JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Shoreline Change Analysis in Kanyakumari District, Tamil Nadu, India

[1] Mohankumar K, [2] V. Emayavaramban

[1] Research Scholar, [2] Professor
[1]Department of Geography, Madurai Kamaraj University, Madurai, Tamil Nadu, India – 625 021.
[2]Department of Geography, Madurai Kamaraj University, Madurai, Tamil Nadu, India – 625 021.

Abstract: This is a Decadal analysis of Shoreline change in Kanyakumari district coast, Tamil Nadu. The coastline of the Kanyakumari district extends to a total of 59 kilometers in the Arabian Sea and 11 kilometers along the Bay of Bengal. The year 2000, 2010 and 2020 open source satellite imagery of Landsat 7 and Landsat 9 are collected from USGS Earth Explorer web site. The present study is adopted with remote sensing techniques and used the GIS tool to identifying the vulnerable areas of the Kanyakumari district shoreline. In further analysis conducted with DSAS are portray that the Kanyakumari district saw very high erosion and very little accretion between the years 2000 and 2020. According to the Linear Regression Rate (LRR) approach, the shoreline migration is vary from -2.21 m to 2.10 m per year, with the average seeming to be 2.10 m per year. The cumulative length of the shoreline is 69.5 kilometers. Erosion reaches its maximum extent at 4 km, while its minimum extent is observed at 37.2 km. The coastline is 21.3 kilometers long and remains unchanged. There is a decrease in the rate of accumulation at a depth of 4.5 km, followed by an increase in the rate of accumulation at a depth of 2.2 km. The shoreline of the Kanyakumari district has the highest accretion rate that is 6.49 meters per year.

***Keywords* - Coast, GIS, Linear Regression, Remote Sensing, Shoreline.**

I. Introduction

The shoreline, which is the interconnection between land and water, is known as being dynamic in nature and provides economic and social security to communities that are located along the coast. Beaches and seashores are transitional zones between land and sea; they host unique and fragile ecosystems that are subject to continuous change as a result of the variable environmental conditions. The movement of the shoreline can be caused by both natural and anthropogenic processes. Sand sources and sinks, shifts in relative sea level, changes in shore geomorphology and other factors, such as these, all contribute to the erosion of the coastline. Waves, currents, tides, and winds are the primary natural factors that influence the coast. Other factors that contribute to the erosion of the coastline include: the construction of artificial structures, the mining of beach sand, offshore dredging, and other human activities. These are some of the anthropogenic factors that contribute to the erosion of beaches. Changes in the shoreline can happen on a variety of time scales, ranging from geological to extreme events that last only a short time (Addo, K. A., & Kufogbe, K. S. 2011). Important and dynamic coastal characteristics can be found at shorelines, which are the intersections of land, air, and water. When the littoral current is disrupted by man-made constructions such as harbours or breakwaters, the shoreline of any open coast will undergo significant changes. By analysing data from satellites, (Nayak, B. U et al. 1994) were able to arrive at the conclusion that the shoreline of the Indian coastline is in a state of constant change. The coastline is a dynamic system that seeks to achieve equilibrium with the available sediment budget and the dominant near-shore ocean forces. Sediment is constantly being deposited and removed from the coastline as the system works to achieve equilibrium (Poulos and Chronis, 2001). Surges of storm water and waves with a lot of energy that are caused by strong winds when combined, severe weather and high tides have the potential to cause catastrophic damage. In addition to causing damage to coastal infrastructure, storms also cause beaches and dunes to recede by several tenths of metres in the span of just a few hours (IOC. Workshop report, 1994). According to the results of various measurements, the level of the sea has risen by approximately 160 mm over the course of the past century, and it is anticipated that it will rise by an additional 310–30 mm over its level in 1990 in the coming century (Warrick, R. A., Oerlemans, J, 1990). The formation of tropical cyclones, which occur when sea surface temperatures reach 26 or 27 °C, is also anticipated to become more common as a result of global warming (Ali, P. Y., & Narayana, A. C. 2014). Unless suitable adaptation strategies are taken in the next few decades, an increase in long term coastal erosion (coastline recession) along sandy coasts can have significant socio-economic effects. It is imperative to have a good knowledge of the relative relevance of the physical processes causing coastline recession as well as of links between consideration (or not) of particular processes and the degree of risk tolerance; understandings that are hitherto lacking will help to sufficiently inform adaptation measures (Ranasinghe, R., Callaghan, D.P., Li, F. et al. 2023). Consider that coastal ecosystems are typically able to support dense human populations, one of the most important aspects of coastal management is keeping track of how these ecosystems change over time

(Moran, 2003). The objective of the present study is to find out the vulnerable areas of shoreline changes by using the remote sensing and GIS-DSAS techniques of the study area.

II. Location Of The Study

Kanyakumari is the southernmost district of Tamil Nadu state in the Indian subcontinent. In terms of population density, it is the state's second-largest district, after Chennai District, the second-most urbanized. The Kanyakumari coastline can be connected all the way from the state line of Kerala to the northernmost tip of Vattakkottai (Circular Fort). The coastline can be described as extending in a north-south direction, a south-west direction and a southeast-northeast direction. From a geographical standpoint, it is located between 77° 2' to 77° 35' East longitude and 8° 7' 30" to 8° 15" South latitude. The coastline of the Kanyakumari district extends for a total of 59 kilometres in the Arabian Sea and 11 kilometres along the Bay of Bengal (Figure 1). The Tamil Nadu Marine fisher folk Census was conducted in the years 2000 and 2010, and it found that the Kanyakumari district contains a total of 42 villages inhabited by fishermen. According to the Fisherfolk 2010 census there are a total of 143388 people living in this area. About 73471 (51.2%) male population and 69917 (48.8%) are female population in the study area.

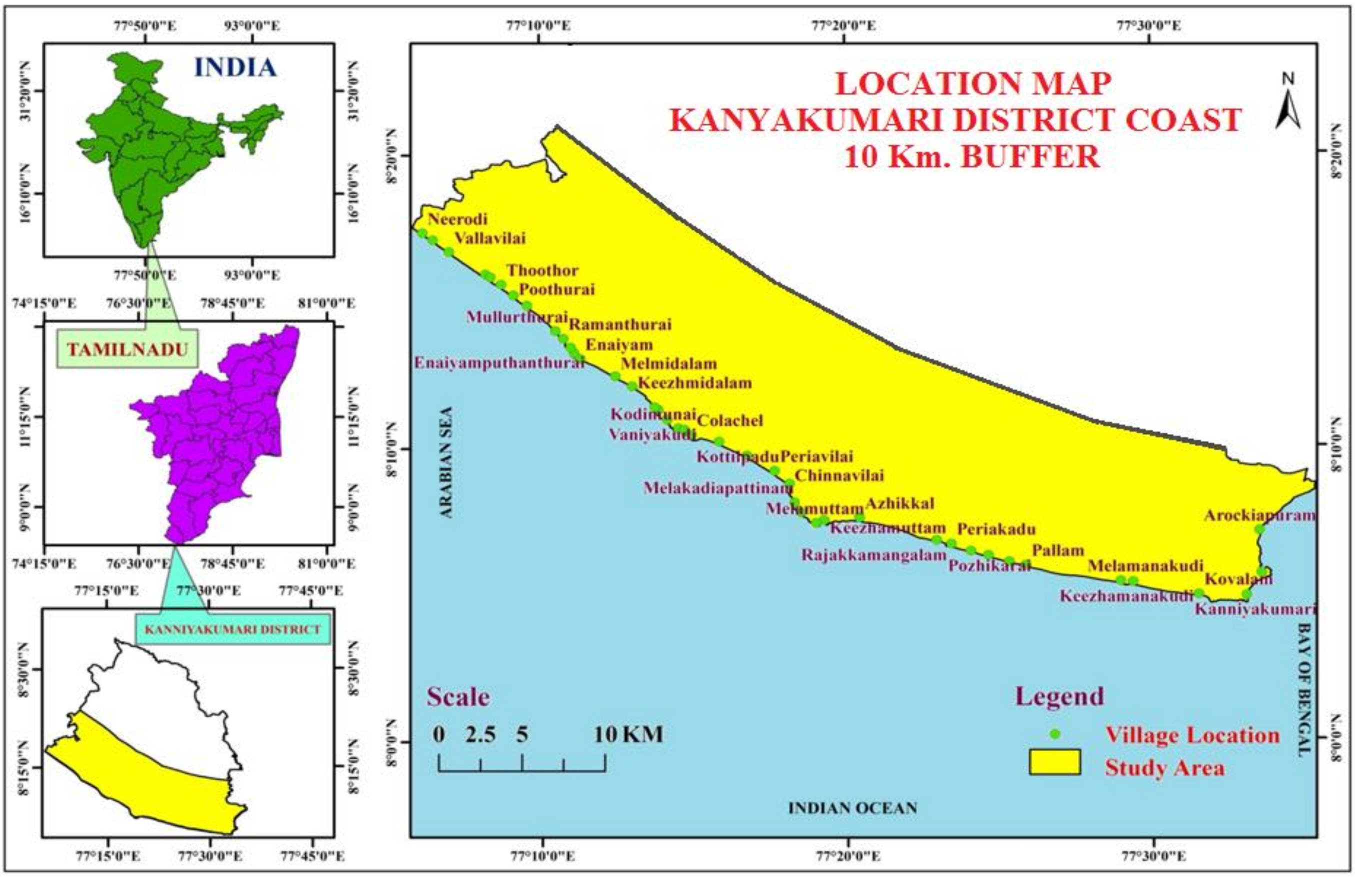


Figure: 1, Source: Survey of India Topographical Sheet

III. Data Base And Methodology

The present analysis is used the digital data of Landsat - 7 and Landsat - 9 imageries for few decades for 2000, 2010 and 2020 were collected from United States Geological Survey website. The present study is analysed with remote sensing techniques of supervised classification. GIS tool is also DSAS application used to be estimating the shoreline changes. The result images were used for identified the Shoreline change detection in Kanyakumari district is analysed using four different periods of data. The data used for high-resolution satellite imagery were obtained from USGS Earth Explorer, carried by the researcher (Table 1).

TABLE: 1 DETAILS OF DATA SET USED FOR SHORELINE CHANGE ANALYSIS

Sl. No.	Data Set	Acquisition Date	Spatial Resolution	Producer	Source
1	Landsat 7 (ETM+)	10/09/2000	30 m	USGS	GloVis
2	Landsat 7 (ETM+)	25/05/2010	30 m	USGS	GloVis
3	Landsat 9	13/09/2020	30 m	USGS	GloVis

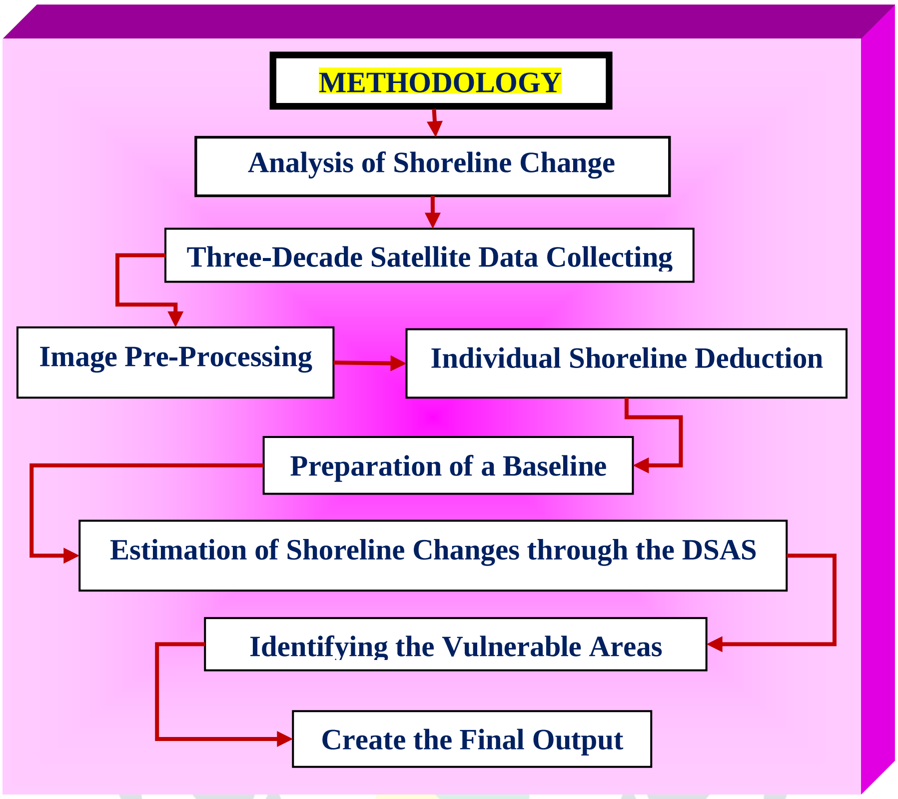


Figure: 2

IV. APPLICATION OF DIGITAL SHORELINE ANALYSIS SYSTEM (DSAS)

Using the ArcGIS software, the coast of the Kanyakumari district was analyzed and its shorelines were extracted from high-resolution satellite images. The data necessary for the analysis is managed in a personal geodatabase using the UTM projection. The steps involved in the process include extracting the shorelines from the satellite data, appending the shorelines into a single file and assigning attributes; generating a baseline and assigning attributes. These steps are completed in ArcGIS in preparation for further work to be done with DSAS. Casting transects, specifying shoreline calculation settings, calculating change rate statistics, joining the results to the transect feature class that was generated and displaying the results in a GIS map are the steps that are carried out in DSAS.

Shorelines were given three attribute fields, which included object ID (a unique number that was allocated to each transect), shape, shape length, ID, DATE_ (the original survey day, month, and year) and UNCERTAINTY values. These attribute fields were assigned to each shoreline. A single shape file was given the addition of three distinct coastline features at the end of the process.

The offshore baseline was created with a 100-meter buffer from the actual most recent shoreline. This baseline is the starting point for all transects. The attribute fields for baseline are object ID, shape (geometry) and shape length (double), which are auto generated and fields for ID (long integer) (a different ID from 0 onwards if the baseline is not a single segment). Group-Long Integer (1 on land, 0 at sea) whether offshore (0) or onshore (1)—Short Integer and Cast Direction—Short Integer (0 for the left and 1 for the right side of the baseline) may be assigned. Out of these three user-created fields, only "Group" is optional, and all other fields are required.

Using DSAS, the subsequent steps are carried out and the default parameters are set in the dialogue box that appears when the Set/Edit default parameters icon in the DSAS toolbar is clicked. This icon is located in the middle of the DSAS toolbar. For the setting known as "Cast Transect Setting," "Baseline" has been chosen as the "Baseline layer," "Group" has been chosen for the "Baseline Group Field," "Offshore" has been chosen as the "Cast direction," "Spacing" has been set to 38 meters, and "Transects length" has been assigned to 1,381 meters. Because the shape file was projected using UTM, the DSAS measures both the spacing and the length in meters. After considering a number of distances, including 1000 meters, 500 meters, 100 meters and 500 meters, the spacing was settled on. For the purpose of the subsequent study, transects with a spacing of 38 metres were chosen. The length of the transects was determined by taking the maximum distance between the baseline and the shoreline, which was then added to the farthest distance from the shoreline. As a result, 38 metres was decided to be the appropriate length for the transect. When configuring the metadata, the details of the user, organization, and location for which the work is being performed must be entered. After clicking the "Cast Transect" icon, which is located next to the "Edit/Set Default Parameters" icon, the Dialogue Box will become visible. The name of the file that will be generated containing the transect is entered into the appropriate box. This file will only be stored in the personal geodatabase that is assigned, so the name must be entered correctly. The DSAS uses the source geodatabase as its starting point. This geodatabase includes both the shoreline and the baseline.

V. Selection Of Statistical Methods

The process will continue on to the next step, which is the selection of the methods for change rate statistics. To accomplish this, select the appropriate approach from the Calculate Change Statistics menu option (Figure 3). The Rates of Linear Regression (LRR) Long-term rates of shoreline change were determined at each transect by calculating the slope of the linear regression through all shoreline positions beginning in 2000 and ending in the most recent year 2020. For the purpose of calculating long-term rates of change, a minimum of three shoreline years were required at each DSAS transect. The method can be utilized, as the study has access to a total of three shorelines at its disposal. The shoreline dates and sources that were utilised for the linear regression analysis of the Kanyakumari district coast are presented in Table 2. The linear regression method of determining shoreline change rates does assume a linear trend of change between the earliest and latest shoreline dates. This is because the linear regression method was developed to analyse the relationship between two sets of data. However, there are clearly some areas where such a linear trend does not exist at all and one such area is the rate at which the shoreline is changing.

TABLE: 2 SHORELINE ANALYSIS DETAILS OF LRR RATE & CLASSIFICATION SYMBOLS

Sl. No.	LRR Rate	Classification	Symbols
1	≥ - 5.0	High Erosion	
2	-5.0 to -2.0	Low Erosion	
3	-0.2 to 0.0	Stable Coast	
4	0.1 to 2.0	Low Accretion	
5	≥ 2.0	High Accretion	

Five distinct categories have been established to categorise the LRR rates of shoreline change for the area under investigation. The rate of erosion is considered high if the rate of landward migration of the shoreline is greater than -5 metres per year; on the other hand, the rate of erosion is considered low if the rate of landward migration is between -5 and -0.2 metres per year. The coast is considered stable if neither landward migration nor seaward progression exceeds -0.2 to +0.0 m/year; if seaward shifting of the shoreline exceeds +0.1 to 2 m/year, the coast is considered low accretion; and more than 2 m/year, the coast is accreting, and the coast is considered high accretion.

VI. Result & Statistics of Shoreline

The study consists of the Kanyakumari district coast (Table 3), which was selected to investigate shoreline changes and the total coastal length of 69.05 km in the study area. Transects were generated with an interval of 38 m and contain 1384 transects in Kanyakumari district. Transects are automatically generated by DSAS perpendicular to the baseline.

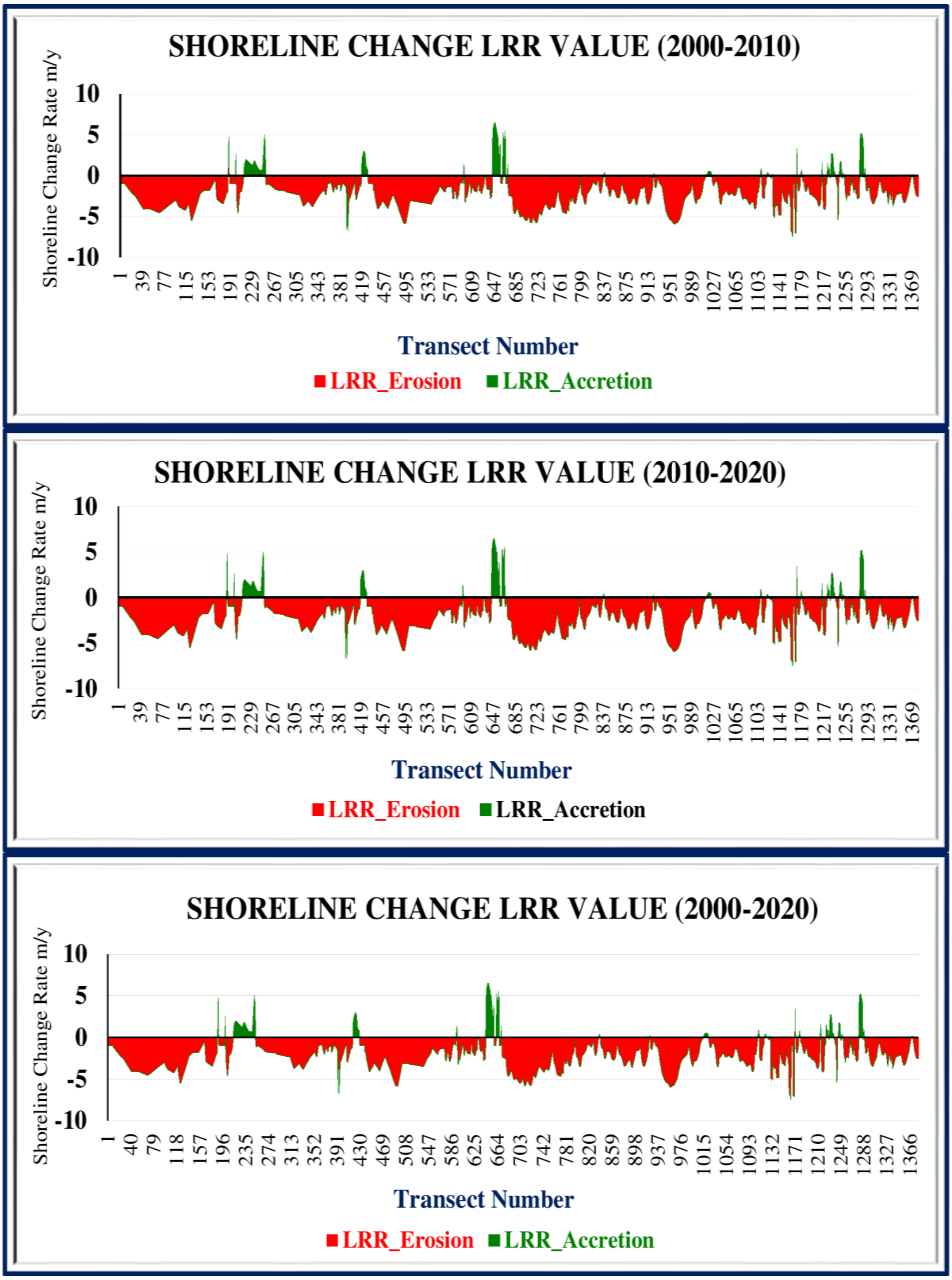
TABLE: 3 SHORELINE STATISTICS OF KANYAKUMARI DISTRICT COAST

Statistical Parameter	Kanyakumari District Coast
Shoreline Length (KM)	69.05
Total Number of Transects	1381
Minimum Shoreline Change Rate (LRR)	-7.48
Maximum Shoreline Change Rate (LRR)	6.49
Mean Shoreline Change Rate (LRR)	-2.21
Mean Erosion Rate m/y	-2.38

Mean Accretion Rate m/y	2.10
Total Number of Eroded Transects	1249
Total Number of Accretion Transects	132
High Erosion - Length in KM	4.0
Low Erosion - Length in KM	37.2
Stable Coast - Length in KM	21.3
Low Accretion - Length in KM	4.5
High Accretion - Length in KM	2.2
overall Trend	Erosion

VII. KANYAKUMARI DISTRICT SHORELINE CHANGE RATE

These satellite images show that the Kanyakumari district has a total coastal length of 69.05 kilometres and is situated in the southernmost part of India. The district has a total of 1381 transects, and the distance between each one is 38 meters. The transects begin in Neerodi and terminate in the village of Arockiapuram. The findings of the study conducted with DSAS are presented in Table 3 and they indicate that the Kanyakumari district found very high erosion and very little accretion between the years 2000 and 2020. According to the LRR approach, the shoreline migration is vary from -2.21 m to 2.10 m per year, with the average seeming to be 2.10 m per year. At each transect, the LRR of shoreline change was determined by finding the slope of the linear regression through all of the shoreline position which beginning with the earliest one in 2000 and ending with the most recent year 2020. During the calculation of the 30-years long-term rate of change, three shoreline years were considered at each DSAS transect. For the coast of the study area, the single highest LRR for erosion measured was -7.48 metres per year. The shoreline of the Kanyakumari district has the highest accretion rate, coming in at 6.49 metres per year.



SHORELINE CHANGE LRR VALUE (2000-2010)
Shoreline Change Rate m/y
10
5
0
-5
-10
1 39 77 115 153 191 229 267 305 343 381 419 457 495 533 571 609 647 685 723 761 799 837 875 913 951 989 1027 1065 1103 1141 1179 1217 1255 1293 1331 1369
Transect Number
LRR_Erosion
LRR_Accretion
SHORELINE CHANGE LRR VALUE (2010-2020)
Shoreline Change Rate m/y
10
5
0
-5
-10
1 39 77 115 153 191 229 267 305 343 381 419 457 495 533 571 609 647 685 723 761 799 837 875 913 951 989 1027 1065 1103 1141 1179 1217 1255 1293 1331 1369
Transect Number
LRR_Erosion
LRR_Accretion
SHORELINE CHANGE LRR VALUE (2000-2020)
Shoreline Change Rate m/y
10
5
0
-5
-10
1 40 79 118 157 196 235 274 313 352 391 430 469 508 547 586 625 664 703 742 781 820 859 898 937 976 1015 1054 1093 1132 1171 1210 1249 1288 1327 1366
Transect Number
LRR_Erosion
LRR_Accretion

Figure: 3

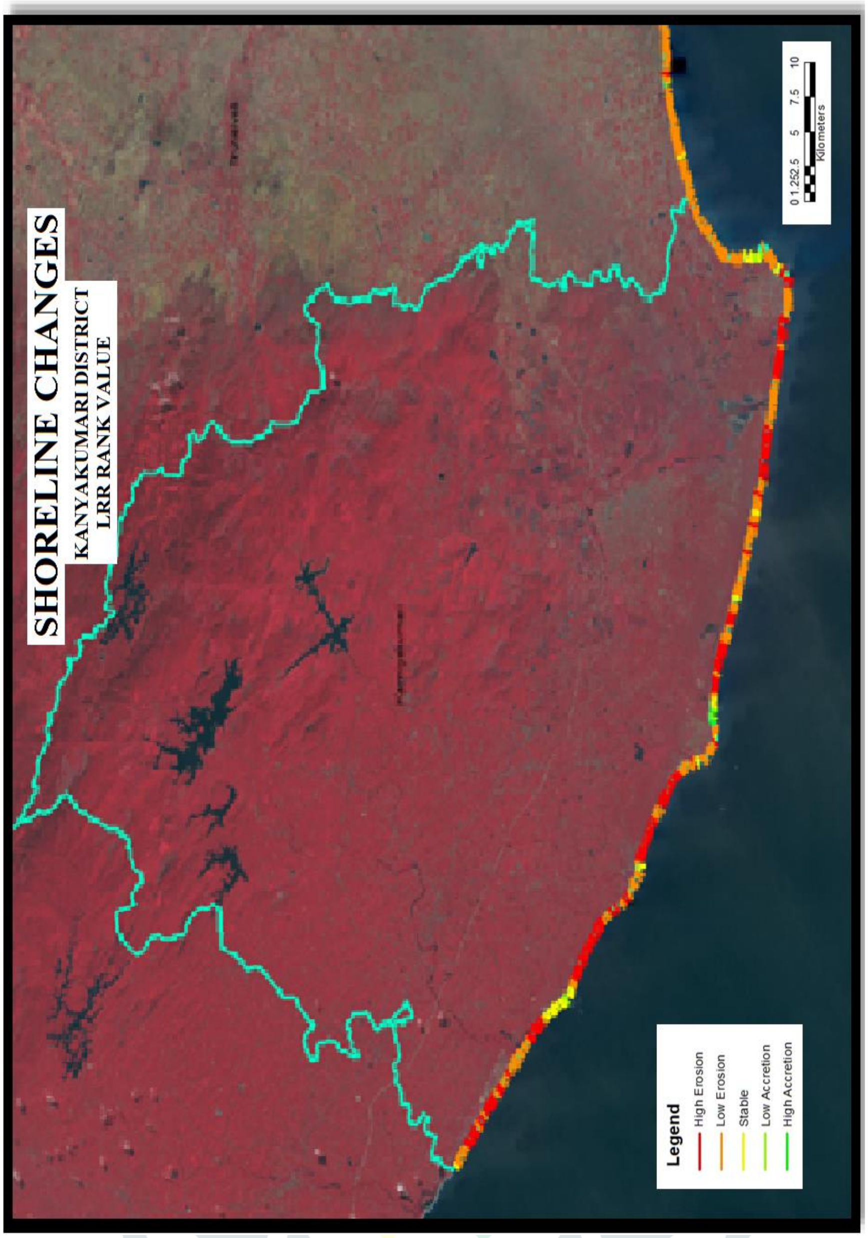


Figure: 4, Source: Landsat-9 imagery

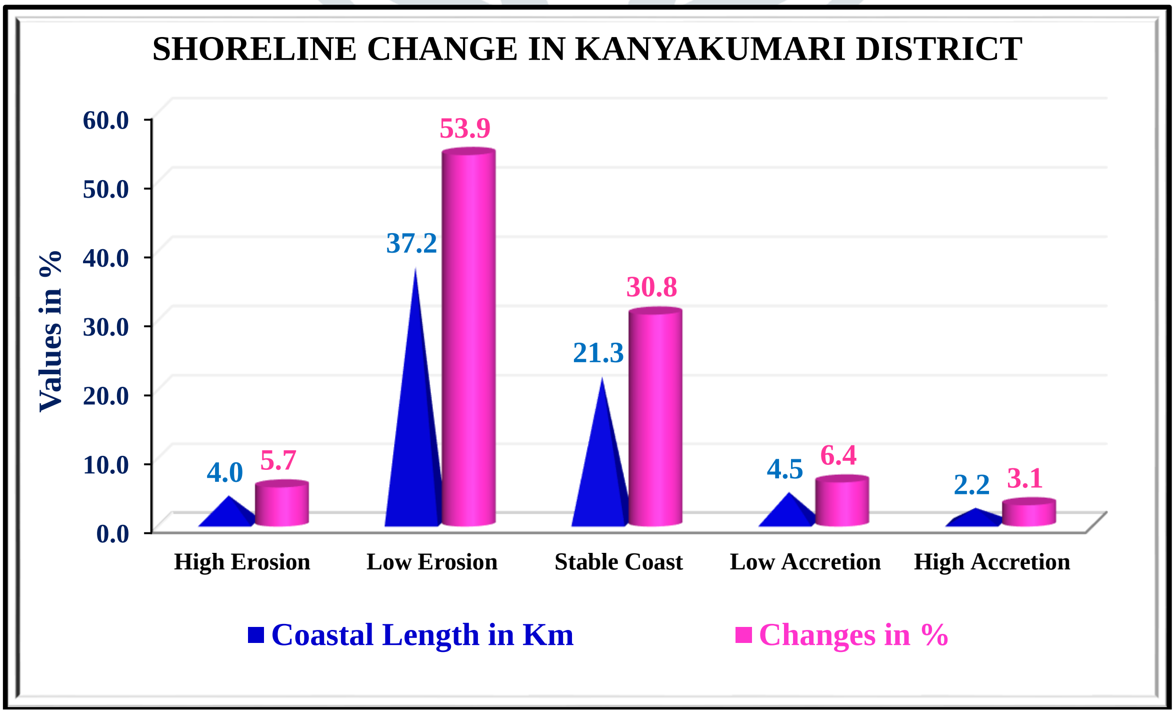


Figure: 5

VIII. CROSS-VERIFICATION AND JUSTIFICATION

The government of Tamil Nadu district disaster management plan 2020 stated that Azhikal, Midalam, Poothurai, Erayumanthurai, Neerodi, and Vallavilai have been identified as vulnerable sites on the coast of Kanniyakumari District. Azhikal, for example, is part of the Neendakarai B Revenue Village in Agasteeswaram Taluk. The height of the sea waves rises during strong wind periods, allowing water to reach houses located 10–15 metres from the coast. On August 22, 2019, the height of the sea wave was around 4-5 feet, and both sea water and sand entered the coastal houses. Approximately 25 houses were affected and it took 3–4 days to drain the water around the houses and another 3–4 days to drain the water inside the houses. The JCB was used to remove the sand from the houses and restoration in this area typically took 10 days *(Kanyakumari District Disaster Management Plan, 2020, Pages 48–49)***.**

IX. CONCLUSION

In the Kanyakumari District, the retreat of the shoreline is a process that is still ongoing. The government has responded to the rapid and significant loss of land by employing a variety of methods of stabilisation in an effort to combat erosion. However, little is known about either the short-term or the long-term ecological impacts that these hard structures might have on the system, particularly in the processes of climate change and sea level rise continue. This is especially in the case of the sea level rises and the climate continues to change. Long-term management solutions for shoreline recession need to be in harmony with the dynamics of the coastal system. This is necessary for the preservation of our coastal and marine resources as well as the maximisation of human utilization. The concept of managing coastal areas according to sound principles are becoming more important. This requires conducting an exhaustive study, establishing goals, planning, and managing coastal systems and resources while taking into account traditional, cultural, and historical perspectives as well as competing interests and uses. It is now widely acknowledged that the coast itself is an extremely valuable natural resource that needs to be properly managed and preserved and that it should not be degraded by development that is not in keeping with its setting. Construction activities and shoreline change such as the construction of harbors, sand mining and mineral extraction have increased the erosion trend along the coast of the Kanyakumari district. The statistics of the Kanyakumari District shoreline change rate show that the stable coast occupied 21.3 kilometres of the 69.05 kilometres of calculated coastal length in Kanyakumari District. This was followed by low accretion (4.5 kilometers), high erosion (4.0 kilometers), low erosion (37.2 kilometers), and high accretion (2.2 kilometers). The current study illustrates an overall change in the shoreline (including erosion, stabilization, and accretion) that occurred over a time period of 30 years from the year 2000 to the year 2020. The statistics of the Kanyakumari Districts shoreline change rate show that the stable coast occupied 21.3 kilometres of the 69.05 kilometres of calculated coastal length in Kanyakumari District. This was followed by low accretion (4.5 kilometers), high erosion (4.0 kilometers), low erosion (37.2 kilometers), and low accretion (2.2 kilometers). Based on the findings of the aforesaid study, we are able to conclude that the Kanyakumari district is vulnerable to coastal erosion. The coastal vulnerable areas of the Kanyakumari district, which include fishing villages such as Azhikkal, Mellamidalam, Eraiyumanthurai, Iraviphuthanthurai, Budhanthurai and Kovalam are in an extremely precarious situation, as shown by the Figure 6. And the stable coastal areas are Arogyapuram, Muttom, Inaiyam, Kotillpadu and Colachel. As shown in Figure 6, the areas of Keezamuttam, Chinnamuttam and Kanyakumari have experienced a significant amount of accretion in the coastlines.

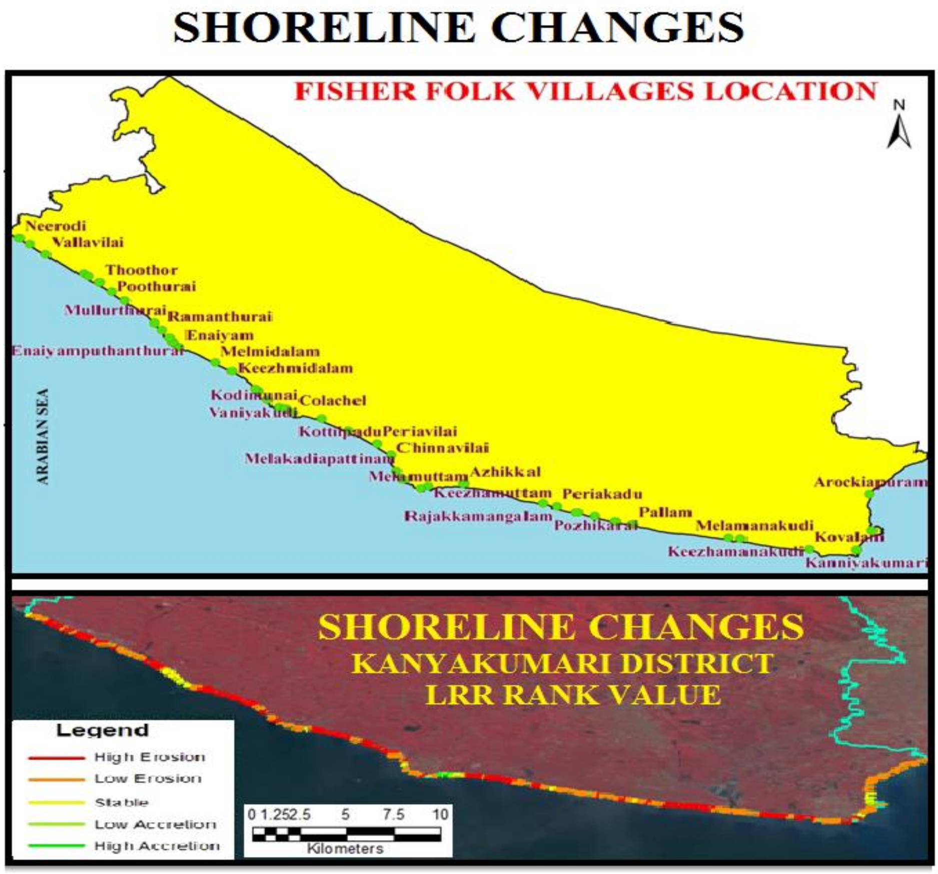


Figure: 6, Source: Landsat-9 imagery & SOI Topographical Sheet

In the overall estimates of how the shoreline has changed over the course of the study period, the temporal differences have been considered. Although the majority of the reasons for shoreline change are attributable to human activity. It is generally believed that coasts are always shifting due to both natural and anthropogenic processes. However, the causes of shoreline change are predominantly human-induced. Our coastline will very certainly be significantly altered in the not-too-distant future as a direct result of climate change and the related rise in sea level. More attention has been paid to shoreline dynamics around coastal infrastructure and ports and up-to-date data are required to better understand and safeguard coastal communities, resources and infrastructure. For the effective management of coastal structures, it is necessary to conduct analyses of long-term shoreline change data, measurements of short-term shoreline movements, an understanding of coastal processes and knowledge of the effects of seawalls, short groins, long groins, and jetties.

REFERENCES

1. Addo, K. A., & Kufogbe, K. S. (2011). Quantitative Analysis of Shoreline Change Using Medium Resolution Satellite Imagery in Keta, Ghana, p-ISSN: 2163-2421, e-ISSN: 2163-243X, 1(1), 1–9. https://doi.org/10.5923/j.ms.20110101.01
2. Nayak, B. U., Chandramohan, P., Kumar, V. S., and Raju, N. S. N., 1994. Surf zone dynamics along the south Karnataka coast between Bhatkal and Ullal, west coast of India. Indian Journal of Marine Sciences, **23**, 189–194. https://api.semanticscholar.org/CorpusID:83351197
3. Poulos, S., & Chronis, G. (2001). Coastline changes in relation to longshore sediment transport and human impact, along the shoreline of Kato Achaia (NW Peloponnese, Greece). Mediterranean Marine Science, e-ISSN: 1791-6763 2(1), 5–14. https://doi.org/10.12681/mms.271
4. IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts, Zanzibar, United Republic of Tanzania 17-21 January 1994. https://unesdoc.unesco.org/ark:/48223/pf0000100138
5. Warrick, R. A., Oerlemans, J., Beaumont, P., Braithwaite, R. J., Drewry, D. J., Gornitz, V., Grove, J. M., Haeberli, W., Higashi, A., Leiva, J. C., Lingle, C. S., Lorius, C., Raper, S. C. B., Wold, B., & Woodworth, P. L. (1990). Sea level rise. In Climate change: The IPCC Scientific Assessment (pp. 257-282). Cambridge University Press. https://www.ipcc.ch/ipccreports/far/wg_I/ipcc_far_wg_I_chapter_09.pdf
6. Ali, P. Y., & Narayana, A. C. (2014). Short-Term Morphological and Shoreline Changes at Trinkat Island, Andaman and Nicobar, India, After the 2004 Tsunami. Marine Geodesy, *38*(1), 26–39. https://doi.org/10.1080/01490419.2014.908795
7. Ranasinghe, R., Callaghan, D.P., Li, F. *et al.* Assessing coastline recession for adaptation planning: sea level rise versus storm erosion. *Sci Rep* **13**, 8286 (2023). https://doi.org/10.1038/s41598-023-35523-8
8. Moran, C.A.A., 2003. Spatio-Temporal Analysis of Texas Shoreline Changes Using GIS Technique. An Unpublished M.Sc Thesis Submitted to the Office of Graduate Studies, Texas A & M University. 117. https://core.ac.uk/download/pdf/147122918.pdf
9. Kanyakumari District Disaster Management Plan, 2020, Pages 48–49. https://kanniyakumari.nic.in/document-category/disaster-plan-en/