

Remote sensing and GIS-based Seashore changes of Tuticorin Zone and Punnaikayal Zone in parts of Thoothukudi Coast, Tamil Nadu, India

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Abstract

Urban coast and Estuary have significant modification as erosion and accretion due to both natural and human intervention. The study was carried out in Tuticorin and Punnaikayal zones in part of Thoothukudi coast from 1968 to 2018. For a detailed study, these zones further divided into three sub-zones, namely as A to F. The SOI Toposheet used for marking the shoreline for the year 1968. The Seashore lines digitised with FCC of Satellite imagery in ArcGIS platform using preprocessed Landsat TM Satellite imagery of 1997 and 2018. Finally, Shoreline changes are measured and analysed by overlay analysis for finding the amount of erosion and accretion between the periods 1968 – 1997 and 1997 – 2018. The findings reveal that in both the zones, more accretion has noticed during the period 1968 - 1997. However, the accretion process has reduced during the period 1997 – 2018. In Tuticorin zone, the accretion was reduced from 2.40 km² to 1.14 km² with the growth rate from 69.63 m²/year to 54.41 m²/year. In Punnaikayal zone, the amount of accretion is reduced from 1.23 km² to 0.04 km² with the growth rate decreased from 42.52 m²/year to 1.81 m²/year. The result concludes that an accretion process reduced and in turn erosion process increased in the coastal region.

Keywords—Erosion, Accretion, Net growth, Growth rate

I. INTRODUCTION

Seashore line changes affects the coastal livelihood and economic conditions and land management, and also it controls the environment [1]-[2]. The coastline is one of the most significant straight highlights on the world's surface, which has a powerful nature [23]. Natural and geological phenomena, sediment transportation and sea-level rise, will cause the seashore line directly [3]. Coastal zones are the world's most diverse and productive environments. Seaside territories additionally incorporate complex biological systems, for example, coral reefs, mangroves, sandy seashores and ocean grass [22]. One of the essential requirements of coastal protection planning work is

to understand the coastal processes of erosion, deposition and sediment transport, flooding and sea-level changes that continually alter the coastline [23]. The sandy beaches were exposed more for the erosion, and accretion activities. Waves, currents, and tides also contributed to the shoreline erosion and accretion process.

The researchers analyzed the trends in waves with respect to erosion and accretion studies in the Arabian Sea, Bay of Bengal and also in the northern Indian Ocean [4]-[5], using historical satellite data-based seashore line measurements [6]- [10], and validated by many scholars [11]-[12]. Shoreline changes are a great concern in the estuaries [13]- [16]. Sediment transportation through littoral current

is also the cause behind in the beach accretion and erosion. The sediment is more deposited in monsoon season and the same was lower in summer and post-monsoon season. The amount of sedimentation accumulation is 1.97 mg/cm²/day to 12.31 mg/cm²/day, in the Gulf of Mannar [20]. Remote sensing plays an important role in spatial data acquisition from an economic perspective [22]. The historical and functional approaches to study shoreline changes along with various landforms help in deciphering the coastal processes operating in an area [22]. Multi-date satellite information has been utilised to analyse about shoreline change and seaside landforms, which gave understanding into huge zone silt transport studies and identifying the long-term change in whole coastline [22]. The Thoothukudi coast has encountered consistent growth from 1969 to 2006 [3]. The present study was carried out in parts of Tuticorin and Punnaikayal areas of part of Thoothukudi from 1968 to 2018.

A. Study Area

The study area forms the part of Thoothukudi coast of Thoothukudi district lies between 8° 36' and 8° 47' N latitude and 78° 6' and 78° 17' East longitude. Length of Coastline is 30 kilometer, and it lies between Threspuram and Kayalpatnam (Fig - 1). The study area dealt with two zones viz Tuticorin and Punnaikayal. Each zone divided into three subzones, a total of six subzones in order of namely A to F designated for further study. The area of each gird covers 30 km². Geologically, the study area composed of sedimentary rocks of tertiary to recent age. Sandy beaches are the more significant occupant along the coast. Earlier reports reveal that in the study area covers the dominance of sandy beaches and also in few places, estuaries and black sands [16]-[17]-[18]. Mangroves, mudflats, dunes, coral reefs, and van island, also present in the southernmost tip of the Tuticorin coast of the Gulf of Manner. The coast of Tuticorin also supports a number of economic activities such as fisheries, salt

pans, urban settlements and industry. Thamirabarani River has got the number of tributaries in the study area, and it controls the erosion and deposition activities in Thoothukudi coast. District Tuticorin experiences a tropical semi-arid climate. The climate here is usually hot and dry, with the hottest months being May-August, and the coldest months of the year being December-February. It reported a maximum temperature of 29.5-40.5C and a minimum temperature of 18.4-26.7C.

II. MATERIALS AND METHODS

The temporal satellite Imageries are highly useful for preparing the shoreline study [19]. In the study, sea shorelines extracted from the Toposheets (1968) and Landsat data sets of TM (1997) and OLI (2018) (Table: I). The Toposheets and Satellite data were re-projected with WGS 1984, Zone of 43N for further process. The seashore lines were digitised using FCC satellite data (during the years 1997 and 2018) as well as Toposheets for shoreline extraction during the year 1968, in ArcGIS platform. Digitised seashore lines are taken as input data and merged to form an overlay line features. The merged line features were taken as input data to create polygon is generated (Fig- 2). The output feature polygon is used to calculate the amount of erosion and accretion between the periods 1968 – 1997 and 1997 – 2018 (Table: II).

Table: I Landsat Satellite data details

Images	Meta data	Scene Details
Landsat 5	TM/ 143/54	05/28/1997
Landsat 8	OLI /143/54	04/04/2018

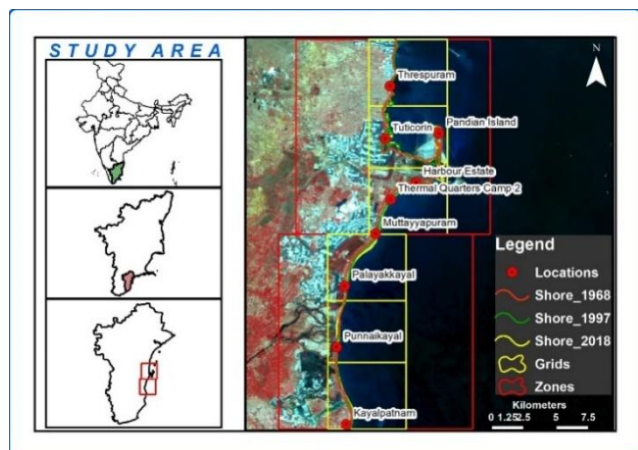


Fig -1: Study Area

III. RESULTS AND DISCUSSION

A. Subzones wise Shoreline Change Analysis

The long-term rate of coastal line changes can be demarcated and calculate the area of erosion and accretion by using satellite imagery [20]. In the present study, historical Satellite images of Tuticorin and Punnakayal coastal zone's shorelines were analysed and calculated the shoreline changes during 1968, 1997 and 2018 (Table: 2). Each zone has further divided into three sub-zones viz A – F for a detailed shoreline change study during the periods of 1968, 1997 and 2018 (Fig 2). The results in details discussed for each zone and subzones are detailed below.

1) *Shoreline Change of Tuticorin zone during the period 1968 – 1997.*

In sub-zones, A, B, and C, more accretion noticed due to natural and human activities (Fig – 3). Tuticorin zone has a harbour. It is one of the 12 important harbours in India. Tuticorin zone is the main urban area of the thoothukudi district. Moreover, Tuticorin zones have salt pans, fishing harbours, and industries are controlling erosion and accretion activities. Subzone A noticed with more accretion (0.58 km^2) and less amount of erosion (0.02 km^2). The overall growth is 0.56 square kilometer with a growth rate of 19.42 meter / year during 1968 – 1997 (Table: II). In Gird B and C also noticed with more accretion. 1.11 km^2 of accretion

has observed in gird B due to the human-made activities. In this sub-zones, northern part of the Tuticorin port, significant and minor fishing harbours, salt industries, urban settlements, (Fig – 6 (B)) and Pandian island (now, it is part of Tuticorin port) are the known and famous features in the study area (Fig – 2 (A)), which controls the erosion and deposition of the study area. In this subzone, a small amount of erosion observed (0.65 km^2), with a overall growth of -0.46 km^2 , with the growth rate of 15.86 meter / year noticed. It is due to the industrial developments as well as natural activities along the coastal track. Whereas, Subzone C, covered with Harbor Estate and Thermal Quarters camp 2 areas. This coast looks like a curve-shaped structure (Fig – 2 (B)). In this sub-zones, more amount of accretion and less amount of erosion observed. It is 0.15 km^2 of erosion and 1.53 km^2 of accretion (Table: II and Fig – 3). Erosion in this area is due to physical construction and maintenance of the structure. The accretion of this area is due to sediment transport from Thamirabarani river and by the current littoral movement in the coastal surf zone. Subzone C has 1.38 km^2 net growth of shoreline changes with the growth rate of $4.75 \text{ m}^2/\text{year}$ during the period 1968 – 1997. It is the high amount of accretion among all girds of Tuticorin Zone. Overall results of Tuticorin zone reveal that this zone exposed to the total amount of erosion is 0.82 km^2 and accretion is 3.22 km^2 during the period 1968 – 1997 (Table: III). Growth rate $82,78 \text{ m}^2/\text{year}$ during 1968 – 1997 was noticed (Table: IV and Fig 5).

2) *Shoreline Change of Tuticorin zone during the period 1997 – 2018.*

During 1997 – 2018, erosion was dominated in the sub-zones A. It is 0.10 km^2 erosion, and less amount of accretion (0.03 km^2) perceived in Threspuram coastal area of subzone A. In this area, Jetties constructed on the sea (Fig – 6(A)). In this jetties, either side erosion observed due to the wave diffraction. The net erosion is -0.029 km^2 with a

growth rate of $-3.26 \text{ m}^2/\text{year}$ (Table: II) in this sub-zones. In sub-zone, B, fishing harbours, Thermal plant and Inigo Nagar (Fig – 6(B)) noticed. In Subzone B, more amount of erosion 0.85 km^2 and less amount of accretion (0.30 km^2) observed with a net growth of 0.55 km^2 during the period 1997 – 2018. This subzone growth rate of shoreline changes is $2.62 \text{ m}^2/\text{year}$ (Table: II). In sub zone C, accretion (0.70 km^2) was noticed. It is due to the accumulation of sediments from Tambraparani river. These sub-zones also under erosion process. It is 0.04 km^2 (Table: II and Fig – 4). The net growth of accretion is 0.66 km^2 with a growth rate of $31.55 \text{ m}^2/\text{year}$. The overall result reveals that the Tuticorin zone dominates with more accretion during the period 1997 – 2018. The total amount of accretion is 1.58 km^2 , and erosion is 0.44 km^2 (Table: III), and the net growth is 1.15 km^2 with a rate $54.51 \text{ m}^2/\text{year}$, during this period (Table: IV and Fig - 5).

3) *Shoreline Change of Punnaikayal zone during the period 1968 – 1997.*

The Punnaikayal zone is a delta of Thamirabarani River. The Punnaikayal zone has exposed to accretion due to accumulation of sediments by drift littoral current though the Thamirabarani river. Moreover, the predominant wave activities contribute the littoral longshore flows from Southern Tamil Nadu make the seashores as a most potent landform of the territory [25]. The sub-zones D, E, and F show that more accretion has dominated during this period 1968 – 1997. These subzones accretions are 0.43 km^2 , 0.32 km^2 , and 0.49 km^2 , respectively (Table: II and Fig – 3). While lesser amounts of erosions observed in gird E and F. The amount of erosions is 0.008 km^2 and 0.005 km^2 . However, there is no erosion in gird D due to the accumulation of sediment deposition along the

coast. The sub-zones D has 0.43 km^2 of net growth accretion. The growth rate of $14.84 \text{ m}^2/\text{year}$ noticed. However, gird E, net growth of accretion is 0.32 km^2 with a growth rate of $10.88 \text{ m}^2/\text{year}$ between the period 1968 – 1997. In F sub-zones, amount net growth is 0.49 km^2 with a growth rate of $16.80 \text{ m}^2/\text{year}$ during the period 1968 – 1997 (Table: II). Overall girds result reveal that, in Punnaikayal zone, has more amount of accretion and less amount of erosion. This zone's total amount of accretion is 1.70 km^2 and erosion is 0.01 km^2 during the period 1968 – 1997 (Table: III). The Zone has accreted by 1.92 km^2 of net growth with a rate of $66.27 \text{ m}^2/\text{year}$ during this period (Table: IV and Fig – 5).

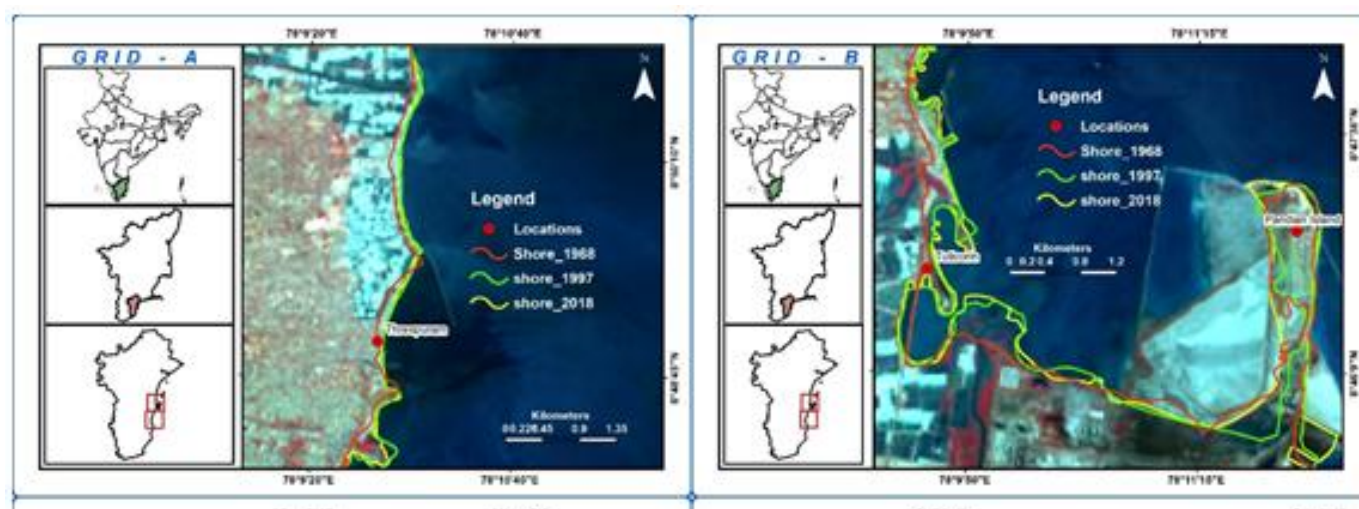
4) *Shoreline Change of Punnaikayal zone during the period 1997 – 2018.*

In sub-zones D, more accretion (0.44 km^2) observed during 1997 – 2018. D sub-zones covered with Palayakkayal coast area. In sub zone D, erosion (0.13 km^2) perceive along the coast of this gird (Fig – 6 (D)) during the period 1997 – 2018. The net growth of accretion is 0.30 km^2 , with a rate of $14.44 \text{ m}^2/\text{year}$. The subzone E noticed with the erosion of 0.47 km^2 , net growth of erosion is -0.47 km^2 during the period 1977 – 2018. The growth rates are $-22.20 \text{ m}^2/\text{year}$. In sub-zones F, the accretion (0.004 km^2) has noticed, and 0.205 km^2 of erosion was observed (Table: II and Fig – 4). Subzone F has 0.20 km^2 of net growth of accretion with a growth rate of $9.56 \text{ m}^2/\text{year}$ during the period 1997 – 2018 (Table: II). Overall results of these subzones reveal that the zone has shown both an erosion and accretion during the period 1997 – 2018. The total amount of Punnaikayal zone's erosion is 0.61 km^2 and accretion is 0.64 km^2 (Table: III). The zone has a net growth of 0.04 km^2 with a rate of $1,81 \text{ m}^2/\text{year}$ during this period (Table: IV and Fig – 5).

Table: II

Gird wise Shoreline Change Analysis

Tuticorin and Punnaikayal Zone Erosion and Accretion					
Periods	Sub zones	Erosion (km ²)	Accretion (km ²)	Net growth (km ²)	Growth rate (m ² /year)
1968 – 1997	A	0.020	0.584	0.563	19.424
	B	0.650	1.110	0.460	15.865
	C	0.149	1.526	1.377	47.490
	D	-	0.430	0.430	14.835
	E	0.008	0.324	0.315	10.877
	F	0.005	0.493	0.487	16.804
1997– 2018	A	0.097	0.029	-0.068	-3.258
	B	0.298	0.848	0.550	26.213
	C	0.042	0.704	0.663	31.551
	D	0.131	0.435	0.303	14.444
	E	0.466	-	-0.466	-22.197
	F	0.004	0.205	0.201	9.560



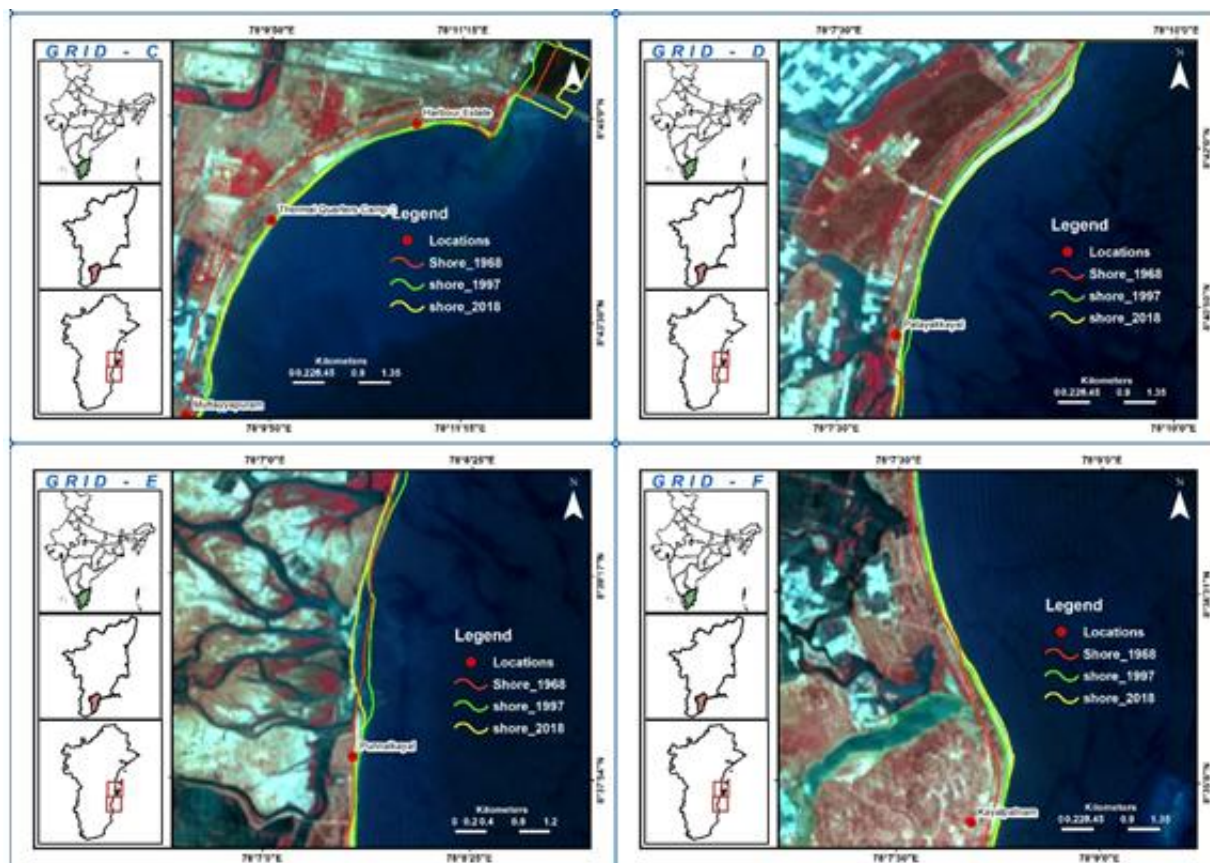


Fig – 2: Sub zones A – F, Shoreline Change Analysis maps

B. Shoreline changes for a period of 1968-1997 and 1997-2018

The shoreline changes in increasing and decreasing trend of sand supply study to be done over a long period. Geologically, Thoothukudi coast comes under from Pleistocene_new age [19]. He has also pointed out that the beach materials of sand, gravel are deposited along this coast due to wave action and currents of backshore [19]. The sea level has to lie down in Thoothukudi coast, because of the seafloor developing by the neo-tectonic activity [20]. The study concludes that accretion dominated between the period 1968 – 1997. While, during period 1997 – 2018, an accretion process decreased in both the zones. In Tuticorin zone, the net accretion is reduced from 2.40 km² to 1.15 km² with a decreasing rate of 69.63 m²/year to 54.41 m²/year. Whereas, in Punnaikayal zone, net accretion is diminished from 1.23 km² to 0.04 km² with a growth rate of reduced from 42.52 m²/year to 1.81 m²/year (Table: IV and Fig 5). These results

indicate that Tuticorin and Punnaikayala zones are under the reduced accretion process.

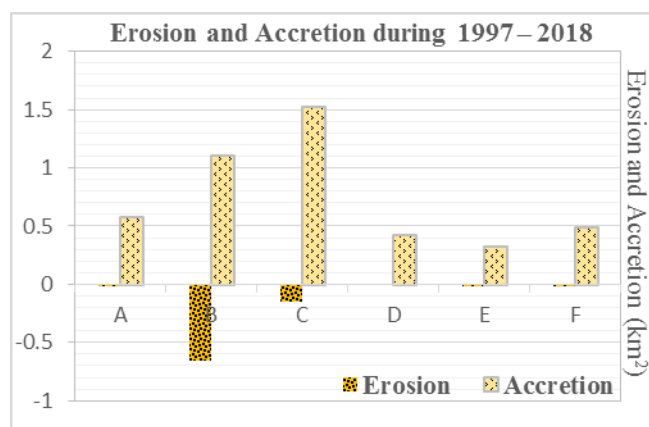


Fig – 3 Shoreline Change During 1968 – 1997

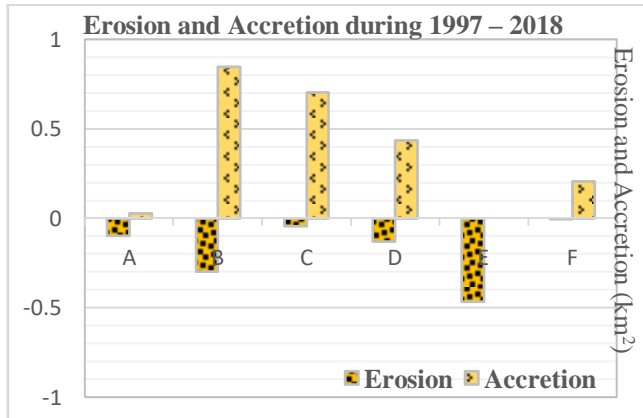


Fig - 4 Shoreline Change During 1997 - 2018

Table: III

Zone wise Shoreline Change Analysis

Erosion and Accretion between Tuticorin and Punnaikayal zone					
Periods	Zones	Erosion (km ²)	Accretion (km ²)	Net growth (km ²)	Growth rate (m ² /year)
1968 - 1997	Tuticorin	0.819	3.220	2.401	82.779
	Punnaikayal	0.014	1.247	1.233	42.515
1997 - 2018	Tuticorin	0.436	1.581	1.145	54.506
	Punnaikayal	0.601	0.639	0.038	1.807

Table: IV

Shoreline change Growth Rate Between Tuticorin and Punnaikayal

Zone	During 1968 - 1997		During 1997 - 2018	
	Net growth (km ²)	Growth rate (m ² /year)	Net growth (km ²)	Growth rate (m ² /year)
Tuticorin	2.401	82.779	1.145	54.506

Punnaikayal	1.233	42.515	0.038	1.807
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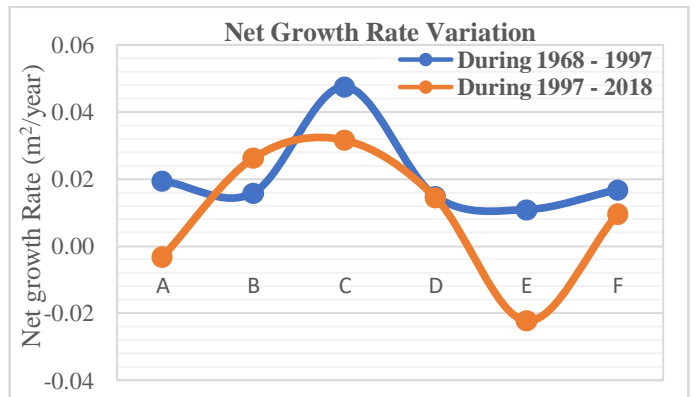


Fig - 5 variations of Net growth Rate between the periods 1968 - 1997 and 1997 - 2018



(A) Jetties Constructed along the Threspuram Coast



(B) Inigo Nager Developed along the Tuticorin coast



**(C) Curve Shape of Coast in Thermal Quarters
Camp 2**



(D) Erosion in Palayakkayal Coast

**Fig – 6 (A-D) Erosion and deposition between the
Tuticorin and Punnaikayal zones**

IV. CONCLUSION

The study carried out to assess the coast zone changes between Tuticorin and Punnaikayal zones in part of Thoothukudi coast. The study concludes that the Urban area of Tuticorin zone has noticed with accretion results and Punnaikayal zone also noticed with accretion results due to both natural and human interventions during the period 1968 – 1997. In 1997 -2018, the accretion results indicate that it is in reducing condition. It indicates that these zones continuously reducing their accretion process. It indicates the erosion activity started in this zone. The study concludes that these zones to be protected from erosion activities.

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