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RESEARCH ATICLE

Shoreline Change Detection Analysis along the Sindhudurg Coast of India using DSAS Technique

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Abstract

Objectives: To ascertain the shoreline changes along south Konkan region, Sindhudurg district, along the west coast of India. **Methods**: The Shoreline Change Detection Analysis (SCDA) was executed by field excursions, GPS surveys, cross-profiling and using satellite data. Toposheets were used for preparing a base map. GPS positions were marked at each location of measurement while surveying. Recorded data were cross-verified and compared with MMB bathymetric charts. Geometrically corrected Landsat imageries from 1991–2022 were used and extraction of the coastlines was performed. This satellite image data were georeferenced and the shorelines were extracted and digitized. The LRR statistical reports on numerically modelled transect lines for all the shorelines were generated and shoreline erosion-accretion rates were calculated. The statistical parameters were estimated with the help DSAS technique. An LRR was counted from 0.01 to 2.86 m, EPR from 1.69-11.21m and NSM upto 69.64 indicating sediment movement. **Findings**: The statistical parameters were evaluated from 1999 to 2022, the LRR value was −0.66 m/yr, the EPR value was - 1.03 m/yr, and the NSM value was −15.66 m. The net shoreline movement of eroded shoreline was 2082.15 m, while accelerated shoreline movement was 1965.75 m. The EPR obtained from DSAS analysis indicates 1.69 % accretion increased up to 11.21 % in 2022. The NSM has been increased up to 69.65 meters within 31 years of evaluation in the study. The results show that a sediment belt, which was about 815 meters wide, developed in the west of coastal axis at ebbing time. Nearly 67.40% of the shoreline is stable with no rate of change. **Novelty**: DSAS analysis help to understand the trend of shoreline migration and sediment transport. The method can be adopted and applied to any coastal tract in the world and help in coastal regulation planning and decision-making.

Keywords: Shoreline Change Detection Analysis (SCDA); Digital Shoreline Analysis System (DSAS); Linear Regression Rate (LRR); End Point Rate (EPR); Net Shoreline Movement (NSM)

1 Introduction

Shorelines are most dynamic and vulnerable to any kind of natural and anthropogenic disturbances. An increase in over-exploitation of the resources, increasing population and infrastructural services in coastal geosystems result in severe pressure on the coastal dynamics leading to coastal insecurity [1]. These variations are associated with many primary and secondary factors like tides, waves, winds, sea level changes, storm surges, coastal processes, sediment transport and human activities. The results of these shoreline changes are very complex and unstable to study and vary from place to place. This affects the estuarine ecosystem and disturbs the intertidal zone and shoreline morphology. The shoreline also shelters several economically significant infrastructures viz., ports and harbours, jetties and groins, aquaculture, mining and reclamation and a very important tourism sector.

The evaluation and monitoring of spatio-temporal changes in these dynamics can help in understanding the pattern of shoreline changes, erosion-accretion, and supporting factors. Such kind of analysis is often time-consuming, tedious and expensive. It becomes impossible for large coastal stretches to survey by using traditional methods. The coasts being dynamic in nature results in spontaneous variation in recorded data and readings even during the short span of field excursions. At the global level, both quantitative and qualitative analysis for shoreline change has been illustrated in various studies by using Landsat satellite images and GIS tools [2]. The limitations of traditional surveying methods can be overcome by using geospatial datasets and analysis tools in Geographical Information Systems (GIS). For long-term shoreline change detection and proper scientific assessment of erosion accretion, historical remote sensing data have been used by many researchers. It is of great significance to extract the shoreline at different time scales and perform a comparative analysis based on estimated data using satellite remote sensing data for mapping and monitoring the shoreline changes at low cost and time [3]. The diachronic analysis of shoreline extraction can be performed by comparing satellite data with cartographic data, deep-water wave climate and the response of hydraulic structures [4]. The water index-based methods were used to identify the changes in shoreline by using Landsat data and applied Normalized Difference Water Index (NDWI) for shoreline extraction [5]. The numerical simulations-based studies were proposed by using coastal research-dedicated. Similarly, the Digital Shoreline Analysis System (DSAS) technique, an extension of ArcGIS software, has been used in many studies to estimate the rate of shoreline change over a given period [6]. A new method of Fuzzy approach and DSAS analysis was used to extract shoreline and continuous assessment of shoreline changes to estimate the vulnerability of shorelines due to human interventions [7]. Most of the previous studies focused on the estimation of erosion-accretion rates but is a lack of information on synoptic estuarine dynamics for long-term shoreline changes and shoreline movement forecasts along the west coast of India [8]. The coastal region of Mumbri creek is lacking in any kind of socio-economic development. Very few similar studies are carried out in the region. Meanwhile, the studies highlight shifting beach dunes and change in land cover along Mumbri creek [9] but the consequences of bridge construction and shoreline changes have not been examined and quantified. In terms of the dearth of information, the present study area and research become more significant.

In recent years, the Konkan region of Sindhudurg has undergone severe modification due to rapid urbanization, awareness in the tourism sector and developing harbours. The small beaches and coves form 'erosion-induced pockets' resulting in the submergence of low-lying coastal and retreating shorelines [10]. A national report published by National Centre for Coastal Research assessed the shoreline changes across the Indian coastline and highlighted the erosion-accretion trends in the past 26 years. It has been reported that about 34% of the west coast of India is undergoing a low to high rate of erosion [11]. The coastal stretch of the south Konkan region is categorized under the micro-tidal zone of the west coast of India. The micro-tidal regions are the areas where tidal range is >1.24 meters. Anthropogenic activities like sand mining, the construction of recreation centers and water sports activities have disturbed the local geosystems. Alteration of coastal hillslopes and uplands into small populated settlements, mining grounds and resorts has changed the land cover of the Sindhudurg district. The study area comprises the Mumbri creek located in the Sindhudurg district of the South Konkan region of Maharashtra state in India. It is dotted with a coastline of emergence with long-stretched beaches, creeks and estuaries. In recent years, the banks of Mumbri creek have undergone impulsive changes. In 2014, a bridge was constructed to connect the entire north Konkan region to the rest of southern Konkan. This ultimately affected the fish catchment of the local population. Meanwhile, the south Konkan region is highly neglected in terms of trade, finance and all other socio-economic well beings. Fishing is the major and only source of livelihood in the region. It is, hence, crucial to understand the changes that affected this livelihood, and the major reason is bridge construction. After the construction, the channel morphology and river bed bathymetry drastically changed and became vulnerable to tidal incursion, changes in sediment characteristics, the recession of mangrove cover, changes in vertical and horizontal circulation patterns of the tidal inlet, etc [12].

The proposed method included shoreline change detection based on bathymetric mapping, cross profiling, and DSAS (Digital Shoreline Analysis System) application to determine Shoreline Change Detection Analysis (SCDA) in recent years along the bridge. The main objective of the present study is to monitor the shoreline changes in the past 23 years from 1991 to

2023. Applying the DSAS technique, the rate of shoreline changes was quantified and changes along the coast of Mumbri Creek were analyzed. It helped to assess the statistical rate of shoreline changes using remotely sensed satellite data such as the Landsat data series. The shoreline changes were classified based on statistical parameters like LRR (Linear Regression Rate), NSM (Net Shoreline Movement) and EPR (End Point Rate) through DSAS techniques [13]. The long-term temporal and spatial changes were estimated and predicted net shoreline movement along the study area [14].

1.1 Study Area

The present study areas include two study sites of Mithmumbri and Taramumbri settlements which are situated in the Devgad Tahsil of Sindhudurg district in the South Konkan region. The region is a tide-dominated creek. Mithmumbri lies between 16° 22' 24.09" N latitude to 73° 22' 22.5" E longitude. Taramumbri lies between 16° 21' 26.28" N latitude and 73° 23' 13.2" E longitude Figure 1.

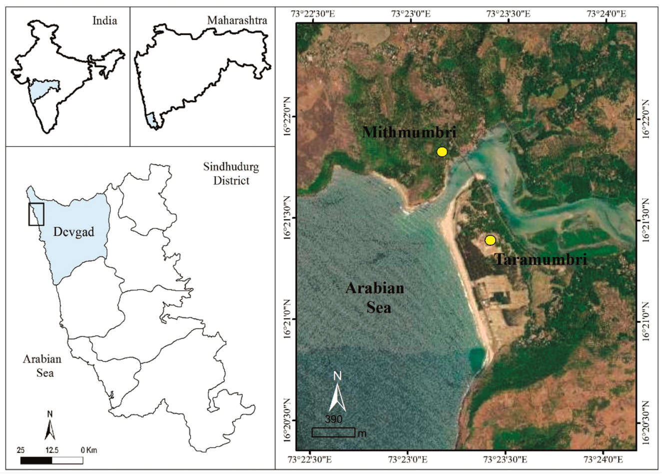

Fig 1. Location of the Studyarea – Mumbri Creek, Devgad in Sindhudurg district, West coast of India

The locations of the study area fall under a micro-tidal zone with >1.24 meters tidal range. A tidal current orients from the northeast direction towards a southwest direction. Geomorphically, the region is classified under micro-tidal, diploid from tidal influence, and oceanic disturbances. The inlet has a meandering path where it turns northwest to the southwest near Taramumbri. It is a region where a wave-dominated sand bar is built. Other associated features are shifting spit-bar near the mouth of the inlet, dispersed rock outcrops, channel bars in the middle course, coastal wetlands, and minor tidal inlets. The maximum elevation of the region is only 52 meters towards the northwest part of the bridge and the minimum achieves zero meters mean sea level. The creek dissects the lateritic plateau and enters into the Arabian Sea at Mithmumbri of Sindhudurg district. Being in a micro-tidal region, the study areas have a tremendous deposition of dunes and exposed beds along the mouth region [15]. It receives an average annual rainfall of 3000mm. The region experiences 31^{0}C and 22.8^{0}C maximum and minimum temperatures respectively. The average humidity ranges up to 71.3%, less than the other study areas. It is highest in July and decreases up to 62.0% in January. The occurrence of storm surges once in 100 years is 1.82 meters [16]. The need for assessment, monitoring, and mitigation of coastal stresses is increasing due to the increase in coastal population and infrastructure. The coastal population of Mithmumbri is 920 and Taramumbri is 1829, according to 2011 census, which might have been increased in 2023. Most of the population (~ 82%) depends on fishing as their main source of income. The present study is crucial to investigate the various hazards and their impacts in the various parts of the coast to draw suitable management plans. However, DSAS analysis helps to understand the trend of shoreline change along the entire study area.

2 Methodology

2.1 Database collection

Spatial data of geographical entities were used to perform advanced geospatial techniques to analyse man - environment relationships. In the present study, advanced computational techniques like DSAS were used with the help of the ArcGIS 10.4 software package. The DSAS is a GIS-based system developed by the United States Geological Survey (USGS). It measures the distance between each shoreline intersection along a transect and the baseline and associates with the date information added by the user, and uncertainty for each shoreline, to generate the statistical parameters like LRR, ERP, and NSM.

Updated and precise coastal studies and bathymetric analysis are always required to get high accuracy in coastal impact assessments [15]. These accuracies help in coastal modeling and simulation monitoring. The data collected during field visits and real-time data was converted into digital form Figure 2 .

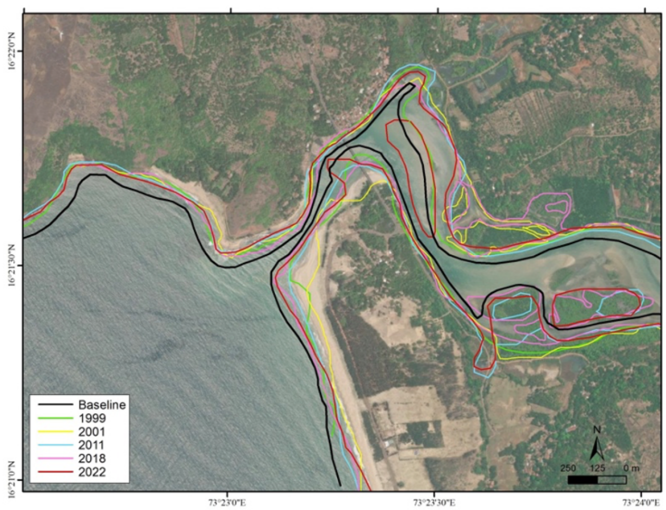

Fig 2. Demarcation of the shorelines with baseline

To cross-reference this data, Maharashtra Maritime Board (MMB)'s bathymetric chart (550/1999) was referred along with various geo-portals, geo-webpages, software packages, and geo-browsers were referred for non-gauging stations like Mumbri creek in the present study. Satellite data was downloaded from the USGS Earth Explorer website. In the present study, Landsat TM (Thematic Mapper), ETM (Enhanced Thematic Mapper), and Sentinel 2 were used to implement SCDA Table 1.

Table 1. Spatio-temporal satellite imagery data used to obtain shoreline data

Dataset	Path/Row	Year of Acquisition	Spatial resolution (m)
Landsat-5 TM	1487/049	14-11-1999	30
Landsat-7 ETM	1487/049	24-08-2001	30
Landsat-8 ETM+	1487/049	27-03-2011	30
Landsat-8 ETM+	1487/049	2/3/2018	30
Sentinel 1	1487/049	4/1/2022	20

2.2 Image Processing of Satellite Imageries

Satellite images used in the present study were initially geometrically corrected to assign a common position. Satellite data was selected with minimum distortion, 0% cloudiness, minimum or absent stripping noise, and distortion, low specific gap masks, etc. the spatial locations of nearshore ground control points (GCPs) were recorded with the handheld GPS during the field visits. Digital image processing was carried out to process the extracted information from satellite images, minimized the errors, and brought to common projections. The images were also re-sampled to align spatial resolution, especially Landsat images and the latest sentinel data acquired in January 2022. The image data not representing shoreline data and do not provide any information, were masked and removed. All distortions were removed to achieve accuracy and errorless satellite data.

2.3 Shoreline Extraction and Digitisation

Extraction of shoreline position shoreline from multi-temporal satellite images included Georeferencing of maps using GCPs and digitizing a shoreline as a polyline in ArcGIS. The images were processed to verify the cloudiness and land-sea interfaces. Shoreline data was obtained through the digitization of shorelines from geometrically corrected images with the help of ArcGIS v10.4 software. The digitized shorelines are for the years 1991, 2001, 2011, 2018, and 2022 with a time interval of 31 years. The satellite data of these years is available with any spectral/radiometric error, hence these years were considered for present study.

Band 3-4 (Landsat-7) and band 4-5 (Landsat-8) were used as input for unsupervised classification. The coastal stretch of the shoreline was identified and digitized manually. The required field geodatasets of DATE_ and UNCERTAINTY_ were added to the attribute table of ArcGIS for each feature class. The DATE_ as mentioned in Table 1 was added as an input, dates of Landsat image acquisition, while UNCERTAINTY_ is incorporated in calculating the standard error, correlation coefficient and intervals given by users. Based on these uncertainties the five shoreline rate-of-change indices were evaluated using DSAS.

2.4 DSAS technique

DSAS is an open-source extension proposed by Environmental System Research Institute's (ESRI) ArcGIS software. ArcGIS version 10.4 was used for the present study. The statistical data analysis techniques include Linear Regression Rate (LRR), End Point Rate (EPR), and Net Shoreline Movement (NSM). LRR statistics were used to determine the slope of the regression line by allowing a least-squares regression line fitted to all shoreline points for transects [17].

EPR was calculated by dividing the total movement of the shoreline i.e., NSM by the time intervened between the two shorelines as shown below.

$$EPR = \frac{NSM}{Time\ between\ the\ oldest\ and\ recent\ shoreline} \quad (1)$$

NSM is the distance between the oldest and latest shorelines for each transect. It determines the total movement between the two shoreline positions Table 2.

Table 2. Classification of rate-of-change LRR, EPR, and NSM

Rate of change (m/year) LRR and EPR	Distance measurement (m) NSM	Status of Transect Rates
Min ≤ -3.0	Min ≤ - 473	Very High
-3.0 ≤ -1.0	- 473 ≤ -157	High
-1.0 ≤ 1.0	-157 ≤ -10	Low
1.0 ≤ 3.0	-10 ≤ 175	Stable Coast
3.0 ≤ 5.0	175 ≤ 525	High
5.0 ≤ Max	525 ≤ Max	Very High

(Source: DSAS v 5.0 User Manual Guide, USGS, 2018)

The statistical reports for each rate of change were classified as shown in Table 3. The SCDA was performed and the region of erosion and regions of accretion were identified and addressed. The shoreline change rate was demarcated using LRR, EPR and NSM methods along the coast of Mumbri creek.

Table 3. Transect casting processusing DSAS tool

Mumbri bridge		Description (in m)
1.	Max. search distance	100
2.	Transect Spacing	40
3.	No. of transect lines	LRR = 259 EPR=259 NSM=259
4.	Smoothing Distance	500

3 Results and Discussion

DSAS technique helped in measuring, quantifying, calculating and monitoring the shoreline changes from multiple sources and historic shoreline positions [18]. It controls the coastline characteristics such as historic coastline dynamics, shoreline change, development and evolution of deposited material along the shore, cliff retreat and erosion, shoreline measurement and modelling. A proper baseline was delineated to calculate the effect of rate-of-change statistics. The baseline was delineated along onshore and offshore zone in the proximity of ~ 80-100 meters distance away from the shoreline. DSAS constructs a series of perpendicular lines to the baseline called transects. The generation of transects is initiated with DSAS baseline settings, shoreline settings, and metadata information. With the proper inputs, one can successfully generate desirable transect and perform SCDA. The number of transect lines assigned for the present study site was 259 Table 2. Maximum search distance (MSD) was assigned as 100 meters to ascribe the distance of transect from the baseline. These transects were onshore and parallel to each other Table 3.

The software evaluated the variation in the shoreline and calculated a series of statistical the rate-of-changes as digitized multi-temporal shorelines (from 1991 to 2022). If the rate-of-change per year values obtained along transects are positive then the section must be undergone accretion. On the contrary, negative values indicate that the shoreline must be eroded/scoured. Thus, transects allow us to ascertain the shoreline rate of change per year. A series of statistical rate-of-change data analysis techniques can be derived within DSAS, based on the comparison between the multi-temporal shorelines.

3.1 Linear Regression Rate (LRR)

The statistical records of LRR determined the slope of the regression line which fitted to all the shoreline transect points. The minimum LRR values recorded were -3.59 to -1.22 m/year indicating the pocket regions of shoreline erosion. Maximum recorded LRR values were +0.02 to +2.86 m/year indicating shoreline accretion. However, the accretion rate was comparatively low. About 15.65% of the shoreline has undergone accretion. As per LRR, the total length of the shoreline which has undergone accretion was 78.64 m and the eroded was 59.28 m since 1991. The left bank of the mouth region of the creek and under the bridge area shows a high erosional value Figure 3. Effect of energy dissipation due to wave refraction caused accretion along the right bank of the mouth region of the creek.

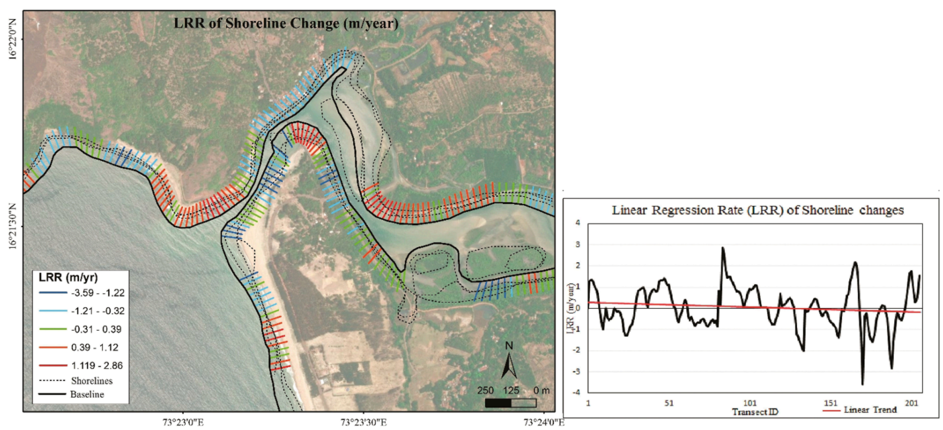

Fig 3. The baseline and transects evaluating LRR statistical parameter. The graph indicates LRR rate-of-change per transect The baseline and transects evaluating LRR statistical parameter. The graph indicates LRR rate-of-change per transect

3.2 End Point Rate (EPR)

The End Point Rate was calculated with the help of NSM. It determined the distance between the oldest and the latest shoreline concerning time. The EPR rate of change, in meters per year with the negative values of -0.01 to -6.96 m/year indicating erosion while positive values of +1.69 to +4.33 m/year indicated accretion. However, a high accretion rate was along the region where the bridge is constructed. About 106.56 m of accretion rate and 134.04 m of erosion rate was recorded by EPR statistics. The total number of transects for erosional statistics i.e. LRR=90 and EPR=119 and accretion statistics i.e. LRR=97 and EPR=128 were identified Figure 4. The erosion and accretion pockets regions were similar to that with LRR-mapped regions.

3.3 Net shoreline movement (NSM)

Net shoreline movement is the distance between the oldest and latest shorelines for each transect. The negative values (up to -78.86 m) indicated shoreline inundation while positive values (~ 69.65 m) indicated shoreline accretion. The net movement of the shoreline recorded 1965.75 m of shoreline accretion and 2082.15 m of erosion indicating equal rate-of-changes Figure 5. The classification of results depends on the distance of variation in meters hence negative distance indicated the recession of shoreline since 1991.

3.4 Statistical assessment of rate-of-changes

The SCDA was carried out from 1991 to 2022. The shoreline dynamism occurs due to various natural and man-made processes. The land-sea transect is mainly determined by waves, currents and beach sediments. The processes become more intense along

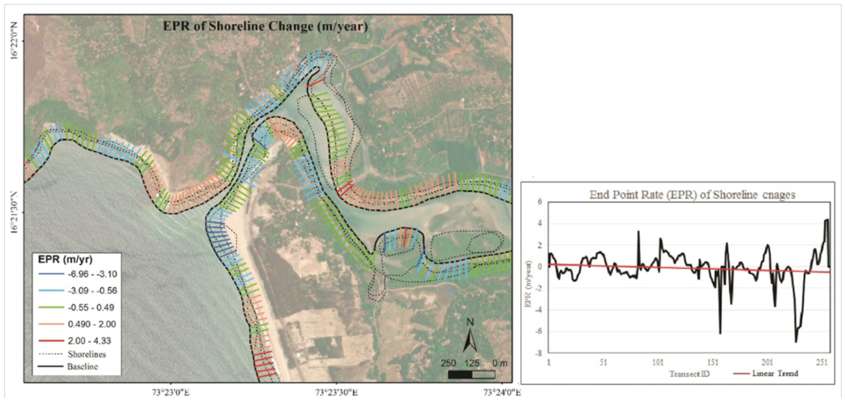

Fig 4. The baseline and transects evaluating EPR statistical parameter. The graph indicates EPR rate-of-change per transect

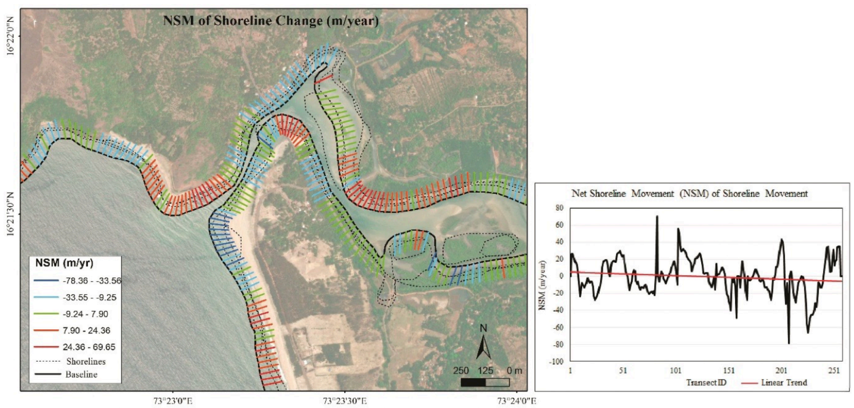

Fig 5. The baseline and transects evaluating NSM statistical parameter. The graph indicates NSM rate-of-change per transect

the creek region. Sediment transport processes are controlled by these processes and can contribute to erosion or accretion of the shoreline. The Mumbri creek is a tide-dominated region. The major sediment source in the study area is due to Mumbri tidal inlet. Tidal fluctuations cause severe sediment movement within the inlet. The ocean currents change the direction in northeast monsoon and southwest monsoon. During the southwest monsoon, sediments are drifted in the north direction in the study area. The construction of the bridge has increased the rate of deposition due to beach nourishment for bridge piers. The phenomena can be seen along the left bank of the creek[(18)]. Once the transect feature class was created and all updates, edits and modifications were done then the data was used to compute change statistics. Three of the calculations i.e., LRR, EPR and NSM were analyzed for the present study to compute the rate of change Table 4.

Table 4. Statistical parameters obtained from DSAS analysis in the study area (1991-2022)

Statistical parameters (All values in meter/year)	LRR	EPR	NSM
Total transects for Erosion statistics	90	119	116
Total transects for Accretion statistics	97	128	133
Total transects with no change in the rate	48	12	10
Maximum Erosion rate	-3.59	-6.96	-78.36
Minimum Erosion rate	-0.01	-0.01	-0.01
Average Erosion rate	-0.66	-1.03	-15.6553
Total length of eroded shoreline	59.28	134.04	2082.15
Maximum Accretion rate	2.86	4.33	69.65
Minimum Accretion rate	0.02	0.01	0.12
Average Accretion rate	0.81	0.92	16.95
Total length of accreted shoreline	78.64	106.56	1965.75

3.5 Historical shoreline changes

The historical evolution of Mumbri creek determined the temporal morphodynamics of shoreline position. The statistical rate-of-changes obtained from DSAS indicate an equal rate of erosion and deposition along the study area Table 5.

Table 5. Shoreline rate-of-change identified estimated from DSAS

	SCDA estimates	Value
1	Rate-of-change (m/year)	
	- LRR	Min -3.59 to-1.22 Max 1.12 to 2.86
	- EPR	Min -42.13 to 23.82 Max 1.69 to 11.21
2	Distance measurement (m/year)	
	- NSM	Min -78.86 to -33.56 Max 24.36 to 69.65
3	Erosion (%)	16.95
4	Deposition (%	15.65
5	Stable coast (%)	67.4

The process of accretion was prominent along most of the regions of the Sindhudurg coast from 1989 to 2009 including some areas under the threat of erosion. About 16.95% of the length of the shoreline of Mumbri creek is under the inundation process Figure 6. The change in the rate of erosion observed in Mumbri creek may be attributed to the modification of water currents due to the construction of the bridge and the corresponding formation of an eddy flow pattern in the creek. This has resulted in 15.65% of accretion along the shoreline. A transect value with zero value indicated neither erosion nor accretion (67.40%) along the shoreline. The net shoreline change rate from 1990-2000 was recorded within the range of +0.84 to -1.94 m/year along Mumbri creek [10]. The shoreline change rate recorded in the present study is 1.12 to -3.59 m/year. This long-term change detection was classified into six classes, viz., very high erosion ($\leq$ -3.0 m/y), high erosion (-3.0 $\leq$ -1.0 m/y), low erosion (-1.0 $\leq$ 1.0 m/y), Stable Coast (1.0 $\leq$ 3.0 m/y), high (3.0 $\leq$ 5.0 m/y), and very high accretion (> 5 m/y). The present study was a first attempt to assess erosion-accretion rates along Mumbri creek, one of the newest areas modified due to bridge construction using the DSAS analysis tool. Overall, DSAS analysis aided to locate the areas under threat of erosion along Mumbri creek.

Fig 6. Photo plates from Mumbri Creek,- a) accretion of construction debris, b) deposition of Ilmenite (titanium-iron oxide) mineral, c) location of a bridge and d) drone view of a bridge and creek mouth to east.

4 Conclusion

The application of the remote sensing and GIS technique is proven to be a productive method for continuous assessment and change detection of coastal dynamics and anthropogenic activities carried along the unexplored areas of the Konkan region along the west coast of India. The shoreline changes using statistical parameters like LRR, EPR and NSM was applied through the DSAS technique. The study concludes that the erosional (16.95%) and accretion (15.65%) rate-of-change remains equal on the entire coast of Mumbri Creek. The SCDA ascertains that the region is highly stable and have no change in shoreline position (67.40%). The net movement of shoreline records 20.82 km of shoreline is eroded. It is due to the effect of wave refraction along the mouth region of the creek and 19.66 km of shoreline is accreted from 1991 to 2022. The statistical parameters evaluated the period of 31 years from 1999 to 2022, the LRR value is −0.66 m/yr, the EPR value was - 1.03 m/yr, and the NSM value is −15.66 m. The net shoreline movement of eroded shoreline is 2082.15 m, while accelerated shoreline movement is 1965.75 m. Being a micro-tidal region, tidal energy is low resulting in accretion across the meandering channel. The study area has developed erosional and depositional pockets. One of the major pockets is the bridge constructed in recent years (2016). Development of channel bars from three (1991) to nine (2022) can be seen, out of which two channel bars are very recent according to local investigators. The study acclaims the application of DSAS in SCDA with the help of remote sensing and satellite imagery. The assessment is limited to a synoptic study of Mumbri creek that can be extended to the other remote areas of the Konkan region and the West Indian coast. More parameters such as NDVI, suspended sediment transport rates, wave pattern and bathymetric change detection can be added in further studies. The SCDA is one of the essential parameters of coastal impact assessment, therefore, more research is required to understand coastal dynamics and the impact of human interventions. Ultimately, based on obtained results, this study offers coastal management practices and mitigations to policymakers along coastal systems.

References

1) Yashar GJ. Detection of coastal dynamics depending on the Caspian Sea level change using remote sensing data: A case study in the Kura geomorphological sub-region (Azerbaijan). *Acta Geodynamica et Geomaterialia*. 2021;18(4):487–501. Available from: https://doi.org/10.13168/AGG.2021.0035.
2) Yan D, Yao X, Li J, Qi L, Luan Z. Shoreline Change Detection and Forecast along the Yancheng Coast Using a Digital Shoreline Analysis System. *Wetlands*. 2021;41(47). Available from: https://doi.org/10.1007/s13157-021-01444-3.
3) Warnadi, A'rachman FR, Hijrawadi SN. Spatiotemporal Shoreline Change Analysis in the Downstream Area of Cisadane Watershed Since 1972. In: and others, editor. IOP Conference Series: Earth and Environmental Science;vol. 412. IOP Publishing. 2020;p. 1–7. Available from: https://doi.org/10.1088/1755-1315/412/1/012007.
4) Waghmare SM, Hanamgond PT, Mitra D, Koti BK, Shinde PS. Application of Remote Sensing and GIS Techniques to Study Sediment Movement along Harwada Beach, Uttar Kannada, West Coast of India. *Journal of Coastal Research*. 2020;36(6):1121–1129. Available from: https://doi.org/10.2112/JCOASTRES-D-19-00170.1.
5) Barik G, Guru B, Sangma F. Shoreline Changes Analysis and Forecast Using Digital Shoreline Assessment System 5.0: Evidences from Parts of East Coast of India. *Journal of the Indian Society of Remote Sensing*. 2021;49:2815–2830. Available from: https://doi.org/10.1007/s12524-021-01424-4.
6) Goksel C, Senel G, Dogru AO. Determination of shoreline change along the Black Sea coast of Istanbul using remote sensing and GIS technology. *Desalination and Water Treatment*. 2020;177:242–247. Available from: https://doi.org/10.5004/dwt.2020.24975.
7) Dewi RS. Monitoring long-term shoreline changes along the coast of Semarang. In: and others, editor. IOP Conference Series: Earth and Environmental Science;vol. 284. IOP Publishing. 2019;p. 1–9. Available from: https://doi.org/10.1088/1755-1315/284/1/012035.
8) Pradhan UK, Mishra P, Mohanty PK, Panda US, Ramanamurthy MV. Modeling of tidal circulation and sediment transport near tropical estuary, east coast of India. *Regional Studies in Marine Science*. 2020;37:101351–101351. Available from: https://doi.org/10.1016/j.rsma.2020.101351.
9) Sapkale JB, Rathod BL. Perception based Study of Coastal Sand Dunes in the Areas of Ratnagiri Coasts, Maharashtra. *Indian Journal of Science and Technology*. 2016;9(7):1–7. Available from: https://doi.org/10.17485/ijst/2016/v9i7/85604.
10) Gunasekaran P, Kankara RS, Selvan SC. Mapping shoreline changes of the pocket beaches using Remote Sensing and GIS – A study in the north Konkan sector, west coast of India. *Journal of Earth System Science*. 2022;131(209). Available from: https://doi.org/10.1007/s12040-022-01945-7.
11) Thakare LM, Shitole TA. Vulnerability Assessment of the Ratnagiri Coast (Maharashtra, West Coast of India). *Journal of Coastal Research*. 2020;37(2):421–432. Available from: https://doi.org/10.2112/JCOASTRES-D-19-00190.1.
12) Thi VT, Xuan ATT, Nguyen HP, Dahdouh-Guebas F, Koedam N. Application of remote sensing and GIS for detection of long-term mangrove shoreline changes in Mui Ca Mau. *Biogeosciences*. 2014;11(14):3781–3795. Available from: https://doi.org/10.5194/bg-11-3781-2014.
13) Nassar K, Mahmod WE, Fath H, Masria A, Nadaoka K, Negm A. Shoreline change detection using DSAS technique: Case of North Sinai coast, Egypt. *Marine Georesources & Geotechnology*. 2019;37(1):81–95. Available from: https://doi.org/10.1080/1064119X.2018.1448912.
14) Quang DN, Ngan VH, Tam HS, Viet NT, Tinh NX, Tanaka H. Long-Term Shoreline Evolution Using DSAS Technique: A Case Study of Quang Nam Province, Vietnam. *Journal of Marine Science and Engineering*. 2021;9(10):1124–1124. Available from: https://doi.org/10.3390/jmse9101124.
15) Subrahmanyam V, Krishna KS, Murthy GPS, Rao DG, Ramana MV, Rao MG. Structural interpretation of the Konkan basin, southwestern continental margin of India, based on magnetic and bathymetric data. *Geo-Marine Letters*. 1994;14:10–18. Available from: https://doi.org/10.1007/BF01204466.
16) Rajamanickara GV, Vethamony P, Gujar AR. Effect of waves in the redistribution of sediments along the Konkan coast. In: and others, editor. Proceedings of Indian Academic Science (Earth Planetary Science);vol. 95 of 2. 1986;p. 237–244. Available from: http://drs.nio.org/drs/handle/2264/6190.
17) Amrutha TK, Reeba T. Shoreline-change detection at Kodungallur – Chettuva region in Kerala state. In: and others, editor. IOP Conference Series: Materials Science and Engineering;vol. 1114. IOP Publishing. 2021;p. 1–8. Available from: https://doi.org/10.1088/1757-899X/1114/1/012026.
18) Dey M, S SP, Jena BK. A Shoreline Change Detection (2012-2021) and forecasting Using Digital Shoreline Analysis System (DSAS) Tool: A Case Study of Dahej Coast, Gulf of Khambhat, Gujarat, India. *Indonesian Journal of Geography*. 2021;53(2):295–309. Available from: https://doi.org/10.22146/ijg.56297.