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Case Study on Impacts of Groyne Structures on Puducherry Coastline

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Abstract - *Coastal areas, the place where the water of the sea meets the land are unique places. Coastal Zones are dynamic interface between land and water and are common locations of high-density development, therefore monitoring of these regions are of immense importance both in terms development and protection of coastal settlement and ecology. Protection may be provided by constructing coastal protection structures such as Sea wall, Groynes, Jetties and so on. This study examines the Shoreline changes that have occurred after the construction of groynes structures along the Puducherry Coastline (Kalapet to Bommiarpalayam) for a period of 3 months (January to April), A handheld GPS device has been used in this study to map the Shoreline changes and this data were then exported to a GIS software (ArcGIS) and were analyzed using DSAS Version 5.0 (Digital Shoreline Analysis System) developed by USGS (U.S. Geological Survey) to determine various factors such as Net Shoreline Movement (NSM), Shoreline Change Envelope (SCE), End Point Rate (EPR) and Linear Regression Rate (LRR) and Weighted Linear Regression (WLR) and evaluate the effects that the Groynes have had on the Shoreline. The use of GPS provides better accuracy compared to conventional surveying methods. Furthermore, Soil samples have also been collected on the lee side of the groyne to determine their sediment characteristics and fall velocity*.

***Key Words*: Coastal Erosion, GIS, Sediment Transport, Groyne, DSAS.**

1. INTRODUCTION

This study focuses on the effects of Groyne field on the Puducherry Coastline. Coastal areas play a major role for the human beings from ancient time for trading, livelihood etc. Due to this phenomenon, rapid urbanization developed on the coastal area and developmental activities were conceded in order to fulfill the requirements of the settlements which have created a negative impact on the coast and its upland. These negative impacts include changes in shoreline such as erosion, seawater intrusion, shoreline modification etc. Coastal zone is increasingly under pressure from human activities such as fishing, sand mining, sewage disposal, urban expansion and tourism. Sand mining and harvesting of Mangroves have a major negative impact on beach stability, it gives the results of beach erosion and drastic shoreline change. To protect the receding shoreline coastal protection structures are introduced such as Groynes, Seawall, Breakwater and Jetties.

1.1 Coastal Area

Coastline is the point of contact between land and water. Due to the rapid urbanization, they are constantly under pressure which leads to coastal erosion, sea water intrusion and shoreline modification. The coastline from Bommayapalayam to Kalapet has been victim to major coastal erosion which has negatively impacted the coastal ecology and coastal settlements. To protect the coastline from further erosion and to regain the lost coastline groyne field were laid along this stretch to trap sediment from travelling in the longshore direction.

1.2 Coastal process and factors affecting it

Coastal erosion not only affects the coastline but also the Coastal settlements and Coastal ecology. If it is not monitored and maintained properly, they will have a devastating impact and have a monetary cost to rehabilitate the coastline. The factors affecting coastal process include activities such as Fishing, Sand mining, Sewage disposal, urban expansion and tourism. This affects the natural process of the coast and cause coastal erosion. Seawater intrusion and shoreline modification. Coastal erosion not only affects the coastline but also the Coastal settlements and Coastal ecology. If it is not monitored and maintained properly, they will have a devastating impact and have a monetary cost to rehabilitate the coastline.

1.3 Preventive Measures

To prevent Coastal erosion, Coastal protection structures have been introduced. These include structures such as Groyne, Seawall, Jetties and Breakwater. Each has different use case depending upon the location and requirement. Our study focuses on Groyne structures and their effectiveness in Puducherry coastline.

2. LITERATURE REVIEW

- The Shoreline change and Impact of coastal protection structures have been determined using Satellite images.
- DSAS (Digital Shoreline Analysis Software) has been used to determine both the short term and long-term changes.
- DSAS (Digital Shoreline Analysis Software) has been used end point rate quantified
- The study states that the combination of Satellite data along with statistical method prove to be reliable.
- Erosion measured was more than predicted due to natural and man-made causes.
- Factors such as Beach changes, Sediment transport and Storm impact are analyzed.
- GPS techniques are faster and provide better accuracy than conventional survey methods.
- GPS techniques prove to be suitable for monitoring the real -time shoreline change accurately.
- Construction of Pier without considering its impacts leads to the erosion of the coastline.
- Monitoring of coastline after implementation of the coastal project has to be performed.
- The management strategy stated will help the engineers to manage the coastal zone during and after the completion of coastal related projects.
- The hydrodynamic processes and morphological stability near the groin are studied using field observations and bathymetric data.
- The numerical model results were validated and found to be in good agreement with the field data.
- The outcome of this research demonstrates that studies similar to ours should be carried out in different parts along the vast Indian coastline to understand the shoreline-evolution.

3. METHODOLOGY

In this project we have used data collected from GPS, open-source data and INCOIS data.

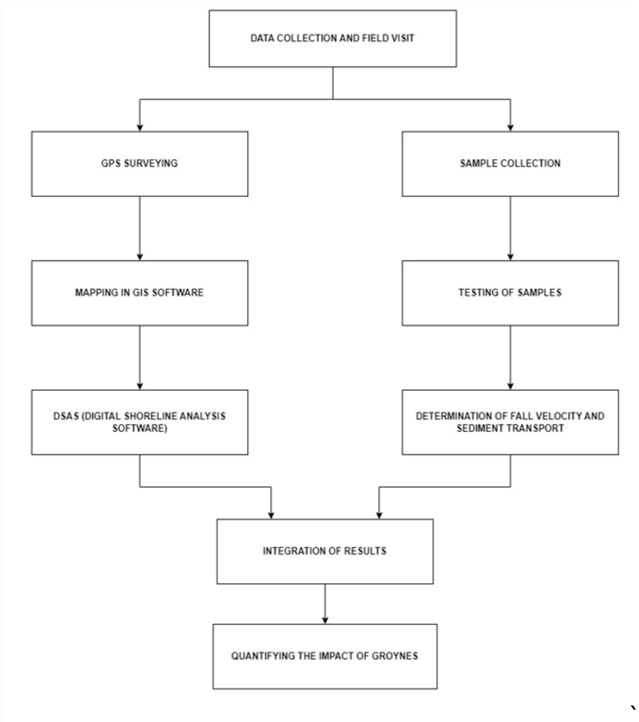

Fig -1: Flowchart of Methodology

3.1 GPS Survey and GIS Analysis

GPS survey is performed using a handheld GPS device. Shoreline, Baseline and two other Reference lines are captured using handheld GPS and the co-ordinates are exported into an excel sheet and the shoreline and baseline are later transferred to GIS software and they are digitized. Other corresponding data such as time, point ID are entered into the attribute table. After digitizing all the shoreline and baseline which has been digitized, we can perform DSAS (Digital Shoreline Analysis Software).

Fig -2: Handheld GPS (GARMIN)

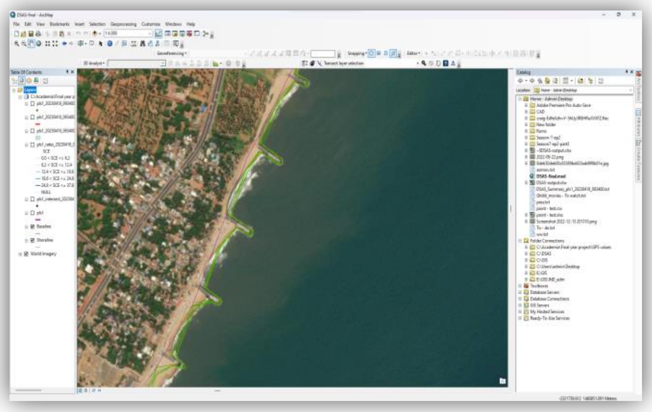

Fig -3: Digitized Shoreline and Baseline in ArcGIS (ArcMap)

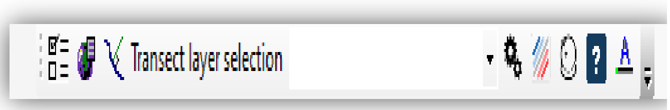

Fig -4: DSAS Toolbar

We have followed the DSAS Version 5.0 user guide for digitizing the shoreline and for casting the transects. After performing the analysis, we get the statistics it includes, End Point Rate (EPR) , Net Shoreline Movement (NSM) and Shoreline Change Envelope (SCE) which can be used to characterize the effects of groyne field on the coastline.

3.2 Sample Collection and Testing

Samples were collected at the lee-side of the groynes at 4 points each spaced 200 m apart. Then sieve analysis was performed on the collected samples to determine the particle size distribution. From this we can determine the sediment characteristics, Mean particle size, fall velocity and Sediment transport rate.

After performing the sieve analysis graphs were made to determine the characteristics of the samples collected at each sample collection points. The median particle size was found to be 0.46 mm. The sample was found be Well sorted, Coarse-skewed and Leptokurtic according to the Coastal Engineering Manual.

Fig -5: Sample Collection Points

4. RESULTS

4.1 GPS Survey and GIS Analysis

The recorded Shorelines and Baselines are then digitized in GIS software (ArcGIS), then Shoreline Analysis is performed using DSAS tool in ArcMap to get the value of parameters such End point Rate (EPR), Net Shoreline Movement (NSM) and Shoreline Change Envelope (SCE) form January 2023 to March 2023.

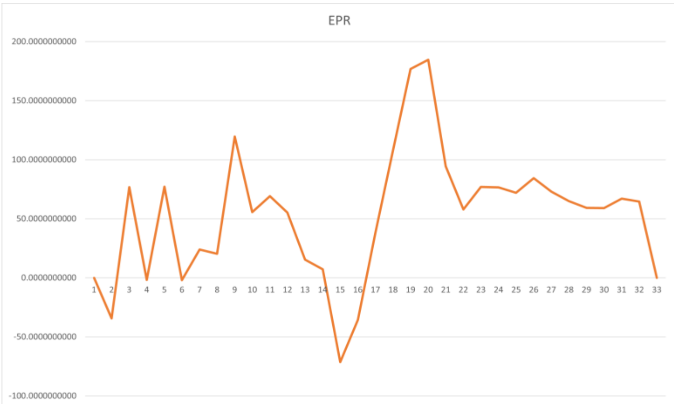

Fig -6: End Point Rate (EPR) Graph

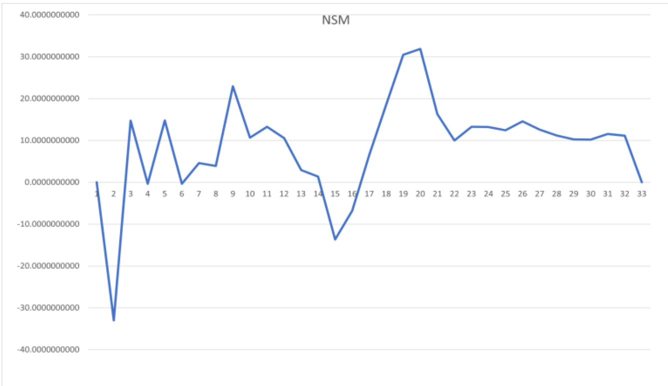

Fig -7: Net Shoreline Movement (NSM) Graph

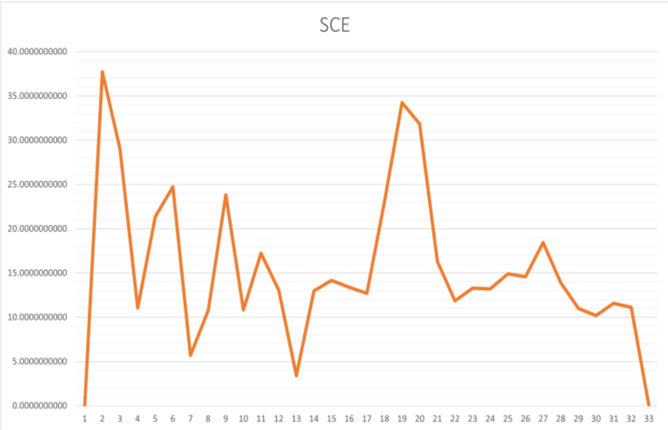

Fig -8: Shoreline Change Envelope (SCE) Graph

From the analysis we have determined the no. of erosional transects to be 5 and no. of accretion transects to be 26 which is more the 80% of the transects. The maximum erosion transect is transect no.2 and maximum accretion transect is transect no.20.

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DISTANCE: SCE (Shoreline Change Envelope, m)

SCE OVERALL AVERAGES:
total number of transects: 31
average distance: 16.5
maximum distance: 37.72
maximum distance transect ID: 2
minimum distance: 3.4
minimum distance transect ID: 13
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Fig -9: Shoreline Change Envelope (SCE) Statistics

Fig -10: DSAS Transect Casting

4.2 Sediment Properties

The collected samples are tested to determine the particle size and the sample are classified. After performing Sieve analysis, the sediment was found to be medium sand which is well-sorted, the distribution is Coarse Skewed and Leptokurtic. The mean particle size and the median particle size (D50) were 0.47 mm and 0.46 mm.

Fig -11: Quartz Particles (Having mean particle diameter of 0.46mm)

Quartz particle were found in the sediment sample and their particle size is compared with the graphs provided in Coastal Engineering Manual we can determine the fall velocity of the sediment particles.

g = 980 cm/sec2
γ_{water} = 0.011 cm2/sec
$\rho_{saltwater}$ = 1.03 g/cm3
ρ_{quartz} = 2648 g/cm3
$R_e = W_f * D / \gamma$ water
R_e = (7 * 0.046) / 0.011
R_e = 29.27
C_D = 4/3 * 980 * (0.046 / 72) * (2.65 -1)
C_D = 2.02

Fall velocity in Salt water
W_f = 7 * 0.977 = 6.839
R_e = (6.839 * 0.04) / 0.011 = 28.59

C_D = 4/3 * 980 * (0.046 / 6.8392) * (2.65 -1)

C_D = 2.12

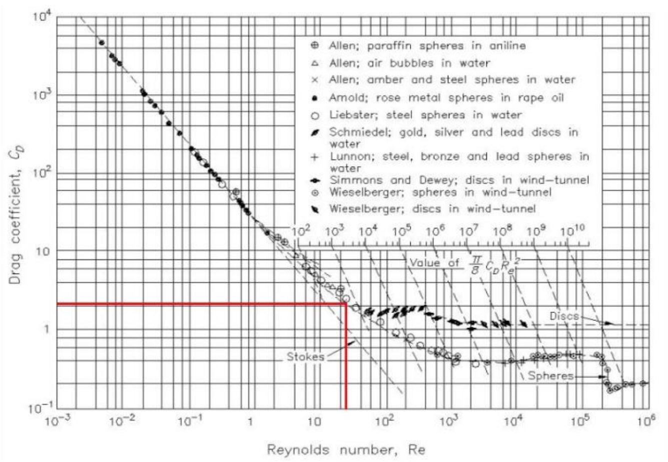

Fig -12: Drag Coefficient as a function of Reynolds number

Therefore, the fall velocity (W_f) = 7 cm/sec (or) 0.07 m/sec

This agrees with the graph provided in the Coastal Engineering Manual.

4.3 Sediment Transport Rate

The Longshore Sediment Transport rate is calculated using Energy-Flux formula using the wave data acquired from INCOIS.

Month	H_0	T_0	α_0
January	0.76	5.36	31
February	0.60	4.66	29
March	0.50	4.30	19

Fig -13: Wave data from INCOIS

$$P_{ls} = \frac{\rho g}{16} \times H_b \times H_b \times C_b \times \sin 2\alpha_b$$

$$H_b = \frac{H_o}{3.33[\frac{H_o}{L_p}]^{\frac{1}{3}}}$$

$$d_b = \frac{H_b}{0.78}$$

$$C_b = \frac{L_b}{T}$$

$$\frac{\sin \alpha_0}{2b} = \frac{C_o}{C_b}$$

$$L_o = 1.56\,T^2 \,;\, C_0 = 1.56\,T$$

$$\frac{\sin \alpha}{\sin \alpha} = \frac{C_o}{C_b}$$

$$Q = {}^{1280}/_{12} \times P_{ls}$$

This is the Energy Flux formula for Longshore Sediment Transport.

$$H_o = 0.76$$

JANUARY:

H_o=0.76
$T_o = 5.36$

$L_o = 1.56(5.36)^2$
= 44.81
$\alpha_O = 31$

$$(H_b) = \frac{H_O}{3.33\left[\frac{H_O}{L_p}\right]^{\frac{1}{3}}}$$

=

$$H_b = 0.89$$

$$d_b = \frac{0.89}{0.78} = 1.14$$

$$C_0 = 1.56(5.36) = 8.36$$

$$c_b = \sqrt{g d_b}$$

$$c_b = 3.34$$

$$\frac{\sin \alpha_o}{\sin \alpha_b} = \frac{c_0}{c_b}$$

$$\frac{\sin \alpha_o \times C_b}{C_o} = \sin \alpha_b$$

$$\sin \alpha_b = \frac{\sin(31) \times 3.34}{8.36} = 0.20$$

$$\alpha_b = \sin^{-1}(0.20) = 11.53$$

$\sin 2\alpha_b$ =0.388

$$P_{ls} = \frac{10 \times 100}{16} \times 0.89 \times 0.89 \times 3.34 \times 0.388$$

$$P_{ls} = 631.97$$

$$Q = \frac{1280}{12} \times 631.97$$

Q =+67410.13 cum/month

FEBRUARY:

H_o=0.60 $L_o = 1.56(4.66)^2$
$T_o = 4.66$ = 33.87
$\alpha_O = 29$

$$(H_b) = \frac{H_O}{3.33\left[\frac{H_O}{Lp}\right]^{\frac{1}{3}}}$$

$$H_b = 0.86$$

d_b=$\frac{0.86}{0.78}$=1.1

$$C_0 = 1.56(4.66) = 7.27$$
$$C_b = \sqrt{gd_b} = \sqrt{9.8 \times 1.1}$$

$$C_b = 3.28$$

$$\frac{\sin \alpha_o}{\sin \alpha_b} = \frac{c_0}{c_b}$$

$$\frac{\sin \alpha_o \times C_b}{C_o} = \sin \alpha_b$$

$\sin \alpha_b$=$\frac{\text{Sin }(29)\times 3.28}{7.27}$ = 0.24

$$\alpha_b = \sin^{-1}(0.24) = 12.70$$

$\sin 2\alpha_b$ =0.43

$$P_{ls} = \frac{10 \times 100}{16} \times 0.86 \times 0.86 \times 3.28 \times 0.43$$

$$P_{ls} = 651.9574$$

$$Q = \frac{1280}{12} \times 651.9574$$

Q =+69542.12 cum/month

MARCH:

H_o=0.50 $L_o = 1.56(4.3)^2$
$T_o = 4.3$ = 28.84
$\alpha_O = 19$

$$(H_b) = \frac{H_O}{3.33\left[\frac{H_O}{Lp}\right]^{\frac{1}{3}}}$$

$$H_b = 0.58$$

d_b=$\frac{0.58}{0.78}$=0.74

$$C_0 = 1.56(4.3) = 6.70$$
$C_b = \sqrt{gd_b} = \sqrt{9.8 \times 0.74}$; $C_b = 2.70$

$$\frac{\sin \alpha_o}{\sin \alpha_b} = \frac{C_0}{C_b}$$

$$\frac{\sin \alpha_o \times C_b}{C_o} = \sin \alpha_b$$

$\sin \alpha_b$=$\frac{\sin(19)\times 2.7}{6.7}$ = 0.1311

$$\alpha_b = \sin^{-1}(0.24) = 7.53$$

$\sin 2\alpha_b$ =0.26

$$P_{ls} = \frac{10 \times 100}{16} \times 0.58 \times 0.58 \times 2.7 \times 0.26$$
$$P_{ls} = 147.6$$
$$Q = \frac{1280}{12} \times 147.6$$

Q =+15744 cum/month

Net drift = + 152696.25 cum/month [From January to March 2023]

The drift occurs in northward direction so it is positive.

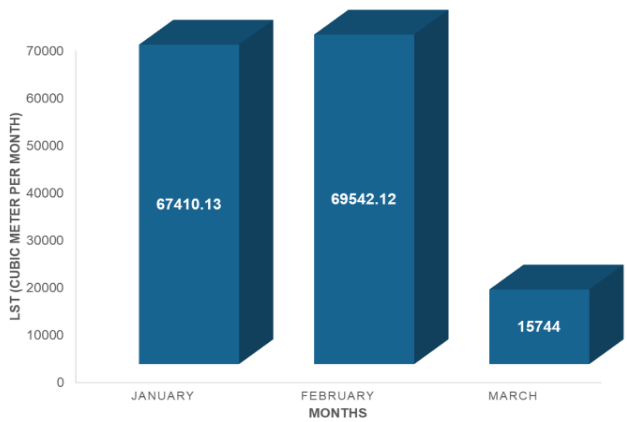

Fig -14: Longshore Sediment Transport from January to March

5. CONCLUSION

From the DSAS analysis it is concluded that there the groynes have not negatively impact the coastline. Significant accretion of the coastline has taken place after the construction of the groynes. Although there is erosion in some places it is found to be very minimal. Linear Regression Rate (LRR) and Weighted Linear Regression (WLR) were found to be 26.11mm/year.

The sediment is classified as medium sand which is well-sorted, the distribution is cross-skewed and Leptokurtic. The fall velocity of the particles is determined as 0.07 m/s. The sediment transport happens only in one direction (i.e.) towards the north which is taken as positive. Longshore sediment transport for the month of March was found to be less compared to January and February. From this data we can conclude that the groynes are performing efficiently in regaining the eroded coastline, although there is erosion in some area it is very minimal are can be compensated by artificial beach nourishment. Once the desired coastal profile is achieved the groynes can be removed and the beach profile will be maintained. This is in experimental phase and there are still on-going studies which are being performed on this topic.

REFERENCES

[1] Vrinda, Ms. and M. A. Mohammed-Aslam. "Assessment of shoreline vulnerability in parts of the coastline of Kasaragod district, Kerala, India." (2021).

[2] Selvan, S. & Kankara, R. S. & Markose, Vipin & Bhoopathy, Rajan & Kalaivanan, Prabhu. (2016). Shoreline change and impacts of coastal protection structures on Puducherry, SE coast of India. Natural Hazards.

[3] Vaidya, Aditee & Kumar, Santosh & Kudale, M.. (2015). Shoreline Response to Coastal Structures.

[4] Veeramuthu,Anandabaskaran & Vijayakumar, G.. (2022). Short Term and Seasonal Observation on Shoreline Changes from Kanagachettikulam to Veerampattinam of the Puducherry Coastal Region Using GPS Technique.

[5] Smith, Martyn & Cromley, Robert. (2012). Measuring Historical Coastal Change using GIS and the Change Polygon Approach.

[6] Smith, Kathryn & Terrano, Joseph & Pitchford, Jonathan & Archer, Michael. (2021). Coastal Wetland Shoreline Change Monitoring: A Comparison of Shorelines from High-Resolution WorldView Satellite Imagery, Aerial Imagery, and Field Surveys. Remote Sensing.

[7] Sumangala, Dhanya & Mohan, Rajarethinam & Vendhan, Mullai & Murthy, M. & Sajeev, R.. (2020). Assessment of Performance of a Groin Constructed on Puducherry Coast - A Case Study. Journal of Coastal Research.

[8] United States. Army. Corps of Engineers. Recreation Task Force. U.S. Army Corps of Engineers Recreation Study: a Plan Prepared for the Assistant Secretary of the Army (Civil Works). Washington, D.C. : [Springfield, VA :] :Headquarters, U.S. Army Corps of Engineers ; [National Technical Information Service, distributor], 1990.

[9] Natesan, Usha & Parthasarathy, Anitha & Vishnunath, R. & Jeba Kumar, G.Edwin & Ferrer, Vincent. (2015). Monitoring Longterm Shoreline Changes along Tamil Nadu, India Using Geospatial Techniques.

[10] Veeramuthu, Anandabaskaran. (2017). Monitoring Shoreline Changes of the Puducherry Coast, South India: A Review and a Case Study. International Journal for Research in Applied Science and Engineering Technology

[11] Himmelstoss, E.A., Farris, A.S., Henderson, R.E., Kratzmann, M.G., Ergul, Ayhan, Zhang, Ouya, Zichichi, J.L., Thieler, E. R., 2018, Digital Shoreline Analysis System (version 5.0): U.S. Geological Survey software release.