geology of the region is unconsolidated sediments. So the resistance towards the wave action is comparatively less. Hence various erosional and depositional changes occur in this area.
- The changes in wave action, wind movement, geomorphology and bathymetry are the main natural influences that change the coastal configuration.
- The eastern tip region of Mandapam noticed a very high amount of erosion. There were possibilities for continuous changes in the future. Necessary precautions such as the construction of groins and concrete articulated blocks are needed in this region.
- The output could be highly useful for coastal zone management authorities for sustainable coastal management of the Ramanathapuram coastal region.

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