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ANALYSIS OF SHORELINE CHANGE IN COASTAL GOA: A STUDY OF GALGIBAG BEACH USING GEOSPATIAL TECHNOLOGIES

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ABSTRACT

Costas are dynamic entities interconnected with man-made and physical factors. The changes along the coastline are well adequate subjected to both short-term and long-run coastal processes. The latest available geospatial technologies have been efficient in providing the data sets from a historical time scale. The present study is focused on comparing the shoreline changes that occur at the Galgibag beach located in Canacona taluka of Goa by integrating fourcoastlines to identify and assess erosion and accretion of the different periods. DSAS analysis of the Galgibag coast is carried out from 1991 to 2020. Net Shoreline Movement (NSM), End Point Rate (EPR), and Linear Regression Rate (LRR) were used to calculate shoreline change rates. The analysis revealed shoreline retreat with an average EPR of 1.81m/year and an average NSM of 26.45mts.

Keywords: DSAS, EPR, Landsat, LRR, NSM

INTRODUCTION

Coasts are dynamic in nature and vital components of the Earth's overall system. The relationship of man and nature is more interactive in the coastal area, and its impacts are primarily visible on the coastline (Tirkey *et al*., 2005), (Dewidar, 2011). It is a continuous mechanism with ongoing both offshore and onshore processes due to changing environmental circumstances (Prasad & Kumar, 2014). These coastal belts are heavily influenced by numerous processes and remain a hotspot, as these regions are regularly inundated as a result of weather and climate effects, as well as natural disasters such as tsunamis, coastline erosion, and destruction from cyclones (Gray, 2007). Similarly, various development projects are undertaken in coastline areas, putting considerable strain on the environment and resulting in a variety of coastal dangers such as soil erosion, seawater intrusion, coral bleaching, and so on(Prasad & Kumar, 2014),(Prasad & Kumar, 2014).

The IPCC in its AR4 noted that the main emphasis on coastal areas and their threats will be on the sea-level rise without stressing much on other factors of global climate change. The effects of global warming on coastal erosion are evident irrespective of its location be it in lower to higher latitude along with melting of permafrost meltsand bleaching and death of corals. (Dewidar, 2011), (Webster *et al*., 2005).The coastlines, globally, experiencing tremendous changes impacting coastal natural habitats. Hence, monitoring of the coastal area is of paramount importance assess the coastal processes and their dynamics (Mujabar & Chandrasekar, 2013).

Monitoring of the coastal area is the need of the hour to protect the land which is mostly destroyed by flooding and coastal erosion. The absence of a comprehensive database at the grassroots level may hamper the development of the coast as well as strategy inputs required to avoid destruction along the coast, both physical and man-made (Winarso & Budhiman, 2001). The recent development in Remote Sensing technology along with GIS application has been an effective tool with the synoptic view, repetitive coverage and multispectral coverages of the earth surface (Tamassoki *et al*., 2014), (Choudhary *et al*., 2013). Both Long term and short-term analysis approaches are obtained in RS and GIS environments to have a better idea. To investigate coastal dynamics, analysis like weighting the coastal parameters, DSAS coastal change and prediction, EPR points are calculated with spatial modeling (Din Hashmi & Ahmad, 2018).

The state of Goa is situated on the West coast of India with 105-kilometre-long coastline dotted with beaches and blessed by cultural heritage sites is a global tourist destination. The recurrent occurrences of meteorological and climatological disturbances in the Arabian Sea in the recent past and the devastating effects of the Asian Tsunami of 2004 in India have underlined the significance of evaluating coastal vulnerability to sea-level rise as a result of climate change (SLR) (Arun Kumar & Kunte, 2012).

Many local studies on Galgibag have assessed the impact of storm surge on the coast. The recent cyclone Tauktae (mid-May 2021) and cyclone Vayu (August 2021) have left a long-lasting impact on the coast of Galgibag along with a change in geomorphology of the coast (Herald, 2021; Time of India, 2021; Times of India, 2021). The work carried out by Nadaf (2019) indicate the formation of spit and bar along the Galgibag river which have further grown and expanded into solid projections, as indicated by satellite images and field observations. Further, it is predicted that the river mouth is narrowing, and if the current rate of deposition continues, the river mouths will be fully choked, with significant ramifications for this portion of the world. (Nadaf, 2019). Hence, in the light of the above discussion, this study is focused on comparing the shoreline changes that occur at the Galgibag beach located in Canacona taluka of Goa by integrating four coastlines to identify and assess erosion and accretion of the different periods.

Study Area

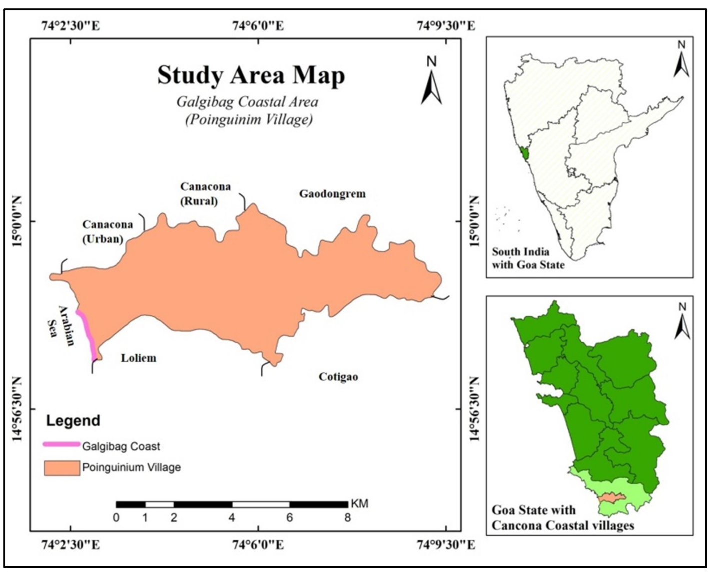

Figure 1: Study Area Map demarcating Galgibag Coast, Canacona, Goa

The study area coastline lies between $74^0 2'30''$ E - $74^0 9'30''$E latitudes to $14^0 56'30''$ - 15^0 longitudes **(Figure 1)**. It includes a portion of Poinguinium village of Canacona Taluka, Goa.Canacona taluka's second biggest river, the Galgibaga, originates in the Western Ghats and flows westward, curving south to join the smaller river for the short gush to the sea. The length of the study area is about 1800 meters. Canacona is home to one of the oldest rocks on the planet (Trondhjemite gneiss), which is 3400 million years old. The quaternary deposits include beach sands and alluvium. The narrow coastal plains are dissected by hills at many places. Several geomorphological characteristics related to marine erosional and depositional processes may be seen along Canacona's shoreline. Long-shore and tidal currents, as well as powerful winds blowing in from the Arabian Sea, have shaped the shoreline (Nadaf, 2019).

MATERIALS AND METHODS UTILIZATION

For the analysis and field observations, Landsat Satellite images (False Colour Composite [543] and True Color Composite [321]), and a topographical map are used. Series of satellite image data were acquired at the inequitable interval between 1991 and 2020, i.e. covering a span of 29 years. These series include four shorelines of years namely; 1991, 2000, 2013 and 2020. The images have been acquired in both summers (February, March, April) and winters (November, December, January) in good quality, with zero effective clouds or sensor defects such as striping. The study area is encountered in TM, ETM and operational land imager/thermal infrared sensor (Path/Row 146/50), with a spatial resolution of 30and 15 meters respectively.

In this study, two methods are used to estimate the rate of changing coastline. The first method; corresponds to the establishment of on-screen digitisation of shoreline (Kankara *et al*., 2015). For a reference, two calculations have been adopted i.e., NDWI and NDVI, to understand the land-water boundary along with the maximum and minimum vegetation indices. For the second method, the Digital Shoreline Analysis System (DSAS) software is used to estimate the rate of shoreline change based on End Point Rate, Linear Regression Rate and Net Shoreline Movement (Dwarakish *et al*., 2009), (Joesidawati & Suntoyo, 2016).In the present research paper, Digital Shoreline Analysis System (DSAS) version 4.3 programs developed by Thileler *et al* (Thieler *et al*., 2009)was used to calculate the rate of shoreline changes for the period of 1991-2020. To examine the Spatio-temporal changes in the coastline, an imaginary baseline was drawn north-south parallel to the present-day coastline at a backward position (user defined). For each coastal length from 1991 to 2020, the computed distance between the set baseline point and the shoreline positions supplied by the programme provides a reliable record of changes in shoreline positions. This time interval (twenty-nine years) was determined to be appropriate for representing the degree of shoreline changes in the study area. Based on the requirement for DSAS processing, 300 transects were generated; perpendicular to the baseline at a 150m spacing alongshore (user defined baseline). The EPR and LRR have been mapped in the analysis. The End Point Rate (EPR) was calculated by dividing the distances of shoreline movement by the time elapsed between the earliest and latest measurements at each transects. The EPR index is further categorized for erosion and accretion that varies from negative and positive numbers in the result. The rate of change in the shoreline was further divided into five categories i.e., Very High erosion, High erosion, moderate accretion, high accretion and very high accretion. The EPR's main advantage is its simplicity of computation and low requirement for shoreline data (two shorelines). NSM calculation was also obtained to understand the change in total area along the coast for the span of twenty – nine years. To determine the shoreline change rates, a linear regression method was founded on a presumed linear trend of change between the oldest and latest shoreline dates, which was plotted with the highest to the lowest rate of coastal erosion (Thieler *et al*., 2009). At the end, long term morphological change has been validated with the demarcation of HTL marking using Garmin GPS etrex10, with reference to high tide data on 19th June 2021 at 10:45 a.m., with a reading of almost on track 121 points. On-field pictures have been also clicked to validate the Galgibagh ground reality scenario due to coastal phenomena.

RESULT AND DISCUSSION

Net Shoreline Movement (NSM)

The change in the total land area along the coastal shorelines can be described in terms of shoreline movement(Ali & Narayana, 2015). The net shoreline movement is measured in terms of distance rather than rate. For NSM calculation, only two shorelines are taken into consideration. For each transect, it reports the distance between the oldest and newest shorelines. The entire distance between the oldest and most recent shorelines is represented by the number. For Galgibag, the Net Shoreline Movement (NSM) varies from 52.63mts at its maximum and 0.27mts minimum between 1991 and 2020 respectively **(Figure 2)**.

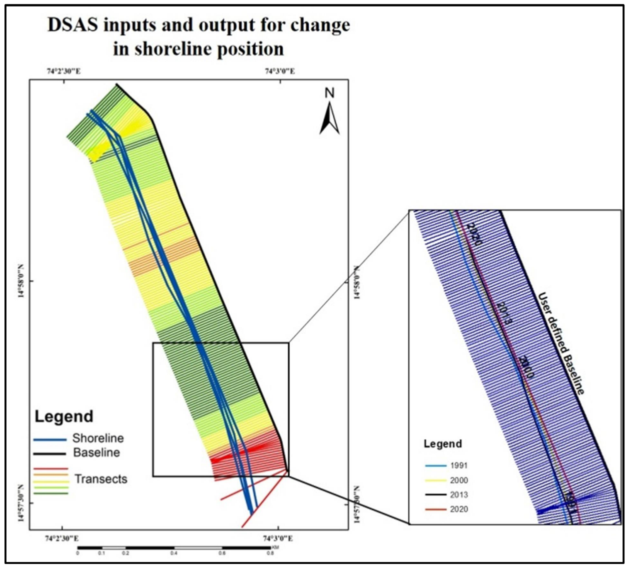

Figure 2: The rate of change in shoreline positions is calculated using input features and DSAS output

End Point Rate and Linear Regression Rate

The EPR is calculated by dividing the distance between the oldest and most recent shorelines by the time elapsed between them(Thieler *et al*., 2009). The EPR's main advantages are its simplicity of computation and the fact that it just requires two shoreline dates. The main disadvantage is that in circumstances where more data is available, the extra data is ignored. Changes in the signs (for example, erosion to accretion) or magnitude, as well as cyclical tendencies, may be overlooked.

The average shoreline retreat for Galgibag Coast i.e.EPR is 1.81 metres per year, calculated by dividing the distance between the shorelines in 2020 and 1991 (52.63 metres) by the time between the two shoreline positions (29 years).

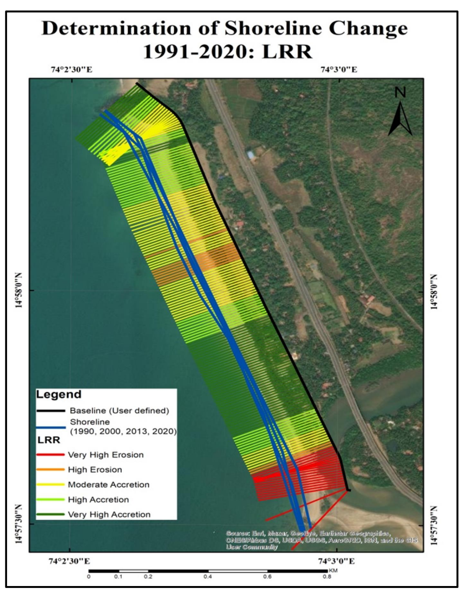

Figure 3: Shoreline Retreat model with reference to LRR

In this calculation, all other shoreline data is ignored. The regression comprises of 300 transects that are represented in **Figure 2**. The LRR analysis revealed that the Galgibag was retreating -0.84 m/yr. An assessment of the region's minimum and greatest LRR values reveals very significant erosion (-1.97 m/yr.) and poor accretion (-0.26 m/year) with respect to different locations along the coast of Galgibag. The distribution of erosion is irregular in the Galgibag area as observed in **Figure 4**, showing the trend of the same. The distribution of the erosion is much higher in between transect ID 34 and 53, with almost distribution of 19 transects out of 300, which is represented with dark red colour in **Figure 3**.

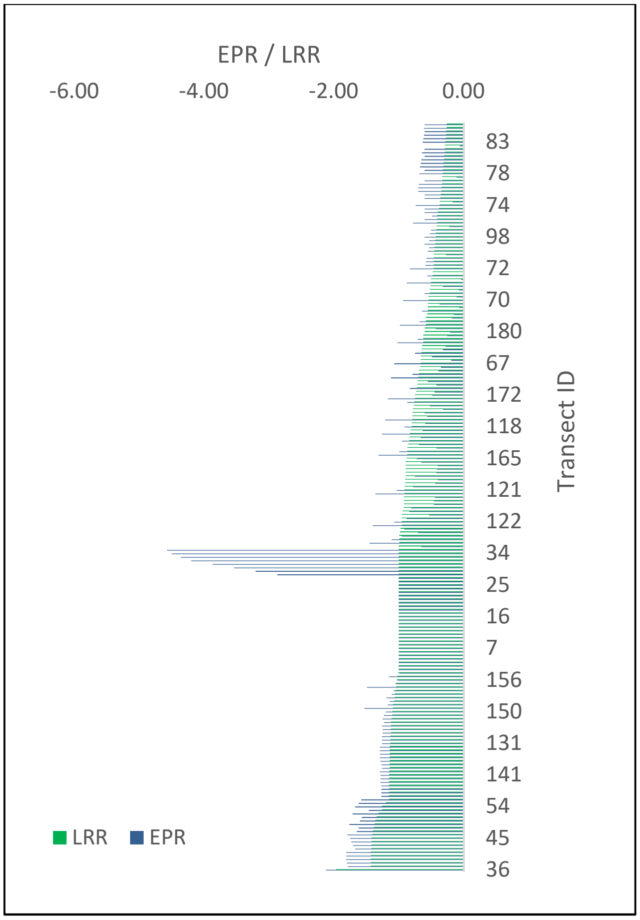

Figure 4: EPR and LRR trend

Out of 300 transects, 87 transects were nullified due to the unavailability of shoreline data with respect to 1991 and 2000. Many places have recorded stable accretion. Only 93 of the 300 transects show stable accretion, indicating that the coastal accretion process is active only in certain areas **(Figure 3 and Figure 4)**. Similarly, high and very High accretion can be observed with 91 transects. The EPR for the other locations indicates that the shoreline is gradually receding, resulting in a decrease in the net coastal land area. Even though it is a lengthy process, permanent land loss poses a substantial danger to valuable land, property, and natural coastal resources, including crucial habitats (Rajawat *et al*., 2015).

Long term morphological change

The Galgibaga river has altered course on the sea face, separating from its smaller twin, the Mashem river, in a dramatic natural or Cyclone Tauktae-induced event. It currently empties into the Arabian Sea directly(Time of India, 2021). Galgibaga's detour to the left, near the sea, was forced by the creation of a spit - a tongue of sand - that has blocked its entrance since ancient times. During the tumultuous Cyclone Tauktae in May 2021, this natural barricade was partially shattered the destructions along the coast can be notified in **Figure 5**.

If the change continues to be the same, there will be disastrous effect on the coast.So, question arises that, will there be any space left for the general people and tourists in the future? Will it eventually promote tourism or put it at risk on the other scale? The high tide line almost has an eventual impact on the beach area, and the evidences states, the falling of trees along the shore at a large number.

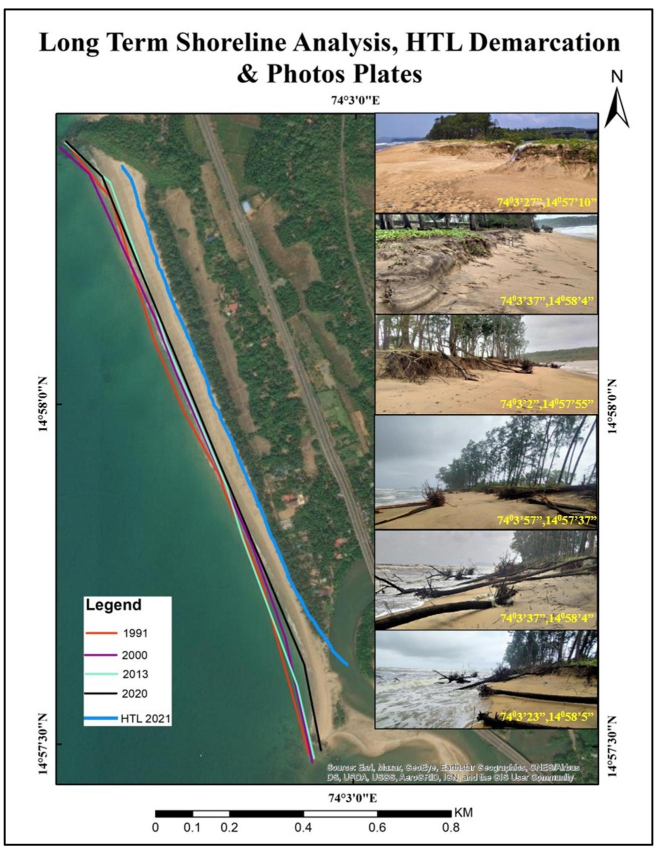

Figure 5: Long term Shore Analysis, HTL Demarcation and Photo Plates of Galgibagh Coast

CONCLUSION

Coastal erosion is a worldwide issue that affects practically every country with a coastline. The sea-level rise either by a physical or man-made entity will likely modify the coast. Even though the change rate is comparatively less but in long run,it will affect the villages located on the shoreline. The DSAS is well- adequate to use to assess changes in the shoreline on a smaller scale to see location-specific damages. The shoreline change has been subjected to 1.81m/year, focussing on the lower portion of the coast. the verified reports also proved the effect of storm surge has been a great influencing in declining the spit to almost 685meters from decades.

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