REMOTE SENSING AND DSAS TECHNIQUES FOR LONG-TERM SHORELINE CHANGE STUDIES IN THARUVAIKULAM DIVISION, THOOTHUKUDI DISTRICT, TAMILNADU, INDIA

Sudhakar, V.*, Gurugnanam, B.†, Kumaravel, S. and Bairavi, S.

1Centre for Applied Geology, The Gandhigram Rural Institute-Deemed to be University, Ganghigram, Dindigul, Tamil Nadu.
2Department of Geology, Thiru Govindasamy Government Arts College, Thindivanam, Tamil Nadu.

*Corresponding author: sudhakarsv380@gmail.com

ABSTRACT
The present study investigates the rate of shoreline changes along the coast of Tharuvaikulam taluk, Thoothukudi district, between the long-term period of 1968 and 2018. The study area has been divided into four divisions based on their coastal villages namely Vembar, Periasamypuram, Vaippar and Kallurani. The shorelines have been extracted for various periods through Landsat Satellite imagery and Survey of India (SOI) Toposheets. The Linear Regression Rate (LRR) method has been used to assess the rate of shoreline changes along the coast with the help of Digital Shoreline Analysis System (DSAS) tool in ArcGIS software. The DSAS tool generated 225 transect lines perpendicular to the shorelines. It has also estimated the LRR statistical report at each transect. The statistical report has been further classified as the classes of High Erosion, Low Erosion, Stable, Low Accretion and High Accretion. Of the 21.4 km length of the coast of Tharuvaikulam division, 52% of low accretion in 10.7 km and 24% low erosion in 4.1km were noticed. Vaippar coastal village was noticed with severe erosion along its 4.8 km coast. The present study thus concluded that low accretion and low erosion have dominated the entire coast of Tharuvaikulam taluk in Thoothukudi district, however, Vaippar zone was noticed with severe erosion during the period of 1968 - 2018.

Keywords: DSAS, LRR, Erosion, Accretion

INTRODUCTION
Shoreline change studies are very challenging for researchers, because of shoreline position have been changing frequently. It's because of its dynamic interface between the ocean and land (Thieler and Hammar-Klose 2000). Moreover, acute erosion caused by the increased storm decreased sediment movement and changing wave climate (Bryant 2005). The littoral currents also a response to erosion and accretion. The eroded materials are moved along the nearshore zone thought littoral current (Coastal Engineering Manual, 2002) as well as the human intervention. Overall the world 44% of the population have been live within 100 km of the coastal area. It is affected by the coastal area, because, rapidly developed the urbanization, fishing harbours (Thieler and Hammar-Klose 2000). Earlier, researches have completed in long term shoreline changes by using remote sensing and GIS techniques (Meijerink1971, Nayak and Saha1985, Prabharrao et.al 1985, Shaik et.al 1989, Kumar K.V et.al 1994, Capobianco et.al.1999, Loveson et. al 1990, Chandrasekar, N et.al., 2000, 2000b, 2011; Ratheesh A et.al., 2014, Amaro et. al. 2002b, Vital 2003a, Vital et.al. 2003b, Charatkar 2004, Rajamanikam 2006, Griffiths,c.j. (1998). Many research, the shoreline changes were investigated with help of remote sensing data with reasonable accuracy (Chandrasekaran A et al., 2013; Muttitanon and Tripathi, 2005; Siddiqui and Maajid, 2004; Ghanavati et al., 2008; Mukhopadhyay et al., 2011; Kumar and Jayappa, 2009; Choudhary et al., 2013). Presently, several studies have used the Digital Shoreline Analysis System tool in ArcGIS Platform to compute the rate-of-change statistics for a time series of shoreline positions. It has generated several statistical reports for shoreline change studies. Commonly, End Point Rate (EPR) and Linear Regression Rate (LRR) methods are implemented to estimate the rate of shoreline change and movement of shorelines (Crowell and Douglas 1997). The LRR methods calculate the least squares regression line for historical shorelines. It has been measuring the distance between the shoreline/transect intersection points. Linear regressions are common statistical
analyses for determining shoreline change rate, which is the rate of erosion or rate of accretion along the shore (Dolan, 1991). In the present study, the LRR statistical method has applied to find out the rate of shoreline changes along the coast of Tharuvaikulam Taluk, Thoothukudi district during the period 1968–2018.

Study Area

The present study was carried out in the coastal boundary of Tharuvaikulam Taluk in Thoothukudi district Tamil Nadu India. It lies on 9° 04' and 8° 58' N latitude and 78° 14' and 78° 22' E longitude. The coast extends a length of 21.4 km in Northern Part of Thoothukudi district. The Coast has been further divided into four zones based on their coastal village boundary limits namely, Vembar, Periasamyapuram, Vaippar, and Kallurani (Fig – 1). An Entire study area mostly has salt pans, and Vembar, Vaippar (located at Sippikulam and Keelvaipar) have located in fishing harbors. The Vaippar coast village has a river delta, this river named as Vaippar River. It is one of the delta regions in Thoothukudi district. Recently, this river has inactive.

MATERIALS AND METHODS

In the present study, multi-year satellite data were used for the extraction of shoreline. Landsat data were used for a different year of shoreline positions, which are Thematic Mapper (TM) in 1997, Enhanced Thematic Mapper Plus (ETM+) data in 2009, and Operational Land Imager data in 2018 were used to extract the shorelines. The survey of India (SOI) Toposheets was used for the year 1968. Coastal Regulation Zone maps were also used for coastal village boundary extraction along the coast of Tharuvaikulam Taluk, Thoothukudi District.

Linear Regression Rate of Shoreline Changes

The study area shoreline was carefully digitized with false color composites of Landsat images. Landsat images were georeferenced with UTM projection of WGS 1984. Digitized shorelines were attributed in DSAS tools in ArcGIS software. The Baseline was generated, parallel to the shorelines and also attributed the baseline to DSAS and give an option like Group id, Uncertainty, offshore, cast-direction for creating the Transect Lines. 214 Transect lines were generated by the software and it is perpendicular to the Shorelines. The transect lines (1 to 214) has been split into four sets of transects for the four village coasts, which are Vembar Coast (1 to 44) (Fig – 2 A, and Fig – 3 A), Periasamyapuram Coast (45 to 78) (Fig – 2 B, and Fig – 3 B), Vaippar Coast (79 to 189) (Fig – 2 C, and Fig – 3 C), and Kallurani (170 to 214) (Fig – 2 D, and Fig – 3 D). The statistical reports of Linear Line Regression (LLR) were generated for Multi-year of Shorelines on each Transect through DSAS Techniques. The statistical LLR result are classified into five categories viz High Erosion (> -4 m/yr.), Low Erosion (-4 to -1 m/yr.), Stable (-1 to 1 m/yr.), Low Accretion (1 to 4 m/yr.) and High Accretion (>4 m/yr.) based on the existing review by Kuleli (2010); Bagdanaviciute et al. (2012); Manik Mahapatra et al. (2014) (Fig – 5 and Table – 2). Finally, the shoreline change rate was demarcated using LLR method along the coast of Thiruchendur Taluk.

RESULTS AND DISCUSSION

Linear Regression Rate of Shoreline Changes

On 13th November 1992, a stronger cyclone (wind velocity of 100 – 130 km/h) wiped the Nineteen coastal villages of Thoothukudi district. Storm surges about 1–2 m high flooded a 70-km stretch of the coast up to 200–300 m inland. During 2004, The Thoothukudi Coastal affected by Tsunami. The Tsunami wave maximum (200m) in near Tuticorin Port and minimum (100 m) in Vembar and Kallurani villages. (Arumugham et al. 1993). Apart from nature,
### Table 1. Shoreline Classification of Tharuvaikulam

<table>
<thead>
<tr>
<th>Classification of Shoreline</th>
<th>VEMBAR</th>
<th>PERIYASAMYPURAM</th>
<th>VAIBAR</th>
<th>KALLURANI</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRR (m)</td>
<td></td>
<td>LRR (m)</td>
<td></td>
<td>LRR (m)</td>
</tr>
<tr>
<td>Length (km)</td>
<td></td>
<td>Length (km)</td>
<td></td>
<td>Length (km)</td>
</tr>
<tr>
<td>Min</td>
<td>Max</td>
<td>Avg</td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>High Erosion</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Low Erosion</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Stable</td>
<td>-0.83</td>
<td>0.96</td>
<td>3.09</td>
<td>1.7</td>
</tr>
<tr>
<td>Low Accretion</td>
<td>1.03</td>
<td>3.42</td>
<td>58.6</td>
<td>2.6</td>
</tr>
<tr>
<td>High Accretion</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

#### Fig. 2. Shoreline change maps of A) Vembar, B) Periasamypuram, C) Vaippar and D) Kallurani
Fig. 3. Linear Regression Rate of Shoreline changes of coastal villages, A) Vembar, B) Periasamypuram, C) Vaippar and D) Kallurani

Fig. 5. Linear Regression Rate of Shoreline Change Map along the Coast of Tharuvaikulam Taluk. Red color indicates the high rate of accretion, Orange color shows that low rate of accretion. Yellow color indicates, the coastal is stable, Dark Green and Parrot Green color are indicate high and low rate of erosion.
Fig. 4. Google Earth Images of study area. A) Vembar Coast (jetties constructed along the shore), B) Estuary of Vaippar River (the mouth of estuary has been changing from 2009 to 2018), C) Wastewater stream mouth in Kallurani coast.

<table>
<thead>
<tr>
<th>Classes of Shoreline</th>
<th>LLR in %</th>
<th>Length in km</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Erosion</td>
<td>18</td>
<td>1.2</td>
</tr>
<tr>
<td>Low Erosion</td>
<td>24</td>
<td>4.1</td>
</tr>
<tr>
<td>Stable</td>
<td>2</td>
<td>5.1</td>
</tr>
<tr>
<td>Low Accretion</td>
<td>52</td>
<td>10.7</td>
</tr>
<tr>
<td>High Accretion</td>
<td>3</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Table: 3

Shoreline Classification of Tharavaikulam and human intervention also affects the shores. In Vaippar river and Kalaignanapuram were severe erosion due to the extraction of heavy minerals like Garnet, Ileminite, and Rutile. (The Hindu, 2013). Moreover, Muthukumaraswamy et al. (2013) experienced in an earlier study, Vaippar, Pachayapuram, and Vembar have severe erosion, but, accretion in the south of Vembar. The present study, assesses the rate of erosion and accretion along the coast of Tharavaikulam division, Thoothukudi district. This coast has a different rate of shoreline change with their coastal villages. The results of these coastal villages reveal that both Vembar and Periasamypuram coastal villages have more low accretion noticed. In Vembar, 58.61 m rate of change in 2.6 km (Table - 2) was noted. It is noted that the rate of changes is graphically increased from 10 to 44 with Transects along the shore (Fig – 3 A). The same length of 2.6 km of the Periasamypuram coast has 71.89 m rate of changes are noticed during the period 1968 – 2018. The transect details reveal that the peak was decreased from 45 to 78 (Fig – 3 B). It is evidenced that the accretion rate has been decreased towards Vaippar. Moreover, 3.09 m and 3.52 m rate of a stable coast have perceived in 1.7 km and 0.9 km lengths of Vembar and Periasamypuram respectively. In Vembar, jetties are constructed on the sea (Fig – 4 A). Whereas, no high and low erosion were noticed in these village coastal (Table – 2). Similarly, Vaippar coast village has noticed with low accretion (33.1 m) in 2.4 km, and stable (5.9) in 1.8 km, but severe erosion also was noticed on this coast. It is -93.6 m rate of low erosion in 3.6 km length of the coast and 1.2 km length of the coast has -77.7 m rate of high Erosion was noticed among 9.0 km length of the coast (Table - 1). In this zone, the peak of the graph shows that the accretion rate has
gradually increased with transects from 80 to 88, but the peak of the graph shows a decreasing trend with transect from 88 to 123 (Fig - 3 C). It indicates the shoreline position has backward movement (erosion) in Vaippar estuary, because, the mouth of Vaippar estuary closed (Fig - 4 B) due to inactiveness of Vaippar river and beach sediments deposited along the estuary mouth through littoral currents movement in the surf zone. After the 153 transects, the peaks were going up, it means the accretion rate has gradually increased towards Kallurani (Fig – 3 C). In Kallurani, of the total length of 4.62km. 3.2km length of the coast has a Low rate of accretion (56.4m) was noticed, and -2.13m of stable coast was noticed in this coastline of 0.7 km. Erosion was also noticed in this area of 0.5 km. Among this, -7.24m is the low rate of Erosion during the period 1968 – 2018 (Table - 1). The transect of this zone falls in between 170 and 214. The graph peaks are similar from 170 to 200, but transects 190 -191 and 209 - 210 peaks have high elevation (Fig – 3 D). It indicates a high rate of accretion, because of sand bars developed across the backwater stream mouth (Fig – 4 C) due to littoral current drift.

**CONCLUSION**

The present study was carried out to assess the Rate of Shoreline change in the coast of Tharuvaikulam division, Thoothukudi district, Tamil Nadu using LLR method through DSAS Techniques. The study concludes that Low Accretion (52%) has dominated in the Entire coast and also, severe erosion was noticed as low (24%) and high (18%) rate of changes in the coast of Tharuvaikulam Taluk. The Vembar and Periasamy puram coastal villages are under low accretion process and less amount of stable zone was noticed. These zones are under safe condition. Whereas Kallurani coastal village also has a low rate of accretion, and a small length of the shoreline is low erosion, stable, and high accretion. But, Vaippar coastal village was noticed with severe Erosion during the period, 1968 – 2018. This zone needs a detailed investigation for the prevention of further erosion.

**ACKNOWLEDGMENT**

The authors are thankful to the Centre for Applied Geology for providing facilities, the authors are also thankful to the USGS for providing Satellite data.

**REFERENCES**


Choudhary, R., Gowthaman, R., & Sanil Kumar, V. 2013. Shoreline change detection from Karwar to Gokarna-South West coast of India using remotely Sensed data. International Journal of Earth Sciences. 6(3), 489-494.


