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SHORELINE CHANGE ESTIMATION: A CASE STUDY OF THE COASTAL TRACT FROM DIGHA MOHONA TO TALSARI, INDIA

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ABSTRACT

The present part of research work is about the change detection in shorelines along the coastal part of Balasore and Medinipur districts of Odisha and West Bengal respectively. The shoreline change analysis for the particular paper from year 1973 to 2025. Shoreline detected by NDWI and MNDWI indices. Then with the help of Digital Shoreline Analysis (DSAS) the statistics of erosion and accretion computed for the selected area. The shoreline length has been changed. Though the change is not drastic.The mean erosion rate is 0.69 mt for the entire selected coastal tract where as the accretion rate is 1.49 mt during these 52 years on average. The Erosion is more dominant over Old Digha though accretion is more prominent in Udaypur area. Accretion is also quite dominant in Mohona area. Apart from these the other statistics like NSM, WLR and EPR are also shown to comprehend the nature of erosion and accretion in the coastal tract. The research work illustrates the shoreline change in the area covering most popular tourist destination of the Bengal and Odisha coast. So, it is an enriched database for further tourism development as well as for the coastal management along this coastal tract.

INTRODUCTION

The eastern coast has several rare as well as distinctive features of its (De.P.K 2015) own. Shoreline or the merging of land and water along the coast is very significant in spatial studies. They are important because they have immense impact on many associated aspects of the area. Though it is not about only the impact, it is far beyond of that. Naturally coastal areas are dynamic and fragile to any kind of change over the time. Erosion and accretion are the most important part of the shoreline change (Jana.A.et.al,2016). So, change may be receding land -water border or projected land-water border. Their change accounted based on some base year. So periodic changes coastal land (Mishra.M.et.al,2025) is very important for the analysis and monitoring the nature of the shoreline change. The shoreline is one of the best indicator of erosion/accretion pattern and environmental change(Kar.P.K.et.al,2021).In this purview the change in shoreline along the Digha coastal tract has been portrait in this research paper.

STUDY AREA

The study area is covering a stretch of coastal tract from Digha Mohona, West Bengal to Talsari, Odisha in east coast of India. The reason behind the selection of the area is the location of major tourist destination along the tract. They area Digha Mohona, Old Digha, New Digha, Udaypur and Talsari in the same belt of shoreline along Bay of Bengal. Udaypur and Talsari is in Balasore district and rest are in Purba Medinipur District. (Fig:1)

DATABASE

It is based on satellite images and Topographical sheet. The satellite images collected from the USGS portal from 1973 to 2025period. The details of the data given in the table

Table:1 Satellite data list for shoreline analysis

Sl no.	Satellite/sensor	Data of Acquisition	Spatial resolution	Data source
1	Landsat4 MSS	22/02/1973	79m	USGS
2	Landsat4/MSS	17/11/1980	30m	USGS
3	Landsat5/TM	23/12/1990	30m	USGS
4	Landsat7/ETM	10/12/2000	30m	USGS
5	Landsat7/ETM	04/11/2010	30m	USGS
6	Landsat8/OLI_TIRS	25/12/2020	30m	USGS
7	Landsat8/OLI_TIRS	15/12/2025	30m	USGS

Source: https://earthexplorer.usgs.gov

METHODOLOGY

The shoreline change analysis has been done with the help of an open-source software extension named DSAS in ARCGIS software. Digital Shoreline Analysis System provides an automated method for establishing measurement locations, performs rate calculations, provides the statistical data necessary to assess the reliability of the rates includes a beta model for forecasting shoreline position (www.usgs.gov).The DSAS or Digital Shoreline Analysis System requires some preprocessing to execute the computation of change rate. DSAS measures the distance between the baseline and each shoreline intersection along a transect, and combines date information, and positional uncertainty for each shoreline, to generate the following change metrics. (www.usgs.gov)

PROCESSING THE IMAGES

The images collected from USGS website. All the bands are studied well before analysis. The images assigned to UTM 45 zone PCS with WGS 84 datum.

DETECTION OF SHORELINE BY NDWI AND MNDWI

The demarcation of shoreline was done by using the NDWI (Normalized Difference Water Index) and MNDWI (Modified Normalized Difference Water Index) from the images. The use of these Indexes is to facilitate the identification process of exaction of shoreline. The actual shoreline determined by many parameters(Roy.S et.al,2018). It defines the configuration of the shoreline. The NDWI and MNDWI helps to define the exact line between water and land along the coast. So, to prepare the images for the extraction of shoreline the application of the formula of the Index is very important. NDWI and MNDWI calculated as follows –

NDWI = (Green band- NIR band)/ (Green Band + NIR band)

Where Green Band is the 0.52-0.59µm and SWIR IS 0.7-0.8µm

MNDWI = (Green band- Shortwave InfraRed)/ (Green Band + Shortwave InfraRed)

Where Green Band is the 0.52-0.59µm and SWIR IS 1.55-1.75µm

The application of NDWI and MNDWI land will be with negative values where as the water will have the positive values in the result. Then the shoreline has been digitized based on these values which provides a clear demarcation between the water-land line. The same method has been followed to detect shoreline from all the images in the study area. Hence the shoreline digitized for 1973,1980,1990,2000,2010,2020 and 2025 for the study area from the acquired images (Fig:2).

COMPUTATION OF UNCERTAINTY

The uncertainty is the reliability factor of each shoreline. It is calculated based on many parameters (Mishra.M, et.al,2025). (Table:2)

The total shoreline position error (Esp) = $\sqrt{(Es^2+Etd^2+Eo^2+Er^2+Ed^2+Ep^2)}$

* Uncertainty (Ur) = $\sqrt{(Ur1^2+Ur2^2+\ldots Urn^2)}$/ Year (1973-2025), where Ur1 represents uncertainty of each year

Table: 2 Uncertainty Calculation for present shoreline change (1973-2025)

Error(E)	1973	1980	1990	2000	2010	2020	2025	Remarks

Positional error(m)	0	0	0	0	0	0	0	
seasonal error (Es)	NA	NA	NA	NA	NA	NA	N. A	*Mean tide data acquired from PSMSL
tidal fluctuation (Etd)	6.9	6.9	6.9	7	7.1	7.1	7.1	
Shoreline proxy offset (Eo)	NA	NA	NA	NA	NA	NA	N.A	
measurement errors(m)	0	0	0	0	0	0	0	*All images are from winter season
Georeferencing /Rectification error (Er)	0	0	0	0	0	0	0	
Digitizing error (Ed)	39.5	15	15	15	15	15	15	*Images are rectified
Toposheet survey offset (Et)	NA	NA	NA	NA	NA	NA	NA	
Pixel error (Ep)	0	0	0	0	0	0	0	
Total shoreline position error (Esp)	46.4	21.9	21.9	22	22.1	22.1	22.1	
Period	1973-1980	1980-1990	1990-2000	2000-2010	2010-2020	2020-2025	1973-2025	
Uncertainty(Ur)	1.180	0.661	0.662	0.664	0.664	0.664	0.256	

BASELINE CREATION AND TRANSECT LINE CASTING

In DSAS baseline is used to calculate the rate-of-change for time series of shorelines. Transects intersect each shoreline to create a measurement point, and these measurement points are used to calculate shoreline change rates(usgs.gov). The baseline is drawn(Hossain.et.al,2022) at 200-meter distance from the latest shoreline (2025) towards the sea. The transects are drawn from the baseline of 1000 meter length to cover all the shorelines at 100-meter spacing from east (Mohona) to west (Talsari).

DSAS (DIGITAL SHORELINE ANALYSIS SYSTEM)

After all the required data input, the DSAS computed the following statistics about the shoreline change rate in the selected coastal tract of Balasore and Midnapore districts. The following statistics auto generated by the method of WLR with 95.5% confidence level for the period of 1973 to 2025 (52 years) in the selected shoreline area. Shoreline Change Envelope (SCE)Net Shoreline Movement (NSM)End Point Rate (EPR)Linear Regression Rate (LRR)Weighted Linear Regression Rate (WLR)

RESULTS AND DISCUSSION

The results are quite evident about active erosion and accretion along the selected coastal tract. It is divided into different zones based on the popular tourist destination spot along this coastal

Table:3 Computed Statistics

Descriptive statistics	Zone-I Mohona	Zone-II Old Digha	Zone-III New Digha	Zone-IV Udaipur	Zone-V Talari	Total Mohona -Talsari
Transect ID Range	1 to 30	31-52	53-76	77-94	95-118	1-118
Total number of transects	30	22	24	18	24	118
Transects showing erosion	19	15	12	1	14	61
Transects showing accretion	8	7	12	17	10	54
Stable transects	0	0	0	0	0	0
Erosional exhibited in transects %	63.33	68.18	50	5.55	58.33	51.69
Accretional exhibited in transects %	26.66	31.81	50	94.44	41.66	45.76
Stable transects in %	0	0	0	0	0	0
Mean shoreline change(m)	0.80	-0.32	-0.05	4.19	0.2	0.81
Max shoreline change(m)	23.18	0.5	2.37	7.77	8.24	23.18
Min shoreline change(m)	-3.17	-1.05	-2.18	-0.7	-5.97	-5.97
Mean Erosion Rate (m)	-1.00	-0.41	-0.54	-0.03	-1.24	-0.69

Standard Deviation of Erosion Rate(m)	1.06	0.38	0.68	0.16	1.78	1.09
Mean accretion Rate(m)	1.72	0.08	0.48	4.23	1.44	1.49
Standard Deviation of accretion Rate(m)	5.10	0.15	0.72	2.31	2.38	3.19

Source: DSAS

tract. The rate of erosion is slightly higher in Old Digha area than Mohona, though both the area is showing significant erosion than any other area. According the Paul.A.k (2002) shoreline water table alteration, development intervention, other human induced land use changes, sediment characters and the high-water level situations on the sea ward side are the factors of erosion along shoreline. The accretion rate is extremely higher around Udaypur in Odisha rather than any other part. Still the Mohona is under a significant level of deposition rate during these 52 years of period. The diverging wave orthogonal are contributing energy conditions favorable for the deposition of sediments along the shoreline (Paul.A.K,2002). The mean shore line change rate(m) is more than 4 meters annually in Udaypur and negligible change occurred in New Digha area. New Digha area seems to be more stable area rather than any other part as it has least erosion and accretion in last 52 years period (Fig:4).

Net Shoreline Movement (NSM): The NSM measures the separation between the oldest and youngest shoreline. It is higher in Udaypur and Talsari area (Fig:5). It is also higher in Mohona area and least in Old Digha area. So, the Old Digha seems to be more stable with the shoreline location during the period under investigation. Weighted Linear Regression Rate (WLR): It is a weighted method of used to measure the rate of change in shorelines in DSAS. The graph is showing (Fog:6) drastic change at Mohona area. The gradual change rate notices in New Digh and Old Digha area. The shoreline around Udaypur and Talsari is also changed a lot from 1973 to 2025. The rate of change is higher in both the coastal part.

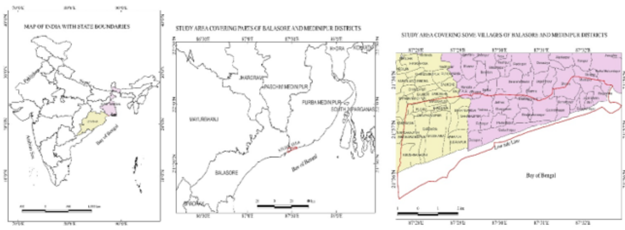
End Point Rate (EPR): It is a statistical technique that is used to compute by dividing the NSM by the year (D. Ambika Et al 2024). It measures rate end point rate. It is again higher in Mohona and Udaypur area (Fig:7). It is least in Old Digha but little bit higher in New Digha than the former. Talsari also have the higher values but not like Udaypur and Mohona area.

CONCLUSION

The shoreline is changing rapidly in the selected section. The mean rate of change is more than 0.81 meters every year. The erosion percentage in the entire selected coastal tract is above 51% (mean:0.69m) but the standard deviation is 1.09 which means the variation in erosion quite surprising even all are within 11-12 km of length. The accretion percentage is more than 45% (mean:1.49m), but the standard deviation is 3.19. It can be inferred that the of accretion rate is absolutely locational, not widely occurring along the coastline under investigation. The NSM values is maximum at Udaypur during the period of consideration(52yr) and the short-term rate (EPR) is maximum at Mohona. Similarly, the consistent higher erosion region is Udaypur-Talsari littoral part. To conclude about the nature of the shoreline change along this particular tract, where some of the most popular beaches have been included, it can be apprehended that it is very dynamic region. Shoreline is changing every year by erosion and deposition partially. Some parts have changed so much that it has encroached the beach. The same number of evidences is also there where the beach extended towards the land. Now the construction of a protection wall along the shoreline is still under construction till the end point of Talsari as noticed during the visit to the study area. The concrete wall has some positive impact on the shoreline stability but at the same time the natural geomorphic process has been intervened by the same. Though the impact of the wall is not considered in the study. A further research work can be carried out on the same factor as an impact to the shoreline change detection of the present area under investigation

CONFLICT OF INTEREST

There are no known conflicts of interest related with this publication



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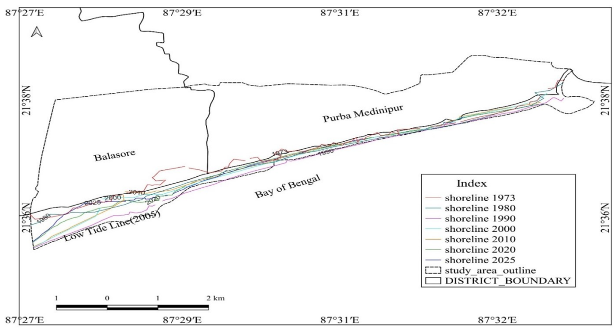

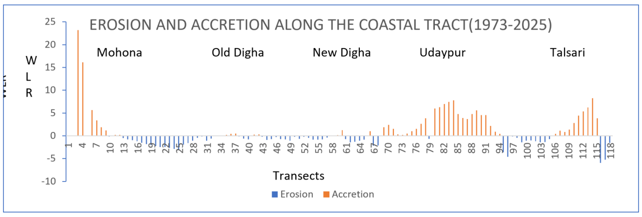

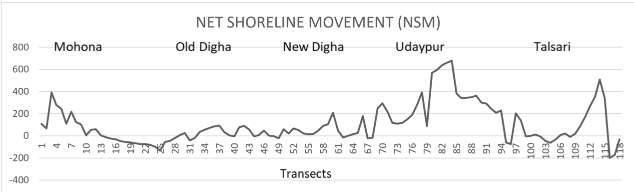

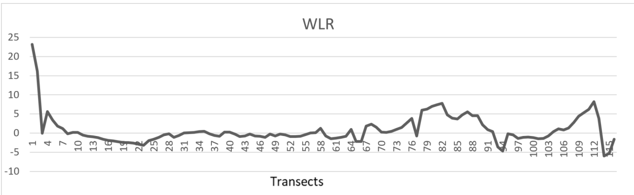

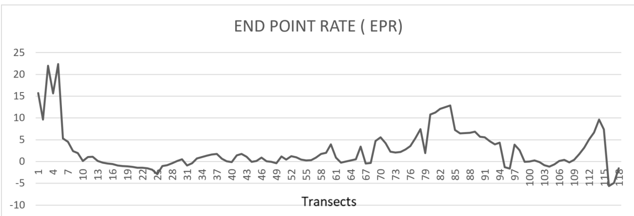

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