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Morphodynamics of the Tidal Inlets of Ennore Creek and Pulicat Lake, North Chennai Coast, Southeast India

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ABSTRACT

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The Ennore Creek and the Pulicat Lake are located north of Chennai city and provide subsistence for a large part of fishing community. The frequent closure of their mouths (inlets) cause problems in fishery. This study has been carried out to identify the morphological changes taken place at the inlets of Ennore Creek (Latitude 13°14'10" N and Longitude 80°19'00" E) and Pulicat Lake (Latitude 13°27'40" N and Longitude 80°19'00" E). Survey of India Toposheet for the year 1974 in 1:50,000 scale was used as a base map and IRS 1A and IRS 1D satellite imagery for 1990 and 1998 were compared with the base map for Pulicat Lake inlet. Shoreline survey has been carried out periodically along the coast adjoining the inlets to find out the morphological changes. Remote sensing satellite imagery of IRS 1D PAN data of 5.6m resolution for 27th March 1999 was used as a base. Data collected as UTM coordinates using real time KGPS during shoreline survey during 2000 and 2001 have been plotted on the image and joined as a shoreline using ArcView GIS 3.2 software. From the study it was observed that enormous accretion has taken place in the inlets, which led to the closure of mouth in recent years. In the Pulicat Lake inlet about 170 m of accretion has taken place during 2000-2001, which has led to the closure of mouth during 2001. In this study for coastline simulation, a numerical model, LITLINE module in LITPACK model has been adopted. Model was run by introducing two jetties on either side of the inlets of Ennore Creek and Pulicat Lake in order to have the ideal solution for eliminating the problem of frequent closing of inlets. It has provided fruitful solution of permanent opening of the inlets. Therefore it is concluded that immediate mitigation measures such as construction of parallel jetties on both the sides of the inlet and/or continuous dredging are to be carried out. It is suggested that a long-term monitoring is essential to have the better understanding and future planning.

ADDITIONAL INDEX WORDS: *Shoreline survey, Remote Sensing, GIS, Numerical modeling.*

INTRODUCTION

The tidal inlets along Chennai coast could not maintain equilibrium throughout the year because of reduced tidal prism on the estuarine side due to change in characteristics of controlling parameters such as wind, river flow, wave, tidal prism, inlet geometry, sediment supply, etc., as explained in COASTAL ENGINEERING RESEARCH CENTER STAFF (1998). The 25 km stretch of coastline, from the Ennore in the south up to the Pulicat Lake inlet in the north is a highly threatened coastal ecosystem, due to the several developmental interventions (SANJEEVA RAJ, 1999). In the present study morphodynamics of two tidal inlets namely, Ennore Creek and Pulicat Lake, located on the north of Chennai city, Bay of Bengal coast of India (Figure 1) has been studied.

STUDY AREA

The Ennore Creek inlet is located at Latitude 13°14'10" N and Longitude 80°19'00" E on the southeast coast of India about 20 km north of Chennai city. The river Kortalaiyar, flowing in the direction of west to east confluences with Bay of Bengal at Ennore passing through the Ennore Creek south of Ennore Port. Two thermal power stations namely, Ennore Thermal Power Station and North Chennai Thermal Power Station located on either side of the Ennore Creek are depending on the creek for coolant water. The Ennore and North Chennai Thermal Power Stations, draw 23 cu.m/sec and 27 cu.m/sec of seawater respectively through Ennore Creek (VAZE *et al.,* 2001). Pulicat Lake is the second largest brackish water lagoon in India. It opens through a narrow opening into the Bay of Bengal at the southeastern end near the Pulicat town. The Pulicat Lake inlet is located at Latitude 13°27'40" N and Longitude 80°19'00" E at a distance of about 40 km from Chennai city, Southeast coast of

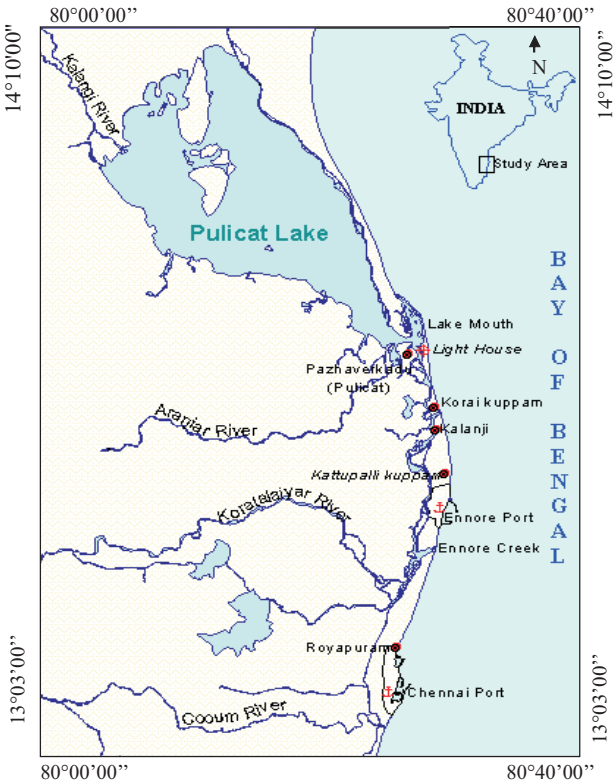

Figure 1. Study Area Map

India. The Pulicat Lake is rich in fish and prawn resources and nearly 50,000 fishermen are living in fringes of the lagoon. The Pulicat Lake is surrounded by 120 villages and two major islands namely, Venadu and Irakkam. The tidal inlet of Pulicat Lake, located at the northeast of Pulicat town is the only opening for the entire lake. This mouth is also the gateway of the local fishermen in the mainland to go in for fishing in the sea.

MATERIALS AND METHODS

Survey of India Toposheet for the year 1974 in 1:50,000 scale was used as a base map and IRS 1A and IRS 1D satellite imagery for 1990 and 1998 were compared with the base map for Pulicat Lake inlet for identifying the morphological changes. Shoreline survey has been carried out periodically along the coast adjoining the inlets of Ennore Creek and Pulicat Lake in order to find out the changes in the configurations, during the year 2000 and 2001. For the survey, a most accurate real time Kinematic Global Positioning System (KGPS), (GPS System 500 Model (Leica Make)) was used. In this equipment, a GPS receiver measures the incoming phase of the satellite signals to millimeter precision. All the data points are stored automatically as UTM coordinate system. The post-processing software, SKI-Pro, is used to process the observations taken by the receiver in order to compute baselines and coordinates.

Remote sensing satellite imagery of IRS 1D PAN data of 5.6 m resolution for 27th March 1999 was used as a base map. Shoreline for the study area from the imagery has been identified and digitized as a baseline and geocorrection has been carried out using ERDAS Imagine Software (8.4 version). Data collected as UTM coordinates using real time KGPS during shoreline survey in November 2000 and September 2001 have been plotted on the image s as a shoreline using ArcView GIS 3.2 software. Satellite data were geo-referenced with measured control points along the compound wall of North Chennai Thermal Power Station and Pulicat Lake. Accuracy has been checked with the measured points on north and south breakwaters of Ennore Port and it shows good agreement. Based on this, configuration of the shoreline during the years 1999, 2000 and 2001 have been identified. Accordingly the resulting accretion or erosion along a particular stretch has been measured using ArcInfo 3.5.2 software.

Numerical modeling is a technique whereby the physical environment of the shoreline can be investigated using computer technology. In an integrated system, if digital data are available, data for numerical modeling could be organized in GIS and provided to the modeling system (LI *et al.,* 1998). LITLINE module of LITPACK model of Danish Hydraulic Institute (DELFT HYDRAULICS INSTITUTE STAFF, 1998) has been used for the modeling study. Field data collected during various periods (KASINATHA PANDIAN, 2002) were used as input for the model. The system of numerical models available in LITPACK software enables one to determine longshore current and distribution of sediment concentration in vertical direction, which ultimately determines sediment transport. Littoral drift mainly depends on wave climate, sediment characteristics and orientation of coastline. In order to identify the morphological changes on the shoreline, LITLINE module was run by introducing two jetties at the inlets of Ennore Creek and Pulicat Lake as management options in order to have the ideal solution for eliminating the problem of frequent closing of inlets. The results of the model are discussed in the following section.

RESULTS AND DISCUSSION

Ennore Creek Inlet

Shoreline survey has been carried out along the coastline near Ennore Creek during 2000 and 2001 in order to identify the changes on the shoreline and their impacts. Changes that took place between these years have been measured for every 500 m distance and the results are presented. From Figure 2(a), it is clearly seen that enormous accretion is taking place in the region. Whereas erosion is taking place at just north of Ennore Creek (3000 m) of about 13.58 m during 1999-2001. Actually that is not the erosion. Due to dredging activity the shoreline shows eroding nature. It is clearly seen from Table 1 that accretion is taking place in the adjacent coast of Ennore Creek inlet during both the years. This has caused continuous dredging to keep the mouth open. The enormous accretion is due to the construction of Ennore Port in the further north. The Ennore coast was accreting, earlier to the construction of the port also. Earlier the accretion has taken place for about a distance of 9 m during the 20year period of 1978 to 1998 (INSTITUTE OF HYDRAULICS AND HYDROLOGY STAFF, 2000). But it is confirmed by this study that the accretion rate has increased tremendously due to the construction of Ennore Port.

Table 1. *Shoreline Changes Observed During 1999 to 2001 at Inlet Regions of Ennore Creek and Pulicat Lake.*

S. No.	Changes in Shoreline During the Year (in m)			Remarks
	1999 to 2000	2000 to 2001	1999 to 2001	
Ennore Creek Inlet				
1	8.67	-3.37	5.30	Southern edge of Ennore Creek inlet (2500)
2	-18.29	4.71	-13.58	Northern edge of Ennore Creek inlet (3000)
3	-11.81	27.13	15.32	Northern side of Ennore Creek (3500)
4	27.14	37.59	64.73	Northern side of Ennore Creek (4000)
Pulicat Lake Inlet				
1	- 21.40	41.69	20.29	Southern end of the region (24200)
2	20.96	22.23	43.19	Southern side of the mouth (27000)
3	53.74	148.83	202.57	Pulicat Lake inlet (27800)
4	-165.97	169.40	3.43	Northern side of Pulicat Lake inlet (28200)

As a management option to keep the mouth of the Ennore Creek open permanently, numerical modeling study has been carried out. Two jetties have been introduced on the coastline, one at the south and the other at the north of the inlet and the LITLINE module has been run. The long shore movement of sand on beaches manifests either as accretion or erosion whenever this natural movement is obstructed through the construction of man made structures like jetties, breakwaters, groynes, etc. Such structures act as barriers to the littoral drift, causing a build up of the beach on the updrift side and simultaneous erosion on the downdrift side. The erosion of coastal property has severe consequences and for this reason, a detailed study of the quantities of littoral drift and the processes that produce this movement is important (KOMAR, 1976). Therefore, the jetties have been considered as 450 m and 250 m long in the south and north of creek respectively and the centre of the jetties have been kept at the existing shoreline in the 0th year. Simulation has been run for a period of 10 years. From the simulation, it is obtained that in the immediate north of northern jetty, erosion will take place at a rate of 156 m during 1st year and 218 m during the 2nd and 3rd years and then a decreasing trend of erosion has been obtained as 206 m, 182 m and 171 m for 5th, 8th and 10th years respectively. From the figure, it is understood that erosion will take place within a distance of 1000 m from the jetty and afterwards accretion will take place. From the output it is seen that from the 10th year onwards the coastline will stabilize since an equilibrium state will be reached by that time.

Likewise, in the immediate south of southern jetty accretion will be taking place at a rate of 176 m in the 1st year after the construction of jetty, whereas, from 2nd year to 10th year the accreting rate will be stabilized at 188 m from the initial coastline. Therefore, it seems that after the construction of

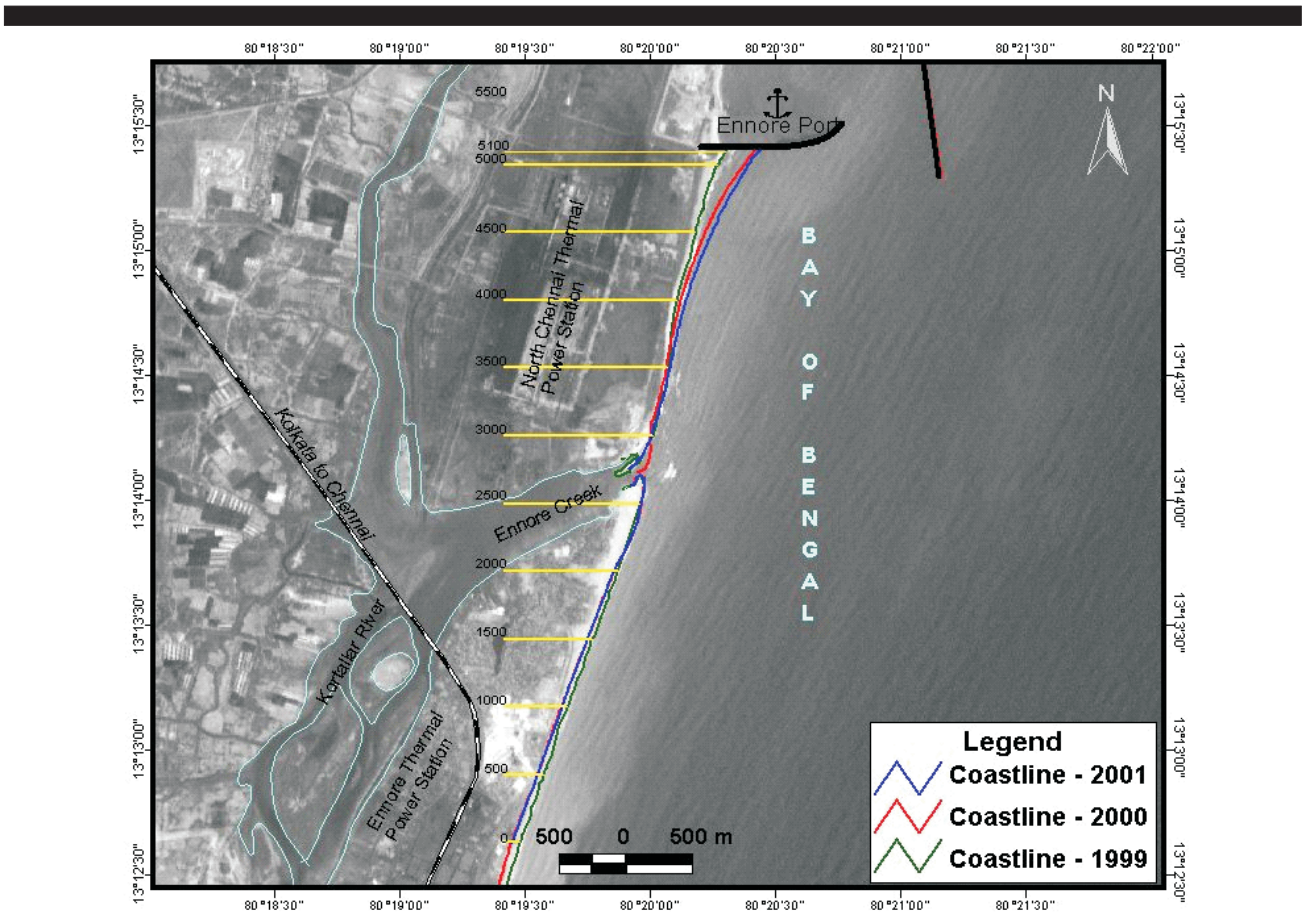

Figure 2. (a) Shoreline changes at the inlet of Ennore Creek .

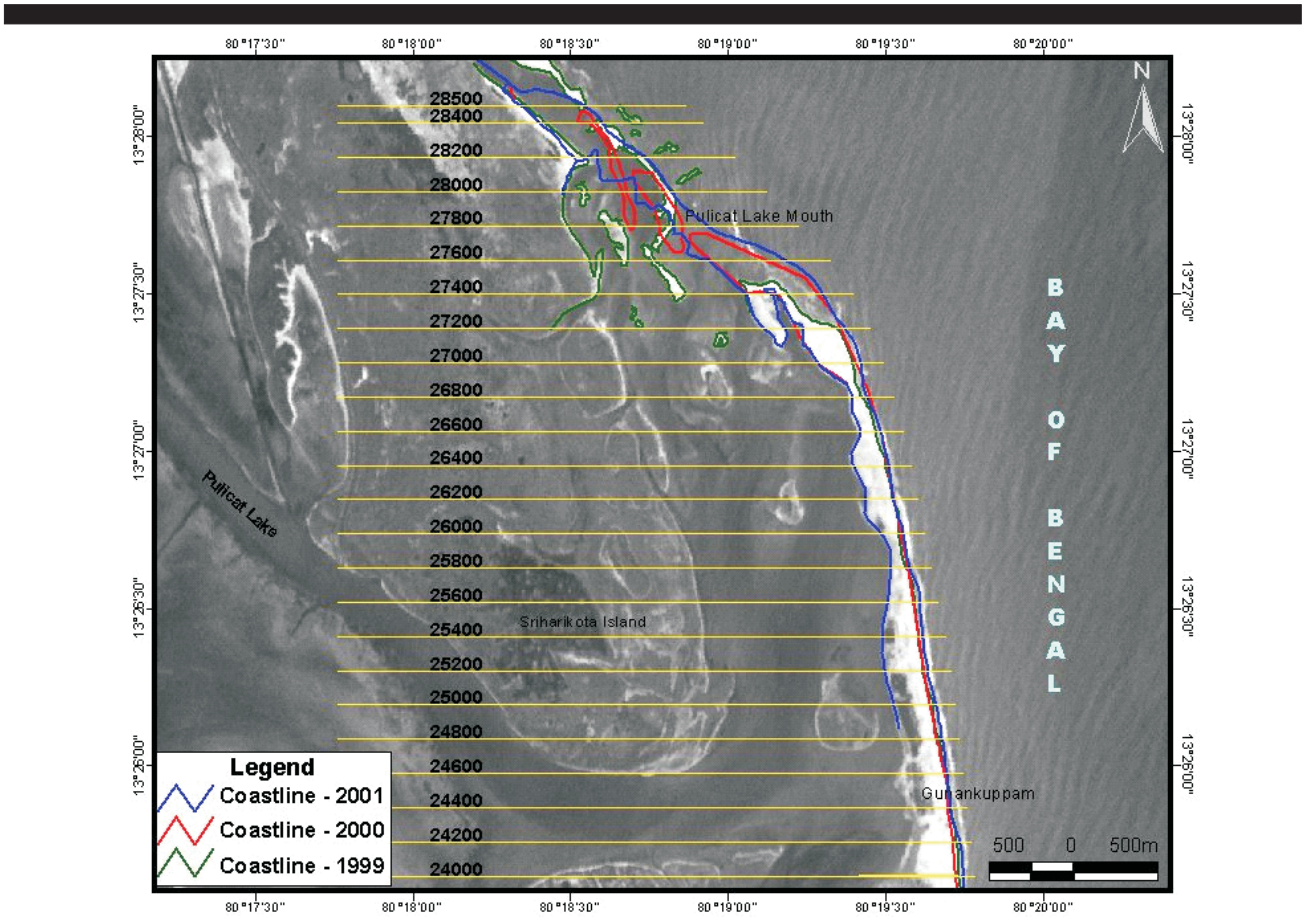

Figure 2. (b) Shoreline changes at the inlet of Pulicat Lake during 1999 to 2001.

jetties on both sides of the mouth, the shoreline will be stabilized from the 10th year onwards on both sides, i.e., attaining an equilibrium condition. This has been confirmed by various researchers by applying the same modeling packages from Danish Hydraulic Institute (LANKA HYDRAULIC INSTITUTE STAFF, 2000; SHARMA *et al.,* 2001; GALAPPATTI, 2001).

Pulicat Lake Inlet

The fish and prawn population of the backwater lagoon depends on the entrance channel of the Pulicat Lake. There are around 20 villages near the bar mouth region on the mainland side. In the recent times the tidal inlet of Pulicat Lake is experiencing frequent closing most part of the year except during monsoon seasons. Hence the salinity of the lagoon rises up and the ecology of the lake is being disturbed which inturn restrict the fish population of the lagoon and thus affects the fishermen's livelihood security.

In order to identify the morphological changes, configuration of mouth during 1974, 1990 and 1998 are mapped using remote sensing and GIS techniques and it is clearly demonstrated that there is a drastic changes in the configuration of the tidal inlet over the years. It is clearly seen that shape of the inlet has changed drastically over a period of time. The results of shoreline survey during 2000 and 2001 were plotted over satellite image of 1999 (IRS PAN data) and presented in Figure 2(b). The orientation of the coast has changed by 80º towards west at Pulicat and the inlet is aligned to north with three openings with an average width of 15 m and a depth of 1.5 to 2 meters during November 2000. Figure 2(b) and Table 1 clearly reveal that the entire zone is prone to accretion during the period of study. At the southern end of the zone (24200 m), the tune of accretion is 20 m and at the southern side of the mouth (27000 m) it is around 40 m during 1999-2001. At the inlet (27400 m) about 200 m of accretion took place during 1999-2001 and at northern side of the mouth (28200 m) about 170 m of accretion took place during 2000-2001 alone. Due to this severe accretion the tidal inlet of Pulicat Lake has been closed from April 2001 until the start of northeast monsoon period (November 2001). This has happened again during 2002 also. The closure of bar mouth has taken place after a gap of 26 years since 1975 as reported in RAMAN, *et al.* (1977). This has caused the choking of the mouth, which is the only active opening to the entire Pulicat Lake for the exchange of seawater with the Bay of Bengal. This has resulted in reduction of fish catch due to non-exchange of seawater with the lagoon as reported in INSTITUTE FOR OCEAN MANAGEMENT STAFF (2001). Tidal fluctuation within the lake is to the maximum of 0.6 m during the active bar mouth opening.

To keep the inlet of Pulicat Lake open, as a management solution, two jetties have been introduced on both the sides of the inlet and a simulation model LITLINE was run. The jetty on the southern side of the mouth has been considered as a longer one having a length of 300 m and the northern jetty having a length of 200 m based on the coastline configuration after trial and error method. The centre of the southern jetty has been kept at the existing shoreline and landside ends of both the jetties have been kept on the same baseline. Simulation has been run for a period of 10 years. The results showed that in the immediate south of the southern jetty accretion will be taking place at a rate of 92 m during the first year itself and the coast has stabilized at the same level till the end of the 10th year. But further south, at about a distance of 250 m erosion will be taking place at a rate of 67 m, 108 m, 175 m and 250 m during 1st, 2nd, 5th and 10th years respectively and the trend is gradually reducing to get stabilized at a distance of 3 km further south. This is because of the configuration of the coastline south of the inlet. Simulation results for the north shows that erosion will be taking place in the immediate north of northern jetty for a distance of 50 m in the first to third years and 58 m, 75 m and 100 m during 5th, 8th and 10th years respectively. This eroding trend has been gradually decreasing towards north up to a distance of 1 km and then accretion will be taking place. Maximum accretion is obtained at a place 2.5 km north of northern jetty for a width of 33 m, 75 m, 100 m, 133 m and 158 m during 1st, 3rd, 5th, 8th and 10th years respectively. Afterwards a declining trend was seen and naturally the shoreline will get stabilized further north after reaching equilibrium conditions.

CONCLUSIONS

The simulation model suggests that the frequent closure of the inlets of Ennore Creek and Pulicat Lake could be prevented by the construction of parallel jetties. Hence, it is recommended that authorities concerned should take mitigation measures by constructing parallel jetties on both the sides of the inlets of Ennore Creek and Pulicat Lake, to keep the inlets alive. Otherwise continuous dredging operations are to be carried out. It is recommended that a long term study should be carried out in the study region to monitor the future effects on the inlets.

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