Mapping of spatial and temporal variation of shoreline in Poompuhar using comprehensive approach

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Survey of India topographic map, Remote Sensing satellite imageries, NHO-Chart, GSI maps and ground-truthing data collected by Tamil Nadu PWD over the past four decades have been used to extract the shoreline during the various periods. In addition NIOT has marked the High Tide Line (HTL) during the years 2006 and 2013 which gives real time information on the behaviour of the shoreline. Data is processed and analyzed using software ERDAS for image processing and Arc-GIS for geospatial analysis respectively. Rate of shoreline changes are estimated by overlay analysis in GIS environment. The influence of natural and anthropogenic processes along the coast which is found to modify the shoreline configuration has been analyzed. Shoreline has been mapped using Landsat satellite data and Tamil Nadu PWD ground truthing data for 1990, 2000 and 2006. It is observed that the shoreline change is more than 30 meters between 1990 and 2006. Studies include linking the natural impacts due to geology of the region and coastal geomorphology influenced by the River Cauvery on the shoreline change.

[Keywords: coastal geomorphology, coastal dynamics, shoreline, erosion, accretion, coastal zones.

Introduction

Known as Kaverippattinam in the ancient Sangam literature, Poompuhar is one of the notable ancient Chola ports in the maritime history of Tamil Nadu. The site is located at the confluence of River Cauvery with the Bay of Bengal on the east coast of India. Description of Poompuhar as the capital port city of the early Cholas are found in the Tamil epics Silappathikaram and, Manimekhalai and Sangam period literature such as Pattinappalai, Ahananaur. Poompuhar's dominant role in the transoceanic trade and commerce with many countries has existed since the beginning of the Christian era. World over, several of the ports towns that existed along the coastal regions have vanished or submerged probably due to coastal erosion, sea level changes, neo-tectonic activity and causes like tsunami etc.

It is observed that the coastal zone which is the zone of transition between the land and sea is dynamic in nature. Due to dynamic nature of coastal zone, the shoreline adjusts itself to maintain equilibrium with changes in land and marine processes. Influences of sea level changes, hydrodynamics, tectonics and human intervention on the coastal processes play a major role in influencing the coastal zone dynamics. In this context, shoreline changes from 1990 to 2013 off Poompuhar has been studied in this paper using comprehensive information from satellite images, physically observed shoreline data, Real Time Kinematic (RTK) surveys and core samples.

Materials and Methods

Geological Setting

The coastal regions of south Arcot, Tanjore and Ramanathapuram is a marine basin in which the estuarine upper Gondawana beds are overlain, on the sea ward side, by marine strata extending from the Albian to the Recent. The stratum attains a thickness of 2500 to 3000m near the coast and must be thicker offshore and in Palk bay. On the east coast of India, patchy submerged shorelines were found between ±30 to ±100 m depth, probably formed during the Late Pleistocene – Holocene transgression.

Sedimentation during the Tertiary period was marked by repeated transgressions and regressions and the Quaternary sediments in the basin consist of sandstones, pebbly sandstones and clays. Two rivers join the Bay of Bengal in this area namely Kaveri, to the south of Poompuhar and Palayar to the north of
Poompuhar. Apart from these rivers, minor streams join Bay of Bengal to the north of Poompuhar.

The sediments in the near shore areas mostly comprise a mixture of clay and sand up to a water depth of 10 m further seaward it changes to sandy. In addition to sands some brickbats and stone blocks have been found between 6 and 9 m water depths. The sea bed is observed to have a gradual slope towards offshore. Beach rocks were observed at various water depths between 8 and 15 m for a stretch of more than 20 km between Tranquebar on the south and Kadaikkadu on the north.

Description of physical characteristics of the site is provided in Table 1.

| Geology | Archaeans, Cretaceous deposits, Quaternary sediments |
| Geomorphology | beach ridges selectively present beach width-68–98 m in the zones of enrichment of heavies |
| Coastal configuration | N–S, NNW–SSE |
| Shelf topography | moderately sloping |
| 20 m contour from shoreline | 8–10 km |
| Wave height range | 0.75–1.25 m |
| Wave height range during cyclones | 3–4 m |

Source: N. Angusamy and G.V. Rajamanickam

**Tectonic Setting**

The South Indian (Peninsular) shield which includes both the eastern and western continental margins of India is not as stable as it was originally presumed. The importance of intraplate seismicity within this shield has recently been realized following devastating earthquakes that occurred during the last few decades. It is also significant to note that most of the Precambrian tectonic lineaments in this Shield are oriented in either a NW–SE or W–E direction, joining the eastern offshore. Major tectonic lineaments and earthquake have locations in the South Indian shield. The coastal/offshore regions of Ongole and Pondicherry have been identified as zones of weakness where neotectonic activity has been established. The Pondicherry offshore experienced an earthquake of magnitude 5.5, in 2001, which was a fairly large event for the South Indian shield. This earthquake was due to reactivation of (MBA) Moyar-Bhavani-Attur lineament, PCL Palghat—Cauvery lineament.

**Data and products**

**Satellite Data**

Landsat TM and ETM+ imageries for with spatial resolution of 30 m have been used for shoreline mapping during the years 1990, 2000 and 2006.

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**PWD Data**

Tamil Nadu PWD, have collected data all along the Tamil Nadu coast over the past four decades. Stationary pillars have been erected near Poompuhar from where distance of highest water line at a particular time on a particular day of a year has been marked using tape. This data has been used for mapping the shoreline during the various years. Shoreline change is derived from the Landsat data for the years 1990, 2000 and 2006 and compared with the PWD field data measurements.

**Survey Measurements**

NIOT has carried out RTK surveys at 100 meter intervals in the year 2011 for marking the High Tide Line (HTL) using the tidal prediction model. The HTL has been transferred to a map. RTK surveys have been repeated at 30 meter intervals over a length of 3.5 kilometres along the shoreline in the year 2013. The difference in HTL locations on the map provides a measure of erosion at the site.
NIOT carried out bathymetry survey over a 2.2 km x 1.2 km coastal stretch in March 2006. The shoreline is generally parallel to the coast with a gentle seabed slope. The depth contours are also parallel to the coast with 3 to 5 m contours located over 200 m away. The ‘0’ contour exists at a distance of 100 m from the shoreline indicating steeper slopes possibly due to erosion from high energy wave action. The MIKE21 digitized bathymetry is shown in Fig. 5.

Sample Collection

Soil samples were collected along the Poompuhar coastal zone to determine possible trends. Grab samples were collected along the shore at 33 locations along the coast. Core samples were collected in 1.5 m water depths at 11 locations at intervals of 300 m. The length of cores ranges from 20 to 33 cm. It is seen from the lithologs of the cores that the southern part of the area is essentially terrestrial with samples typical of alluvial regime, where in there is a presence of uniform well rounded to sub-rounded sand grains without any shell fragments and the absence of salty taste. Northern part of the area is essentially marine with flatted nature, present shell fragments.
The five various shoreline features have been merged within a single attribute table, to enable the multiple coastline files to be appended together into a single shape file for further analysis. Digital Shoreline Analysis System (DSAS) version 4.2, an extension of ESRI ArcGIS software was used to calculate shoreline rate-of-change statistics from a time series of multiple shoreline positions.

The inputs comprise comprehensive data from field measurements, remote sensing imageries, secondary data from PWD and analysis of core samples in the intertidal areas. Landsat shoreline data of years 1990, 2000 and 2006 has been compared with the PWD field measurements and RTK data of 2011 and 2013. Published secondary information on shoreline change is also analyzed to arrive at the rate of shoreline change.

**Results**

Shoreline changes have been mapped using satellite imagery in the years 1990, 2000 and 2006. Shoreline has been extracted from the respective years, validated with data measured by PWD. RTK surveys have been carried out by NIOT in the years 2011 and 2013 to map the HTL. Difference in the HTL provides measure of shoreline change. It is observed that shoreline change of more than 30 meter is mapped off Poompuhar coast between 1990 and 2013.

Analysis of core samples in the southern stretch (upto a distance of 700 m from Cauvery confluence) indicate presence of rounded soil particles which are of terrestrial origin. The core samples collected along the northern stretch indicate presence of angular and sub angular grains which are of marine origin. This indicates possible subsidence of the southern shoreline just north of River Cauvery confluence. It is possible due to lack of sediment input from the Cauvery. Analysis of grab samples indicates terrestrial soils along the surface.

**Discussion**

Temporal shoreline change have been extracted from the Landsat Satellite imagery in the respective years 1990, 2000 and 2006 and ground truthing data of Tamil Nadu PWD from 1980 onwards up to 2009. Distance of high water line has been marked based on ground measurements on a particular day at a particular time with reference from the PWD pillars.
RTK surveys have been carried out along a 3.5 kilometre stretch starting from the Cauvery river confluence point up to an aquaculture pond located northward at 30 meter interval in the year 2013 and over a 1 kilometre stretch at 100 meter interval during 2011. From RTK and Landsat data shoreline has been extracted and validated with PWD shoreline data. Based on comparison of the various data sources, it is observed that shoreline has eroded by 30 meter between 1990 and 2013.

Shoreline erosion in Poompuhar from 1979 to 1988 is calculated as 8 meter. The rate of shoreline change 0.65 meter erosion per year as per ICMAM report (2009).

![Shoreline change off poompuhar from 1990 to 2013](image)

Conclusions

Coastal erosion assessment for the Poompuhar coast has been carried out using RTK Survey, Landsat Satellite imagery, PWD data. The results show approximately 30 meter erosion for 23 years period. Analyses of core samples confirm presence of soils of terrestrial origin in the southern stretch while northern stretch comprises sediments of marine origin. The impact of geological phenomena, coastal geomorphology and tectonic setting of the area on the erosional trend cannot be ruled out.

Geomorphology of the area is characterised by beach ridges near Porto Novo 7 Km away from the coast line, while in Poompuhar the ridges are located nearshore. Even though the shoreline is straight, trending N-S with beach ridges tapering from North to South there is possibility of land submergence as observed from the cores. It can be inferred that the shoreline has retreated 30 meter between 1990 and 2013, at the rate of 1 meter per year. Predicted shoreline in 2020 would be 7 meter inland in the absence of any human intervention.

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References