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Assessing Coastal Erosion Dynamics: Geo-spatial analysis of Marakkanam Coast's Socioeconomic and Environmental Influences

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ABSTRACT

Coastal erosion poses a significant threat to vulnerable communities worldwide, exacerbated by anthropogenic activities and climate change. Despite global recognition, coastal management strategies in developing nations like India often overlook the socio-economic vulnerabilities of coastal communities. This research focuses on Marakkanam, Tamil Nadu, investigating the dynamics of coastal erosion over three decades. Through remote sensing and GIS analysis, coupled with field visits, the study unveils the intricate interplay between natural and human-induced factors shaping coastal landscapes. Landuse Landcover analysis reveals a shift towards agricultural, salt pan, and aquaculture activities, providing insights into potential links with coastal erosion. Shoreline analysis using DSAS software identifies erosion and accretion patterns, highlighting areas prone to extreme changes. Hotspot analysis further refines these findings, pinpointing erosion and accretion hotspots. Contrary to expectations, the study finds no substantial influence of socio-economic activities on coastal erosion in Marakkanam, attributing primary causative factors to geological characteristics. In response, practical recommendations are proposed, including strategic placement of boulders and rocks and casuarina plantation, aimed at guiding sustainable coastal management strategies that balance environmental preservation and socio-economic well-being.

INTRODUCTION

Coastal regions across the world are increasingly experiencing significant shoreline changes, particularly in the form of coastal erosion, which poses serious threats to both natural ecosystems and human settlements. Coastal erosion is a dynamic and continuous process involving the removal and redistribution of sediments by wave action, tidal currents, and other marine forces. While such processes are naturally occurring, their intensity and frequency have increased in recent decades due to the combined effects of climate change and anthropogenic interventions (Zhang et al., 2004; Mishra et al., 2023).

The acceleration of coastal erosion has been strongly linked to global environmental changes, including sea-level rise, increased storm intensity, and altered sediment transport dynamics. These factors contribute to shoreline instability and increase the vulnerability of coastal communities, particularly in developing countries where adaptive capacity is often limited (Cutter & Emrich, 2006; Wang et al., 2021). In addition to natural drivers, human activities such as dam construction, sand mining, dredging, and coastal infrastructure development have significantly disrupted the natural sediment balance, further exacerbating erosion processes (Pandian et al., 2004; Misra & Balaji, 2015).

In the Indian context, coastal zones are of immense socio-economic importance, supporting livelihoods through fisheries, agriculture, salt production, and tourism. However, rapid population growth and unplanned development along the coast have intensified pressure on these fragile environments. Despite the growing recognition of coastal vulnerability, effective management strategies often remain inadequate due to limited integration of scientific analysis with policy frameworks (Rajan et al., 2020; Natesan et al., 2015). The need for comprehensive, data-driven approaches to understand shoreline dynamics has therefore become increasingly critical.

Geospatial technologies, particularly remote sensing and Geographic Information Systems (GIS), have emerged as powerful tools for monitoring and analyzing coastal changes over time. These techniques enable the assessment of shoreline movement, land use transformations, and erosion-accretion patterns with high spatial and temporal accuracy (Kumaravel et al., 2013; Mutaqin, 2017). The application of the Digital Shoreline Analysis System (DSAS) has further enhanced the capability to quantify shoreline change rates and identify erosion-prone zones, making it a widely adopted method in coastal studies (Sheik, 2011; Velsamy et al., 2020). In addition to physical processes, understanding the interaction between socio-economic activities and coastal dynamics is essential for sustainable coastal management. Changes in land use, particularly the expansion of aquaculture, agriculture, and salt pan activities, can influence coastal morphology and sediment dynamics (Misra & Balaji, 2015; Mishra et al., 2022). However, the extent to which these human activities contribute to coastal erosion varies across regions and requires detailed spatial analysis. Against this background, the present study focuses on the Marakkanam coast in Tamil Nadu, a region characterized by dynamic shoreline changes and increasing human interventions. By integrating remote sensing, GIS-based analysis, and field observations, the study aims to assess the patterns of coastal erosion and accretion over a multi-decadal period. Furthermore, it seeks to examine the relative influence of environmental and socio-economic factors in shaping coastal dynamics and to provide insights for sustainable coastal management strategies.

STUDY AREA

Marakkanam is a 'Panchayat town' situated in Viluppuram district of the southern state of India, Tamil Nadu. Latitude and longitude coordinates are: 12.186952, 79.927895. It is well connected to the state capital Chennai. Marakkanam is situated in the north of Pondicherry at a distance of 40 Kms and in the east of Tindivanam at adistance of 30 Kms. It is perched at a height of 14 metres (45 feet) above mean sea level. The places near Marakkanam are Tindivanam, Kalpakkam, Koonimedu, Murukkery, Brahmadesam, Nallalam, Soonambedu and Kadapakkam. The town was connected to Vijayawada in Andhra Pradesh through the Buckingham Canal, a 420 km long fresh water navigation canal. The 110 km Stretch from Marakkanam to Chennai is called South Buckingham Canal. It was constructed by the British Raj. The canal is said to be an important waterway during the late nineteenth and the twentieth century. The study area which I have taken has the total area of 377.67 sq.km and the total shore length that is studied under this project in Marakkanam is 29.24 sq.km. The coastal geomorphology and shoreline characteristics of this region are similar to other parts of the Coromandel Coast, which are highly dynamic and vulnerable to erosion (Rajesh et al., 2016; Sheik Mujabar & Chandrasekar, 2013).

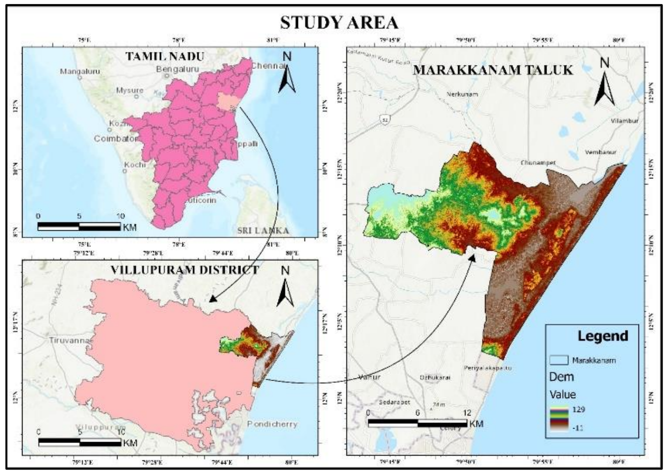

Fig.1: Location of Map of the study area

METHODOLOGY

The methodology involves three stages: a) Collection of base data b) Processing of data and analysis c) Compilation of data results and recommendations using analysis. The collection of data depends on the nature of the study. On the basis of the topic and nature of the study, the base data that has to be collected are decided.

Collection of base data

The collection of the base data is the first and foremost stage and this step plays a pivotal role in the analysis. The base data used for this study are the satellite data for four years.

a. 1992 – Landsat 4-5 TM C2L1: Path 142, Row 052
b. 2002 - Landsat 7 ETM+ C2L1: Path 142, Row 052
c. 2011 - Landsat 4-5 TM C2L1: Path 142, Row 052
d. 2025 – Landsat 8-9 OLI/TIRS C2L1: Path 142, Row 052

Table 1: LANDSAT- 5 BAND COMBINATIONS

Landsat 5 (TM sensor)	Wavelength (micro meters)	Resolution (meters)
BAND 1	0.45 - 0.52	30
BAND 2	0.52 - 0.60	30
BAND 3	0.63 - 0.69	30
BAND 4	0.76 - 0.90	30
BAND 5	1.55 - 1.75	30
BAND 6	10.40 - 12.50	120
BAND 7	2.08 - 2.35	30

Table 2: LANDSAT – 7 BAND COMBINATIONS

Landsat 7 (ETM+ sensor)	Wavelength (micro meters)	Resolution (meters)
BAND 1	0.45 - 0.515	30
BAND 2	0.525 - 0.605	30
BAND 3	0.63 - 0.69	30
BAND 4	0.75 - 0.90	30
BAND 5	1.55 - 1.75	30
BAND 6	10.40 - 12.5	60
BAND 7	2.09 - 2.35	30
PAN BAND	.52 - .90	15

Table 3: LANDSAT- 8 BAND COMBINATIONS

LANDSAT 8	Wavelength (micro meters)	Resolution(meters)
BAND 1	0.433 to 0.453	30
BAND 2	0.450 to 0.515	30
BAND 3	0.525 to 0.600	30
BAND 4	0.630 to 0.680	30
BAND 5	0.845 to 0.885	30
BAND 6	1.56 to 1.66	30
BAND 7	2.10 to 2.30	60
BAND 8	0.50 to 0.68	15
BAND 9	1.36 to 1.39	30
BAND 10	10.3 to 11.3	100
BAND 11	11.5 to 12.5	100

A Digital Elevation Model (DEM) is a representation of the bare ground (bare earth) topographic surface of the Earth including trees, buildings, and any other surface objects. The DEM data is obtained from the SRTM (Shuttle Radar Topography mission) 1-Arc Second Global. The obtained DEM data is used to obtain information like Slope and Aspect elevation data offer worldwide coverage of void filled data at a resolution of 1 arc-second (30 meters) and provide open distribution of this high-resolution global data set. Some tiles may still contain voids. Users should check the coverage map in Earth Explorer to verify if their area of interest is available. Please note that tiles above 50° north and below 50° south latitude are sampled at a resolution of 2 arc-second by 1 arc-second. A topographic map differs from other maps in the way that they represent the terrain's horizontal and vertical location. Contour lines, colour, symbols, labels and other geographical representations are used in combination. The topographic sheet used here is surveyed during the year 1976 and the scale used in the topographic sheet is 1:50000.

Processing of Data and analysis:

Once the data has been collected then it has to process using various analysis. The selection of the analysis to be done for the data is done based on the topic and the nature of study of the project. The collection of the base data and the processing of data and analysis is majorly dependent on the topic and the nature of the study, The data is analysed using three main analysis:

Landuse Landcover analysis:

Earth observations from space platforms play a crucial role in generation and dissemination of information on LULC pattern in a timely and reliable manner providing vital inputs required for optimal land use planning. Land use and land cover analysis provides critical insights into human-induced changes and their environmental implications in coastal regions (Misra & Balaji, 2015; Kumaravel et al., 2013). There are many levels of classifications that is used in Landuse Landcover analysis. The level of classification to be used in the study is decided upon the demand of analysis of the study. The classes that are mentioned in the study depend on the level of classification that is chosen for the analysis. The Landuse Landcover analysis is done for two years 1992 and 2025. This analysis is done by taking satellite data as a base and by dividing the area into 13 classes. Level-2 classification is done in this analysis of Marakkanam coastal area.

Shoreline Change Detection:

The shoreline change detection is done to analyse the change of the shoreline in the Marakkanam coast from 1992 to 2025. The Digital Shoreline Analysis System (DSAS) is a widely used tool for quantifying shoreline change rates and identifying erosion and accretion patterns (Sheik, 2011; Velsamy et al., 2020). The analysis of the shoreline change helps to assess the severity of the coastal erosion in the Marakkanam coast that is the major finding that has to be done in the study. The shoreline change detection is done using DSAS

(Digital Shoreline analysis system) and ArcGIS Pro. The Toposheets used as the baseline and the shoreline of 1992, 2002, 2011 and 2025 which is obtained from the Landsat data are used as the input data for the DSAS analysis. The shoreline representation of the analysis is done based on the shape length that is the change in shoreline based on the distance of erosion and deposition from the baseline in terms of meters.

Hotspot analysis:

This analysis is done in the Marakkanam coastal area to identify the hotspots. Once the shoreline analysis is done the next step is to find out the hotspots. The hotspots in this study depict the erosion and accretion prone areas in the coast. The main aim of the hotspot analysis is to find out the areas that are highly prone to erosion and accretion. Identification of the areas of erosion and accretion are the vital part of analysis in the study of coastal erosion. This Hotspot analysis makes the study much simpler by the identification of the hotspots. The Hotspot analysis is the identification of sites where the erosion and deposition is high and this analysis helps us to find out the reasons for the cause of the erosion.

Compilation of Data results:

In this step the results of analysis are compiled and the result is ready for interpretation. In the compilation of data, the results obtained from the analysis done for the study is collected and the results of the analysis are correlated. The results from Landuse Landcover analysis, Shoreline change detection and Hotspot analysis are correlated and compiled for the analysis. After the compilation of the data from the above-mentioned analysis, a result can be framed.

RESULTS AND DISCUSSIONS:

Landuse Landcover analysis:

In the Landuse Landcover analysis the topographic sheet, Google earth and satellite data is used to create the Landuse Landcover map**.** This map is created using level-2 classification. In the level-2 classification the map is divided into 13 classes. They are:

a. Aquaculture
b. Built-up
c. Crop land
d. Forest
e. Forest plantation
f. Forest Scrub
g. Plantation
h. Saltpan
i. Sand
j. Scrub land
k. Stony waste,
l. Water body
m. Marsh

This analysis is done to analyse the changes in the Landuse/Landcover patterns due to the activities involving changes in land terrain cutting of high grounds and hillocks, filling of low-lying areas and reclamation affecting drainage patterns need to be brought out. This project involves the analysis on whether the relationship between the coastal erosion and socio-economic activity is positive or negative. The landuse Landcover analysis mainly focuses on the changes that have taken place over a period of time. In this study the period from 1992 to 2022 is analysed. The main aim of this study is to analyse the change in the landuse of the study area over the above-mentioned period of time. The total study area is studied under 13 classes in the level-2 classification. The level - 2 classification is selected for the landuse Landcover analysis because this gives the clear picture of the landuse as it involves more classes. The lower classification level has very few classes so it provides very less information about the landuse.

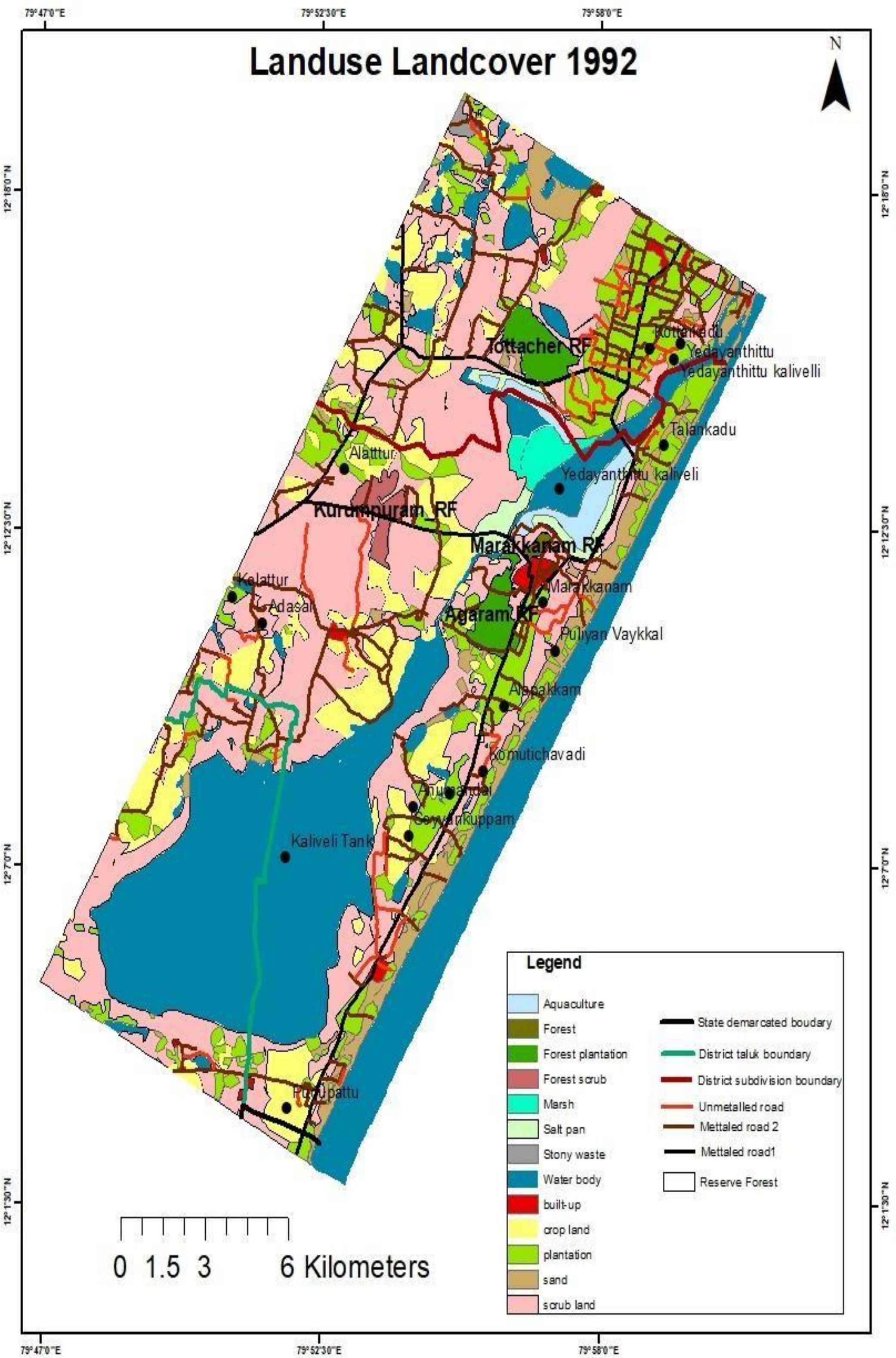

Fig.2: Landuse Landcover Map 1992

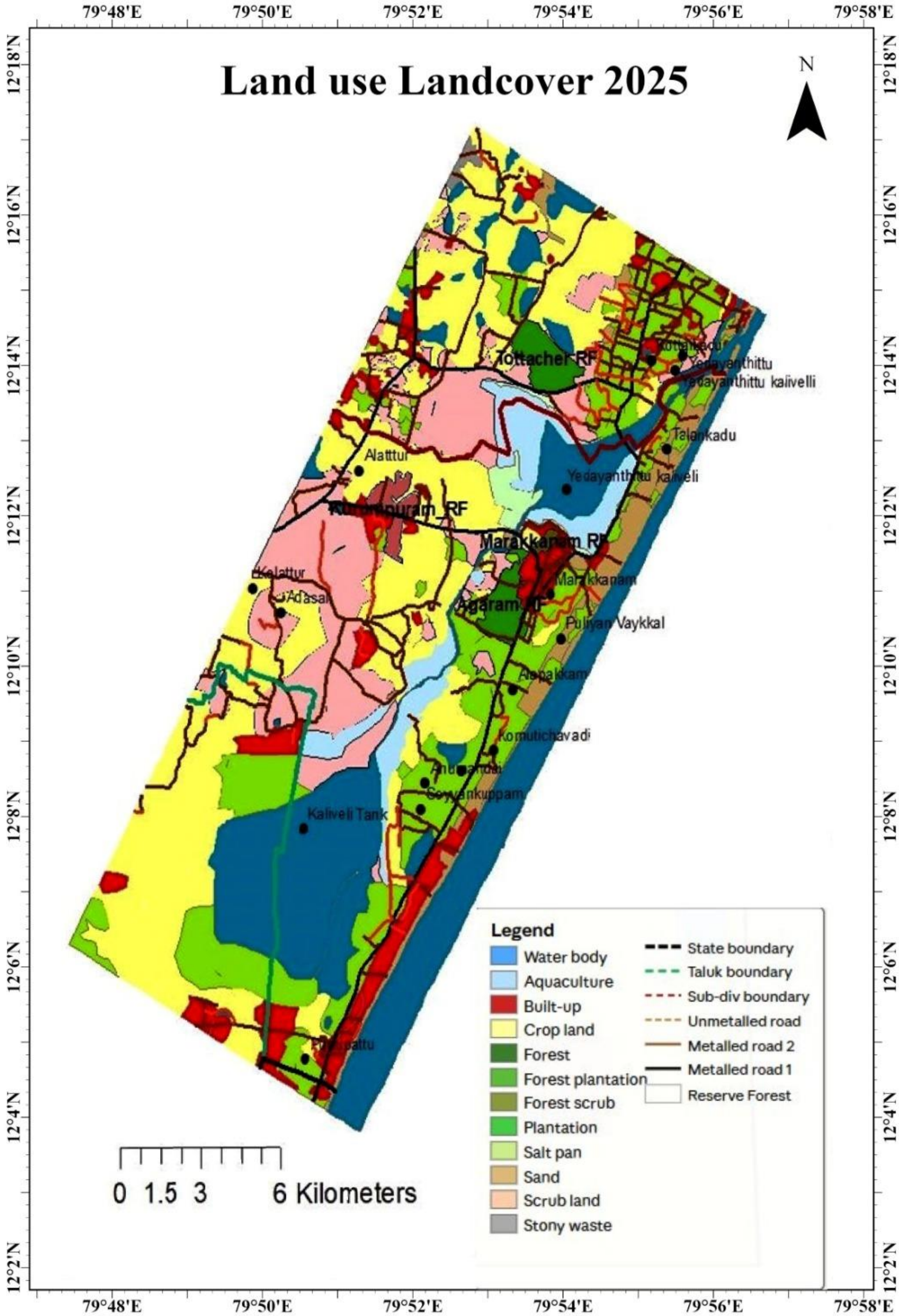

Fig 3. Landuse Landcover Map 2025

Table 4. Tabulation of the area of LULC in 1992 and 2025

S.No.	Class	Area in 1992 (Sq. Km)	Area in 2025 (Sq. Km)	Area in % (in 1992)	Area in % (in 2025)
1	Aquaculture	4.58	16.95	1.18	4.35
2	Built-up	3.11	29.29	0.80	7.52
3	Crop land	43.59	112.16	11.32	28.81
4	Forest	0.40	0.40	0.10	0.10
5	Forest Plantation	6.66	3.15	1.72	0.80
6	Forest Scrub	2.50	2.43	0.64	0.62
7	Plantation	52.85	66.60	13.72	17.10
8	Salt Pan	4.05	3.17	1.05	0.81
9	Sand	19.65	14.56	5.10	3.74
10	Scrub land	129.66	56.55	33.67	14.52
11	Stony waste	0.69	0.83	0.17	0.21
12	Water body	114.88	83.18	29.83	21.36
13	Marsh	0	0	0	0

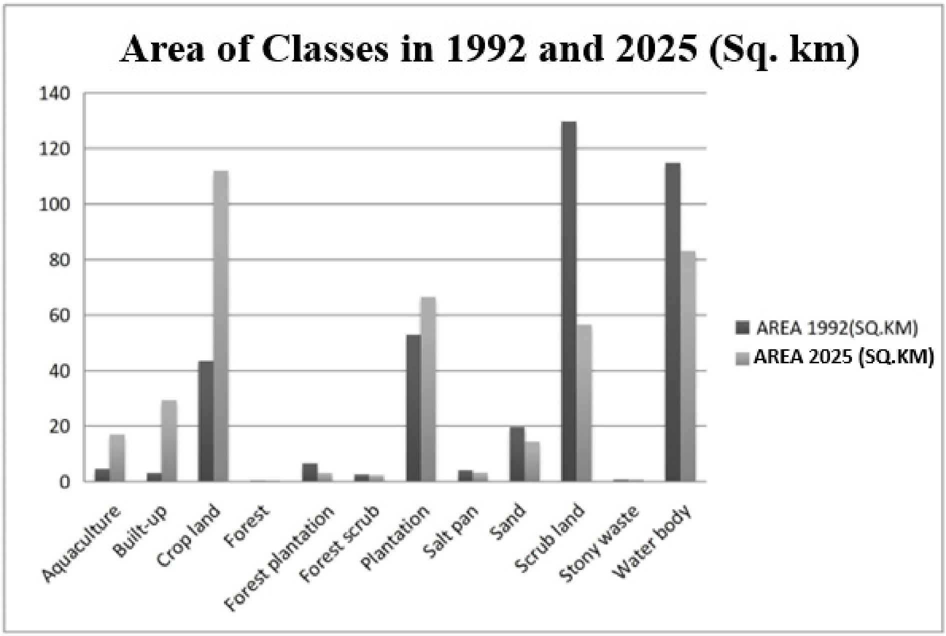

Fig 4. Area of LULC classes in 1992 and 2025

From the Landuse Landcover analysis done it is clearly visible that the Landuse pattern has changed and the socio-economic activity has been increased over years. The Socio-economic activities which mainly take place here are: Agriculture, Salt pan, and Aquaculture.

The Data has been tabulated and graphically represented which shows that these activities have increased in a notable amount from 1992 to 2025.

SHORELINE ANALYSIS:

The Shoreline analysis involves the Baseline and the shoreline. The baseline taken here is the Toposheet and the shoreline of the years 1992, 2002, 2011 and 2025 is taken for analyzing the change of over these years. By taking the baseline and shorelines as base data the shoreline analysis is done using the DSAS software and Arcpro 3.o. The observed erosion and accretion patterns are consistent with findings from other coastal studies along the east coast of India (Arun Kumar & Kunte, 2012; Pereira et al., 2022). The gathered data from the satellite imagery can provide useful preliminary information for understanding the dynamic behaviour of shoreline variation in a specific area. Data gathering, shoreline demarcation and shoreline change length are all part of the technique used in the study.

The steps involved in DSAS shoreline analysis are: a) Shoreline Demarcation, b) Baseline construction, c) Transect generation, and d) Calculation of the distance from between baseline and shoreline at each transect. Here the shape length is taken as the main parameter to be analysed the shoreline change that has happened over years. The transect has been constructed on 2 bases: a) Transect landward, b) Transect seaward.

The transect landward is constructed by taking into account the shift of shoreline towards land so that the erosion can be calculated. The area where the Transect landward shape length is high is the area prone to high erosion. The transect seaward is constructed by taking into account the shift of shoreline towards the water so that the accretion can be calculated. The area where the transect seaward shape length is high is the area that is prone to high accretion.

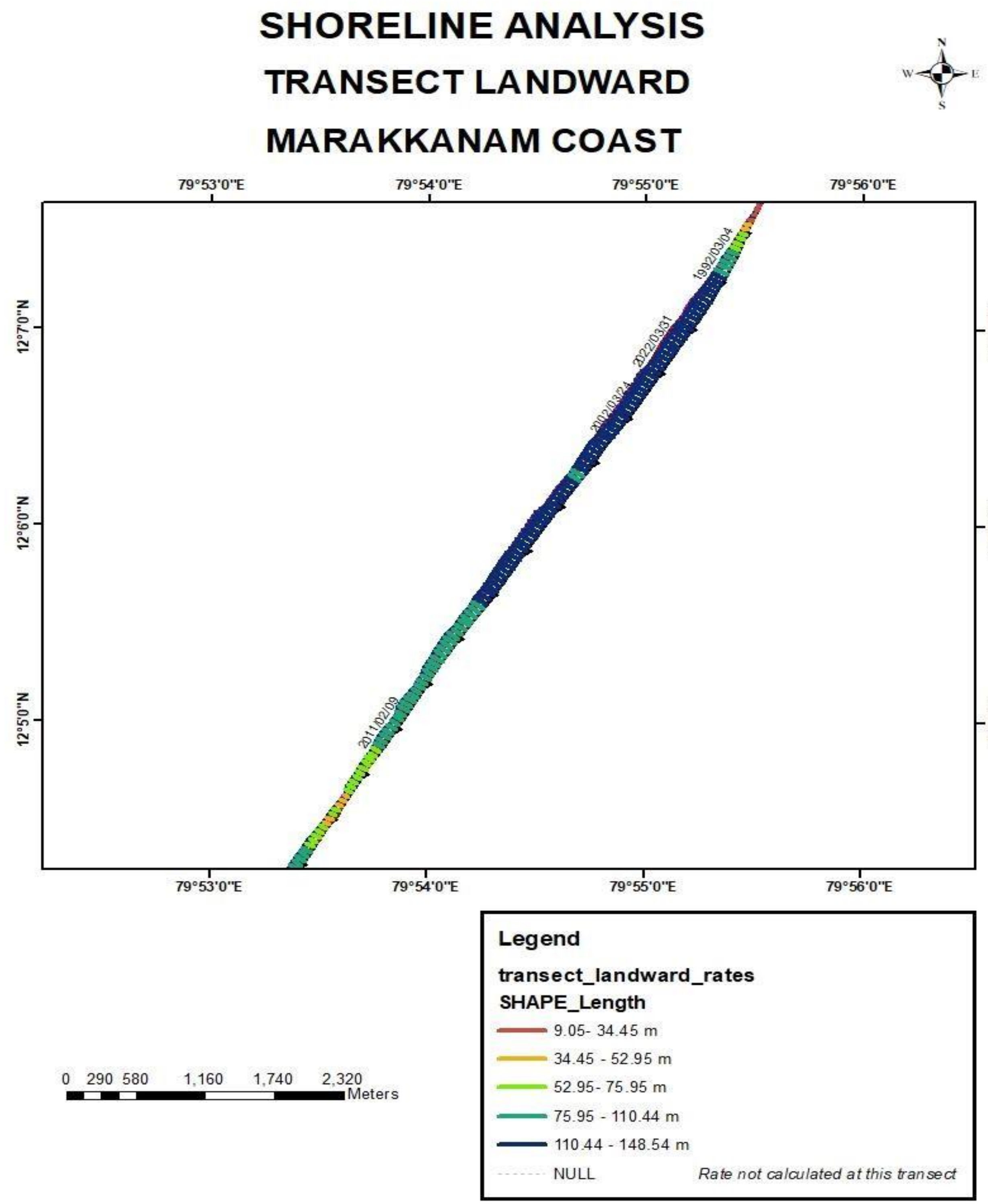

Fig.5: Shoreline analysis of transect landward layout

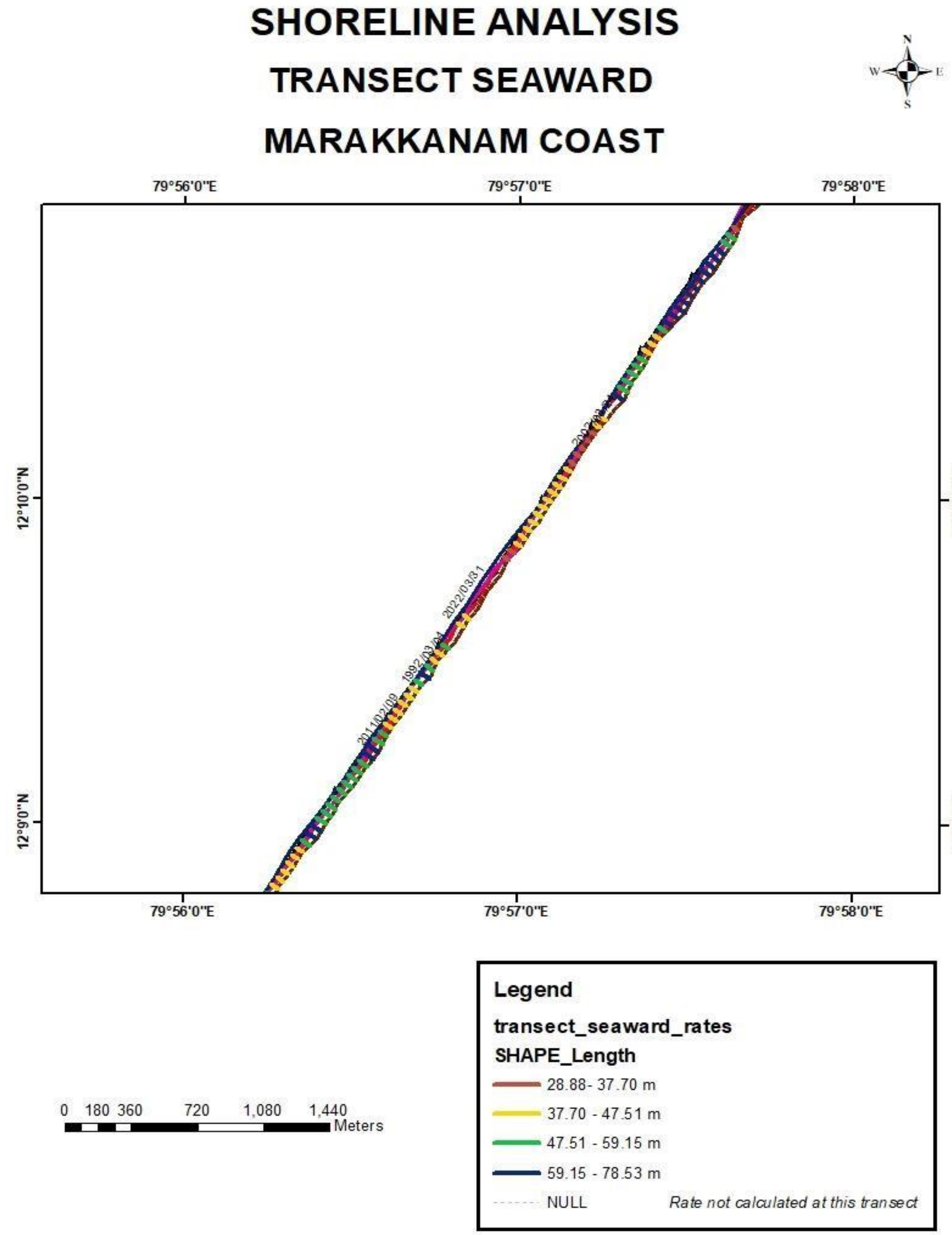

Fig.6: Shoreline analysis of transect seaward layout

In the representation of high deposition and accretion zones, they are divided into classes as very low, low, moderately, moderately high and high erosion and very low, low, moderate, moderately high and high accretion zones**.**

Table 5: Tabulation of erosion zone

S.No.	Erosion zone	Range (in m)
1.	Very low	9.05 – 34.45
2.	Low	34.45 – 52.95
3.	Moderate	52.95 -75.95
4.	Moderately high	75.95 - 110.44
5.	High	110.44 – 148.54

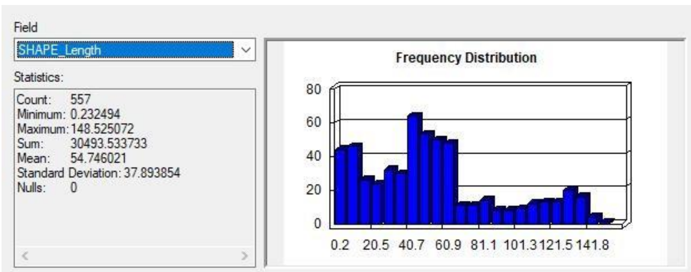

Fig.7: Frequency distribution Erosion**.**

The erosion rates have been recorded using the DSAS software and divided into five classes. From the data the mean length of erosion happening per year is 54.74m. According to the frequency level the erosion happening between 40.7m and 60.9m is high. So, this gives the inference that in most of the eroded area shown in the shoreline, the shape length of the transect ranges between 40.7 to 60.9m

Table 6: Tabulation of accretion zone

S. No	**Accretion zone**	**Range (in m)**
1.	Very low	28.88 – 37.70
2.	Low	37.70 – 47.51
3.	Moderate	47.51 – 59.15
4.	Moderately high	59.15 – 78.53

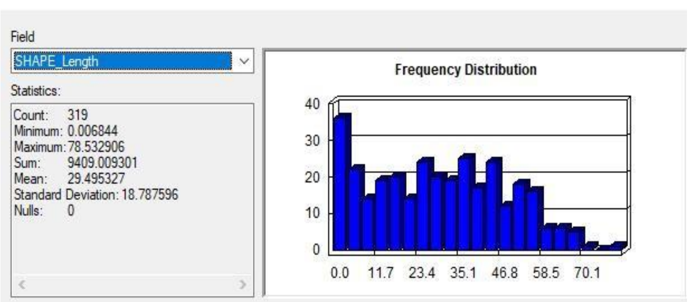

Fig.8: Frequency distribution of accretion

Here the accretion rates has been calculated, where it is observed that the mean that is the average length of accretion is calculated as **29.49m**. And as per the frequency distribution of the accretion, the shape length of the transect denoting deposition **1to 11.7m.**

In the DSAS shoreline Analysis denotes the erosion level and deposition level. Using the analysis the mean erosion and accretion level can also be obtained. The mean erosion and accretion level gives the average rate of erosion and deposition taking place every year in every zone.

HOTSPOT ANALYSIS:

The Hotspot analysis is the Geo processing tool to identify statistically significant hot spots. Here the hotspot analysis is used to identify the high erosion and accretion prone zones that are the extreme values on both sides. Identification of erosion hotspots is essential for coastal risk assessment and management planning (Gomez et al., 2020; Mishra et al., 2023). Such an identification in correlation with other analysis helps to come to a conclusion. In the hotspot analysis the areas where there is a) High erosion and b) High accretion has taken place are identified and highlighted. The highlighted areas are analysed to find the reason for the high erosion and accretion that has taken place in those areas.

Two layouts have been produced, that shows the extent where high erosion and accretion has taken place. Here the figure for high erosion zone blue shows the highest erosion. In the high erosion area layout blue line shows the highest erosion rate and brown shows the lowest erosion. The high erosion area layout only focuses on the high erosion prone areas. The high accretion area layout mainly focuses on the areas that have high deposition compared to the other areas. Here the blue transects show the high accretion area and the brown transect shows the low accretion areas. So the main aim of the hotspot map layout produced is to highlight the areas that are highly prone to erosion and accretion. On the basis of the hotspot analysis the causes of the erosion and deposition can be identified in correlation with suitable other analysis for coastal erosion.

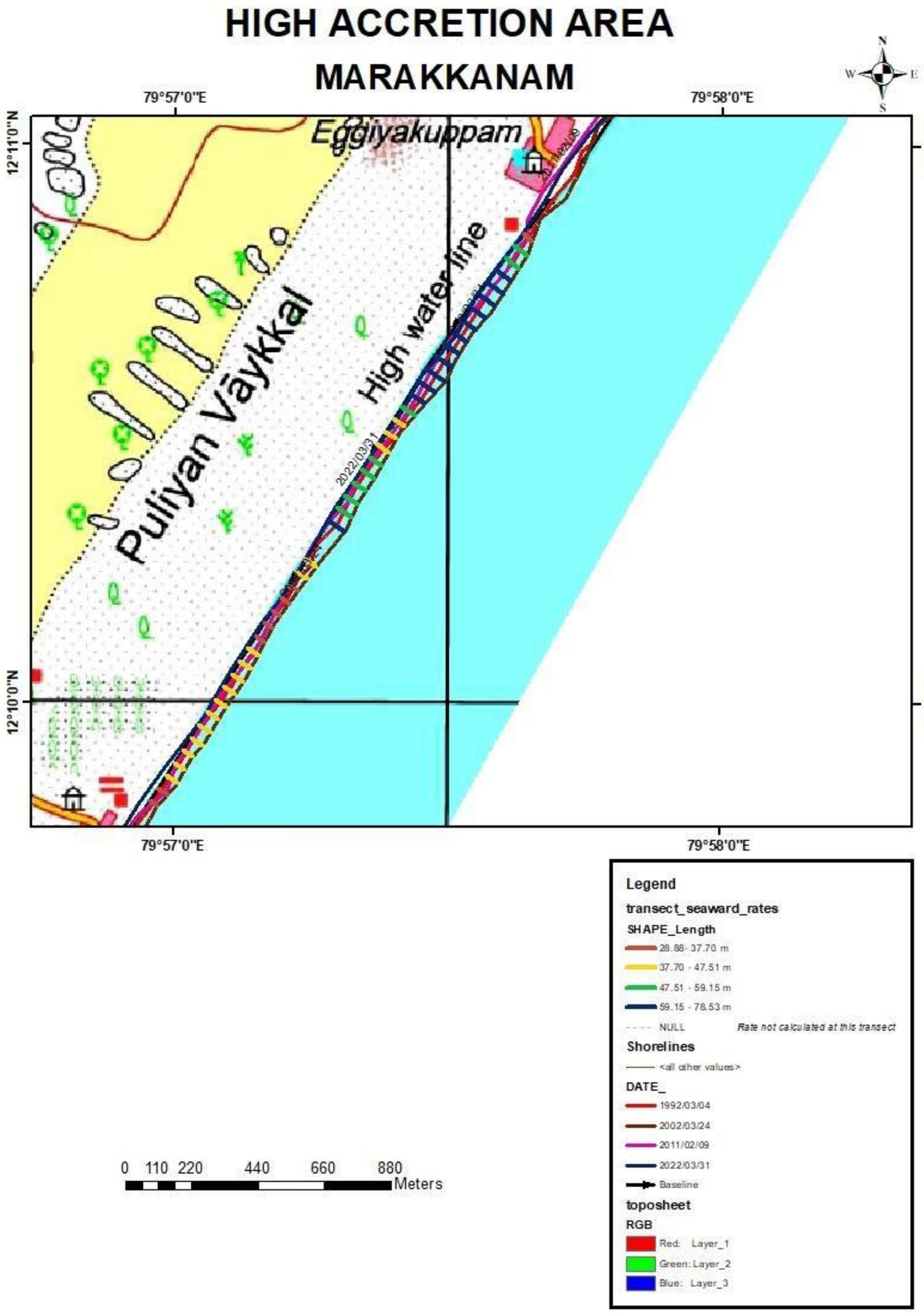

Fig.10: High accretion area

INTERPOLATION:

In the hotspot analysis after identifying the spots of erosion and accretion, zones were analysed based on the anthropogenic factors (socio-economic) and natural factors that influences the coastal erosion. From the field visit and analysis it is inferred that the continental shelf is the reason for the erosion taking place along the coast. Variations in continental shelf depth and coastal slope play a significant role in controlling wave energy and sediment transport processes (Dwarakish et al., 2009; El-Mahdy et al., 2022). The increase in the depth of the continental shelf along the coast from Marakkanam beach to Viluppuram beach and the increase in the slope in coastal areas along the coast is the reason for erosion. The increase in the slope is shown in the photograph and increase in the depth of the continental shelf is depicted in the interpolation method from the line graph and the figure attached below. Interpolation is a method of fitting the data points to represent the value of a function. It has a various number of applications in engineering and science that are used to construct new data points within the range of a discrete dataset of known data points or can be used for determining a formula of the function that will pass from the given set of points (x, y) or simply the process of obtaining the unknown values from the known values given.

Here interpolation technique is used for the identification of the depth of continental shelf. Random points of the continental shelf are plotted using the google earth adjacent to the areas that has been mentioned in the graph's x- axis. A tabular column has been created using the data and the data has been processed. The following picture depicts the increase in the slope along coast.

Table 7: Tabulation of the range of continental shelf

S.NO	RANGE (in m)	Depth
1.	-13 - -17	Very low
2.	-17 - -22	Low
3.	-22 - -27	Moderate
4.	-27 - -32	Moderately high
5.	-32 - --37	High

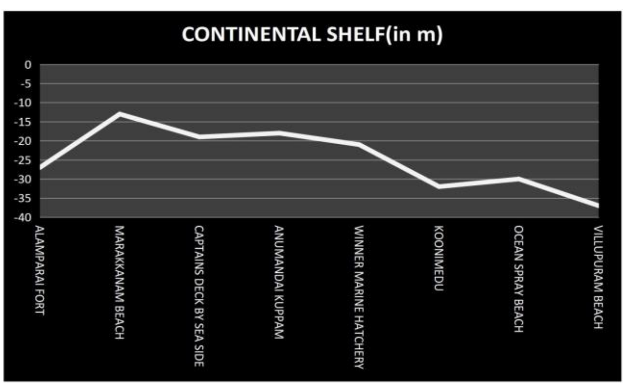

Fig.11: Line graph of continental shelf

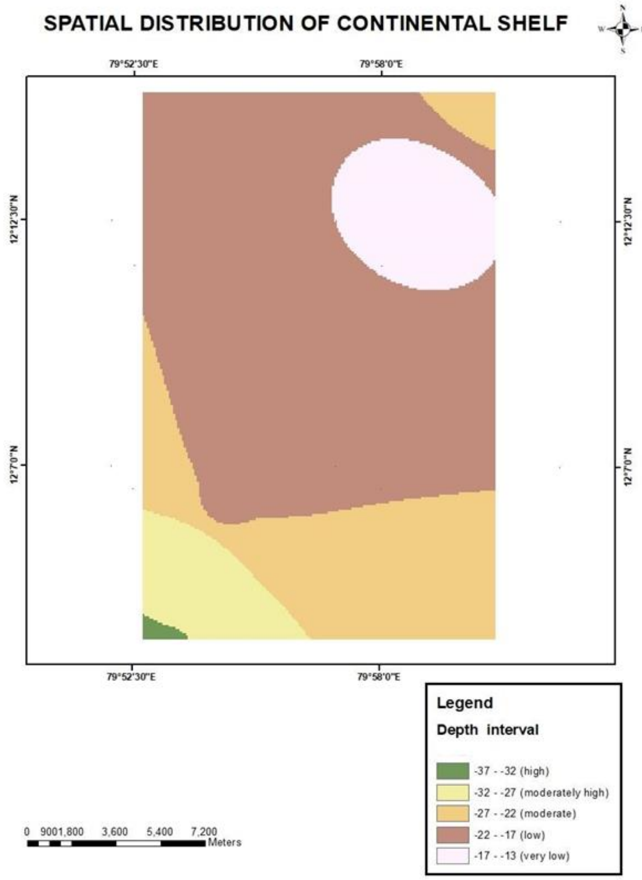

Fig.12: Spatial distribution of continental shelf

RECOMMENDATIONS:

The coastal erosion occurring in Marakkanam is mainly due to the slope in the shoreline and the increasing depth of continental shelf from Marakkanam beach to Viluppuram beach. There is no relationship between the socio-economic activities and the coastal erosion in the study area. Structural and nature-based coastal protection measures such as boulder placement and vegetation barriers have been widely recommended for erosion control (Camfield & Morang, 1996; Rajan et al., 2020). The coastal erosion occurring in the Marakkanam coastal area can be controlled by the following:

a) Adding of boulders and rocks to the shores: Adding some solid structures like boulders and rocks in the shoreline helps in controlling the coastal erosion to a great extent. Already this step has been taken in Puducherry by the government.

b) Planting Casuarina :

Planting of casuarina can be useful for controlling the coastal erosion. Mangroves also act as a coastal barriers but the soil type in the Marakkanam coastal area doesn't support the growth of the mangrove plants since the soil in Marakkanam has sandy texture. The mangrove can only grow in the mixture of sandy and clayey or the soil with completely clayey texture. The soil type in the Marakkanam coastal area supports the casuarina plantation. Planting casuarina in the coastal area acts as a wind breaker and binds the soil which helps in controlling the coastal erosion. So, such sustainable ways should be used so that the coastal erosion can be controlled.

CONCLUSION:

This research aimed to comprehensively assess the dynamics of coastal erosion along the Marakkanam Coast, with a specific focus on the socioeconomic and environmental influences contributing to this phenomenon. The study employed a multidimensional approach, combining remote sensing, Geographic Information System (GIS) analysis, and field visits to gain insights into the complex interplay of natural and anthropogenic factors shaping the coastal landscape. Integrated geospatial approaches are essential for understanding coastal dynamics and supporting sustainable coastal management strategies (Tian et al., 2020). The analysis commenced with an exploration of the global context, acknowledging the pervasive issue of coastal erosion attributed to both natural processes and human activities. The escalating threats posed by coastal erosion worldwide underscore the urgency of understanding and mitigating its impacts on vulnerable coastal communities. The research, situated in the Marakkanam region, sought to bridge the gap in coastal zone management strategies, particularly in developing nations like India, where the vulnerability of coastal communities has not been adequately addressed in national climate change plans. The study's focus on Marakkanam, a Panchayat town in Tamil Nadu, unveiled critical insights into the evolving coastal dynamics over a three-decade period. Through Landuse Landcover analysis, the research tracked changes in socio-economic activities, revealing a notable increase in agriculture, salt pan operations, and aquaculture. This shift in land utilization patterns was instrumental in understanding the potential linkages between human activities and coastal erosion.

Shoreline analysis utilizing DSAS software provided a detailed assessment of erosion and accretion patterns along the Marakkanam Coast. The identification of erosion-prone and accretion-prone zones through transect analysis facilitated a nuanced understanding of the spatial distribution of coastal changes. Hotspot analysis further pinpointed areas of extreme erosion and accretion, laying the foundation for a comprehensive investigation into the causative factors behind these dynamics. Field visits and subsequent analysis indicated a significant correlation between coastal erosion and natural factors, particularly the depth of the continental shelf and the slope along the shoreline. The study refuted any substantial influence of socio-economic activities on coastal erosion in the Marakkanam region, attributing the primary causative factors to geological characteristics. In response to the findings, the research proposes practical and sustainable recommendations for coastal erosion control. Suggestions include the strategic placement of boulders and rocks along the shoreline and the implementation of casuarina plantation, recognized for its efficacy in binding soil and acting as a windbreaker. The recommendations provided aim to guide future coastal management strategies, emphasizing the need for a balanced approach that considers both environmental sustainability and socio-economic well-being.

REFERENCES

1. Arun Kumar, A., & Kunte, P. D. (2012). Coastal vulnerability assessment for Chennai, east coast of India using geospatial techniques. *Natural Hazards, 64*, 853–872. https://doi.org/10.1007/s11069-012-0266-9
2. Camfield, F. E., & Morang, A. (1996). Defining and interpreting shoreline change. *Ocean & Coastal Management, 32*(3), 129–151. https://doi.org/10.1016/S0964-5691(96)00049-2
3. Cutter, S. L., & Emrich, C. T. (2006). Moral hazard, social catastrophe: The changing face of vulnerability along the hurricane coasts. *Global Environmental Change, 16*(3), 271–282. https://doi.org/10.1016/j.gloenvcha.2006.03.006
4. Dwarakish, G. S., Vinay, S. A., Natesan, U., Asano, T., Kakinuma, T., & Venkataramana, K. (2009). Coastal vulnerability assessment of the future sea level rise in Udupi coastal zone of Karnataka state, India. *Ocean & Coastal Management, 52*(9), 467–478. https://doi.org/10.1016/j.ocecoaman.2009.07.007
5. El-Mahdy, M. E. S., Saber, A., Moursy, F. E., Sharaky, A., & Saleh, N. (2022). Coastal erosion risk assessment and mitigation measures. *Ain Shams Engineering Journal, 13*(3), 101621. https://doi.org/10.1016/j.asej.2021.101621
6. Gomez, M. L. A., Adelegan, O. J., Ntajal, J., & Trawally, D. (2020). Vulnerability to coastal erosion in The Gambia. *International Journal of Disaster Risk Reduction, 45*, 101439. https://doi.org/10.1016/j.ijdrr.2019.101439
7. Kumaravel, S., Ramkumar, T., Gurunanam, B., Suresh, M., & Dharanirajan, K. (2013). Remote sensing and GIS-based shoreline change studies. *International Journal of Innovative Technology and Exploring Engineering, 2*(4), 211–215.
8. Misra, A., & Balaji, R. (2015). Decadal changes in land use/land cover and shoreline. *Environmental Monitoring and Assessment, 187*, 1–13. https://doi.org/10.1007/s10661-015-4600-9

9. Mishra, M., Kar, D., Santos, C. A. G., da Silva, R. M., & Das, P. P. (2022). Cyclone impacts on shoreline changes. *Marine Pollution Bulletin, 174*, 113262. https://doi.org/10.1016/j.marpolbul.2021.113262

10. Mishra, M., Chand, P., Beja, S. K., Santos, C. A. G., da Silva, R. M., Ahmed, I., & Kamal, A. H. M. (2023). Quantitative assessment of coastal erosion using geospatial tools. *Science of the Total Environment, 875*, 162488. https://doi.org/10.1016/j.scitotenv.2023.162488

11. Mutaqin, B. W. (2017). Shoreline change analysis using DSAS. *International Journal of Sustainable Development and Planning, 12*(7), 1203–1214. https://doi.org/10.2495/SDP-V12-N7-1203-1214

12. Natesan, U., Parthasarathy, A., Vishnunath, R., Kumar, G. E. J., & Ferrer, V. A. (2015). Monitoring shoreline changes along Tamil Nadu coast. *Aquatic Procedia, 4*, 325–332. https://doi.org/10.1016/j.aqpro.2015.02.044

13. Pandian, P. K., et al. (2004). Coastal erosion processes along Tamil Nadu coast.

14. Pereira, G. F., Gurugnanam, B., Goswami, S., & Choudhury, S. (2022). Coastal erosion analysis using geospatial techniques. *Journal of the Geological Society of India, 98*(9), 1261–1270. https://doi.org/10.1007/s12594-022-2172-5

15. Rajan, S., Nellayaputhenpeedika, M., Tiwari, S., & Vengadasalam, R.(2020). Mapping coastal vulnerability in Tamil Nadu. *Human and Ecological Risk Assessment, 26*(7), 1879–1895. https://doi.org/10.1080/10807039.2019.1700235

16. Rajesh, J., Lakshumanan, C., Karthick, P., & Govindaraj, V. (2016). Coastal vulnerability and shoreline changes. *Journal of Global Resources, 1*, 81–88.

17. Sheik, M. (2011). Shoreline change analysis using DSAS. *Geo-spatial Information Science, 14*(4), 282–293. https://doi.org/10.1007/s11806-011-0480-9

18. Sheik Mujabar, P., & Chandrasekar, N. (2013). Coastal erosion hazard assessment. *Natural Hazards, 69*, 1295–1314. https://doi.org/10.1007/s11069-013-0752-1

19. Tian, H., Xu, K., Goes, J. I., Liu, Q., Gomes, H. D. R., & Yang, M. (2020). Shoreline changes along China coast. *ISPRS International Journal of Geo-Information, 9*(10), 572. https://doi.org/10.3390/ijgi9100572

20. Velsamy, S., Balasubramaniyan, G., Swaminathan, B., & Kesavan, D. (2020). Multidecadal shoreline change analysis. *Arabian Journal of Geosciences, 13*, 1–12. https://doi.org/10.1007/s12517-020-06087-2

21. Wang, X., Zhang, W., Yin, J., Wang, J., Ge, J., Wu, J., & Lam, N. S.(2021). Assessment of coastal erosion vulnerability and socio-economic impact. *Ocean & Coastal Management, 215*, 105953. https://doi.org/10.1016/j.ocecoaman.2021.105953

22. Zhang, K., Douglas, B. C., & Leatherman, S. P. (2004). Global warming and coastal erosion. *Journal of Coastal Research, 20*(2), 399–413. https://doi.org/10.2112/1551-5036(2004)020