Marine Geographic Overview of Coastline Changes with a View of Locating Submerged structures in Ancient Harbour Poompuhar

Dr. T. Sasilatha[1], Mr. M. Ashok Kumar[2], Dr. T. Baldwin Immanuel[3], Mr. H. Mohammed Fadil[4], Mr. G. Mohendran[5]

[1]Professor and Dean, deaneeem@ametuniv.ac.in
[2]Project Associate, ashokeee@ametuniv.ac.in
[3]Associate Professor, bimmanuelt@ametuniv.ac.in
[4]Junior Research Fellow, fadileee22@ametuniv.ac.in
[5]Project Associate, mohendran.dpp@ametuniv.ac.in

ABSTRACT
Tamil Nadu's coast is lined with numerous ports. A coastal investigation was carried out along the submerged harbour city of Poompuhar. Many historic ports are placed far hinterland whilst the remaining ports are located on the coasts and partly submerged underneath the sea. The earliest evidence of maritime activity along the Indian coast dates to the fourth millennium B.C. As a result, numerous outlying settlements were submerged in the sea or relocated to the hinterland as a result of coastline changes. Geospatial evaluation of coastline modifications at a selected location consists of topographic sheets, satellite imageries, and collected MBES data across the study area. Archaeological websites play a prime position in figuring out palaeo-coastline. The development of geographic information system (GIS) analysis capabilities can be applied in archaeology research. The current state of the ancient port of Poompuhar and the possible causes of shoreline changes at various locations along the coast are discussed in this paper. The semantic representation of Poompuhar is done using the MBES data procured by the research vessels of the National Institute of Ocean Technology.
KEYWORDS: Geospatial Evaluation, Coastline, shoreline erosion, MBES data, GIS, Poompuhar.

1. INTRODUCTION

Poompuhar was once a bustling ancient city and port of Tamil Nadu, India, and is a historical and coastal port that arose with the early Chola kingdom's increasing maritime trade. Poompuhar, a busy port and ancient trade town represent Tamil culture and civilization up to 200 CE. Puhar is situated along the sea coast, near the mouth of the Kaveri river. During AD 500, large shore waves destroyed and washed away the city. Submerged parts and scattered destruction have been discovered in onshore and offshore excavations along the Bay of Bengal's coastal lines in Tamil Nadu. The Sangam (300 BC-AD 300) and post-Sangam Tamil literature Purananuru, Agananuru, Natrinai, Pattinappalai, Silappathikaram, and Manimagalai have detailed the culture and social systems, buildings, architecture, land use/cover, maritime history, and the impact of intercontinental trade on local systems. The significance of Silappadikaiam as a sourcebook for the archaeologist lies in the reality that Poompuhar is stated to have prolonged over a region of four Kavatham about 30 square miles. Later excavations revealed scattered Poompuhar remains along the coast from Kadaikkadu in the north to Tharangampadi in the south, as well as up to 2-4 kilometers west on the

landward side and up to 8 kilometers east to a water depth of 8-15 meters inside the Bay of Bengal. (Sundaresh et al., 2004; Gaur and Sundaresh, 2006; Sundaresh and Gaur, 2011; Tripati et al., 2017).

2. OFFSHORE/ONSHORE SURVEY OF THE STUDY AREA

Excavation both on land and sea was required to reconstruct Poompuhar's early history and the people's social, economic, and religious lives, as well as their contribution to India's cultural expansion in Southeast Asia. The major goal of the survey was to conduct a bathymetric investigation and locate wrecks or structural remains using side scan sonar, echo sounders, and magnetometers. The exploration area spread from Vanagiri to Nayakkankuppam, approximately 20 kilometers along the coast and approximately 8 kilometers in the sea (Rao, S.R. 1988).

The survey was limited to certain areas with a depth of 7-23 meters, and the slope was found to be steeper in the shallow area. The slope changes sharply at a depth of about 17 meters, after which the slope is gentle. Echo images, when correlated with sonography, show that the sea floor is covered with sand. There is no penetration to a depth of 7-8 meters in the coastal region. The presence of acoustically transparent clay elsewhere in the area is indicated by an echo sounder, which shows the penetration of 2-3 meters.

3. METHODOLOGY

3(a). Multibeam Echo Sounder (MBES)

Bathymetry is the study of the depths and surfaces of bodies of water. Bathymetric data is used to assess the effects of climate change, as well as land subsidence, beach erosion, and sea level rise. A hydroacoustic beam is directed by a multibeam echo sounder (MBES) to measure the depth beneath the floating platform (Fig1). The MBES detects the vertical elevation between a shoreline structure and its transducer. The MBES emits several signal beams in various directions. The hydroacoustic beam's delay between transmission and reception after its reflection off the bottom is used to determine depth. Understanding the sound velocity and beam directions is essential.

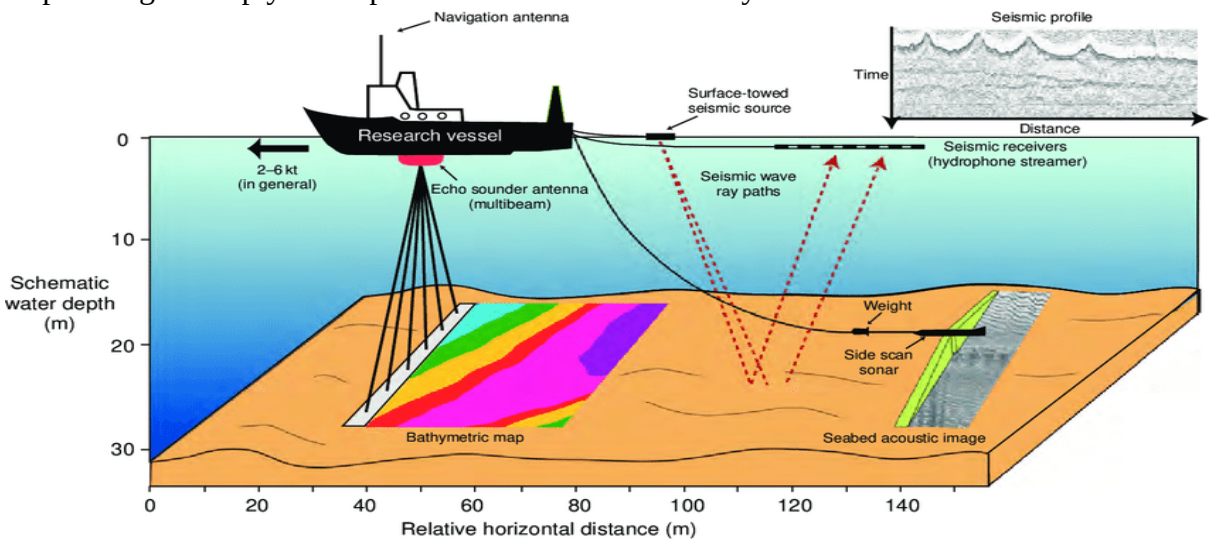

Fig 1: Representation of Research vessel undertaking Geographic survey

Bathymetric data obtained from multibeam echo sounders is one of the fundamental data types used in seafloor system modeling. The collected MBES data, along

with previous and current satellite images, are used in geospatial analysis of shoreline changes in the Poompuhar port area. This study used topographic maps and satellite images to identify shoreline shifts in the coastal region. Once completed, manual beach digitization was used to obtain shores from various years.

3(b). Sub-Bottom Profiling (SBP)

Sub-Bottom Profiling (SBP) equipment can be used to determine the physical characteristics of the ocean floor. Small-scale sedimentary structures and processes have been measured with high temporal and geographic resolution using sub-bottom profilers. Marine researchers have extensively adopted the systems due to their ability to collect data quickly and in an unobtrusive manner. Sound pulses are typically transmitted into the shallow sub-seafloor sediments by sub-bottom profilers using a single channel source. The sea floor and following buried sediment layers are reflected by sound pulses based on variations in acoustic impedance (hardness).

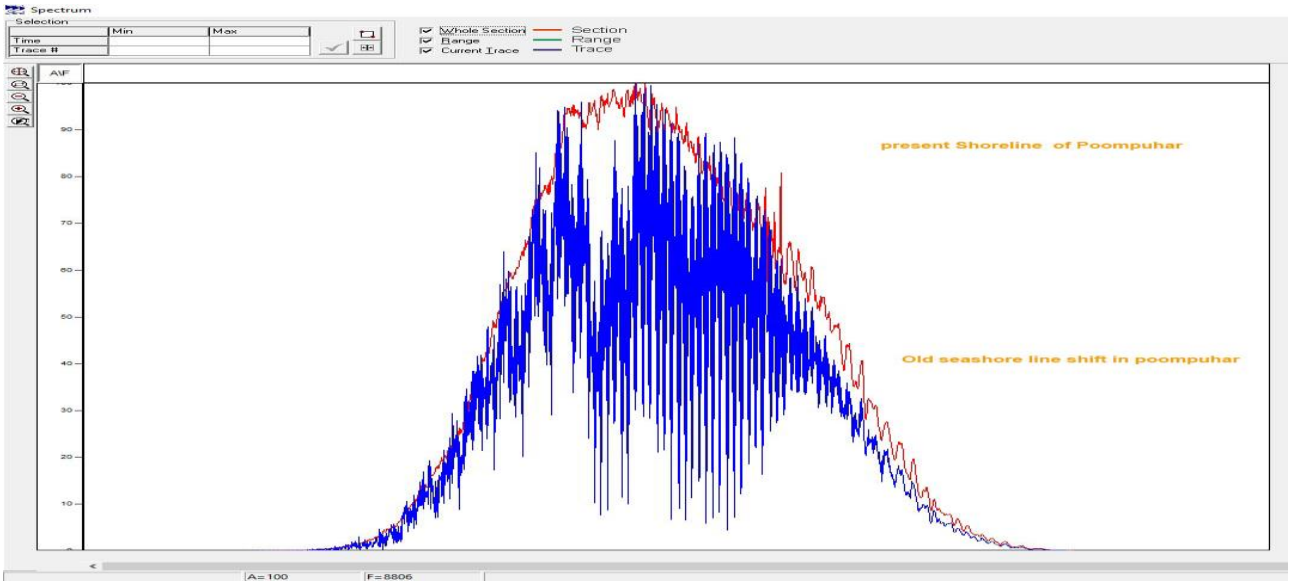

Fig 2: Sub Bottom Profiling in study Region

The density and the speed at which sound travels through a material determine its acoustic impedance. The submerged layers' depth is determined by how long it takes the sub-bottom profiler to return and record the signals (Fig 2).

3(c). Mapping ArcGIS

Shorelines are digitized using processed data procured from raw data from the National Institute of Technology. These digitized shorelines were then mapped for various years to analyze erosion and accretion at the study region. GIS is used to calculate erosion and accretion (Schmidt, B et al., 2021).

4. ANALYSIS

Coastal erosion has partially submerged coastal monuments such as Poompuhar, Vanagiri, and Tranquebar along the Tamil Nadu coast. During the archaeological research in the submerged area, several structural remnants, including fallen walls and scattered dressed stone blocks, have been found. A few steps lead to a stage and numerous other structural remnants. Because of solid submerged streams and Civilization, the structures were severely damaged and scattered. They are thought to be man-made and may be part of temple complexes based on their arrangement and

shape. The most precise possible date for the submergence of these structures is estimated to be around 1500 years based on archaeological confirmations on land (Sara et al. 2004). The major cause of the submergence of these structures is extreme coastal erosion prevalent in the region.

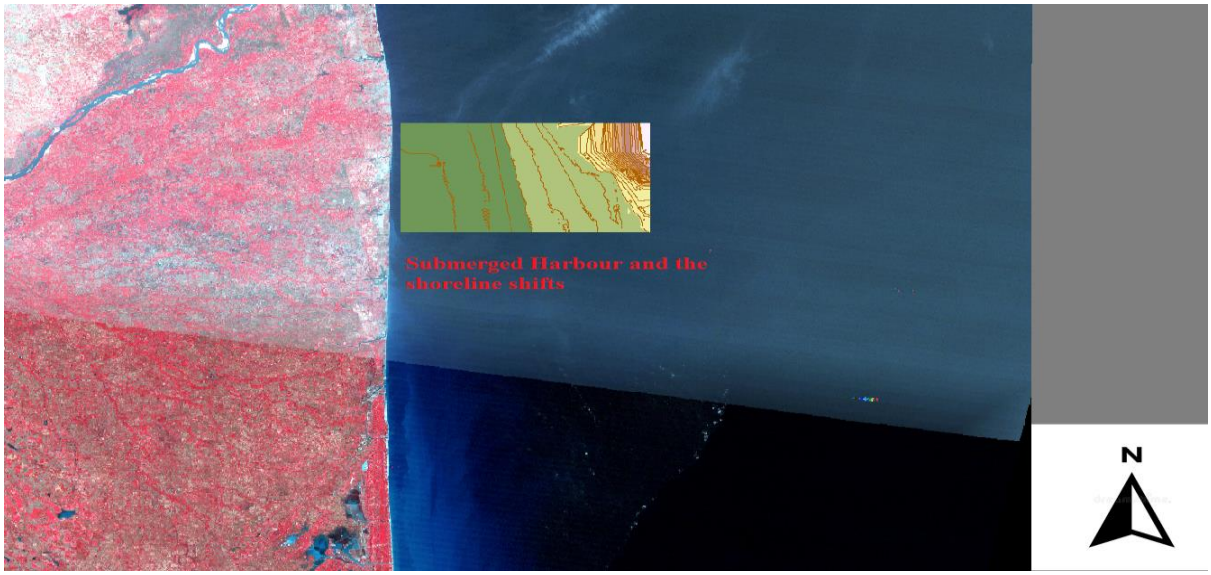

Fig 3: Model representing mapping of submerged port in ArcGIS

In the geospatial analysis of shoreline changes at a specific location, topographic maps, satellite images, and field data are all used. The movement of the coastline at various locations over time is detected in this work using topographic maps and satellite photos. Shorelines were manually digitized on-screen to collect shorelines from various years. ArcGIS 10.1 was used to implement this technique (Ajvazi. B et al 2019). After obtaining the vector layers of the shorelines from various years, ArcGIS computes the rate-of-change statistics from numerous historical shorelines. The results show how the shorelines in space have changed over time.

Fig 6: Terracotta ring well at submerged Poompuhar

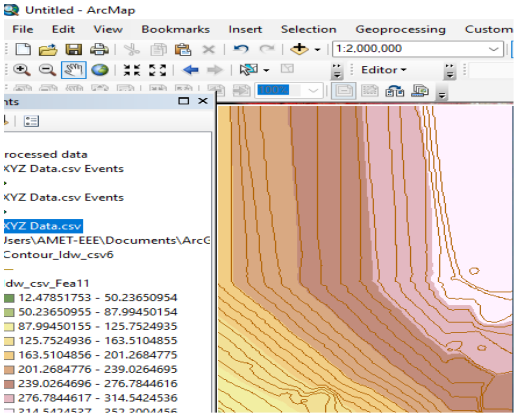

Fig 7: Shoreline shifts of Poompuhar

5. DISCUSSION AND CONCLUSION

Poompuhar is a flourishing port town with maritime activities with the rest of the world, including Rome, China, Ceylon, and South East Asian countries. The remnants of ancient villages that had been submerged

underwater were discovered during the maritime archaeological excavation off Poompuhar, and the submergence of these towns has been partially substantiated. Almost all of the archaeological information recovered during on- and off-shore explorations in and around Poompuhar consisted of Sangam Period brick structures, terracotta ring wells, storage jars, and clay patches. These structures were most likely the remains of a contemporary public building, wharf, and reservoir. The diving results validate the geophysical survey data. The discovery of megalithic pottery and associated ware, as well as other remains from the off-shore area, demonstrate that Poompuhar's ancient habitation extended beyond the present shoreline. The geomorphology of the zone like shoreline edges close to Port 7 Km absent from the coastline, whereas in Poompuhar the edges are found nearshore. It can be deduced that the shoreline has withdrawn 30 meters between 1990 and now, at the rate of 1 meter per year.

6. ACKNOWLEDGMENT

The first author Dr. T. Sasilatha Professor and Dean sincerely acknowledge the financial assistance received from the Department of Science and Technology (DST) - Digital Poompuhar Project, India.

7. REFERENCES

1. Vora, K.H. 1987: A note on geophysical explorations for marine archaeology off Tamil Nadu coast, India. International Journal of Nautical Archaeology, 16(2): 159-64
2. Tripati, S. 2017: Seafaring Archaeology of the East Coast of India and Southeast Asia during the Early Historical Period. Ancient Asia, 8:1–22
3. Sundaresh, Jayakumar, S., Gaur, A.S., Chandramohan P. and Jena, B.K. 2004: Submergence of Poompuhar - Study based on underwater explorations and coastal processes. 3rd Indian National Conference on Harbour and Ocean Engineering, NIO, GOA, 820-832.
4. Sundaresh and Gaur, A. S. 2011: Marine archaeological investigations on Tamil Nadu coast, India: an overview. In: Asia-Pacific Regional Conference on Underwater Cultural Heritage Proceedings (Eds: Staniforth, M. et al.). Museum Foundation of the Philippines, Manila, 233–248
5. Rao, S.R: Underwater Exploration of submerged towns near Tranquebar (Tarangambadi) on Tamilnadu Coast, RECENT ADVANCES IN MARINE ARCHAEOLOGY.
6. Rao, S.R. 1988 (cd.) Marine Archaeology of Indian Ocean Countries. Goa.
7. Schoff W.H. 1912 (ed.) Periplus of the Erythrean Sea, London.
8. Sundaresh*, R. Mani Murali, Jaya Kumar Seelam & A.S. Gaur: Shoreline changes along Tamil Nadu coast: A study based on archaeological and coastal dynamics perspective, Indian Journal of Geo-Marine Sciences Vol. 43(7), July 2014, pp. 1167-1176.
9. Sundaresh, ManiMurali R, Gaur A S, and Prachi Vaidya. Shoreline changes in Poompuhar – Tranquebar Region, Tamil Nadu, India – Gleaned from Archaeological and Remote Sensing evidence,. in presented in the seminar on"national conference on coastal processes, resources and management, 5-6, February 2010. 2010. at CESS, Thiruvananthapuram.
10. Suresh P K, D. P, M J, and G. N. Shoreline changes along the

Poompuhar and Tranquebar coasts of Tamil Nadu. in the Proceedings of the INCHOE-2004, Goa. 2004.

11. Henrico, I., & Bezuidenhout, J. (2020). Determining the change in the bathymetry of Saldanha Bay due to the harbour construction in the seventies. South African Journal of Geomatics, 9(2), 236–249.
12. Ajvazi, B., & Czimber, K. (2019). A comparative analysis of different DEM interpolation methods in GIS: Case study of Rahovec, Kosovo. Geodesy & Cartography, 45(1), 43–48.
13. Schmidt, B., Borchert, R., Gundlach, B. (2021): Bathymetry Model Generation and 3D Visualization Based on Multibeam Echo sounder Measurements, report on current research activities, Bochum University of Applied Sciences, Bochum
14. Rao T, Geophysical survey of marine archaeological sites off east coast of India. 1992. 14. Rao S, Underwater exploration of submerged towns near Tranquebar (Tarangambadi) on Tamilnadu coast. 1991.
15. NIO Tech. Report, Marine Archaeological Explorations in Poompuhar waters. 1997, National Institute of Oceanography, Goa. No.NIO/SP/13/97
16. Gaur A. S. and Sundaresh, Underwater Exploration off Poompuhar and possible causes of its Submergence, 1998, Puratattva, 28: 84-90.
17. Puliyur Kesigan, S. V. S., மண$ேமகைல $ல$ம் ைஉர$ம், Manimekalai Source and Text (Tamil), Saran Books, Chennai, 2021, p. 368.
18. Muthusamy, R., Kaveripoompattinam (Poompuhar): history through the ages, Blogger.com, 13 January 2017.
19. Ramasamy, S. M., Kumanan, C., Saravanavel, J. and Gunasekaran, S., Coordinates and chronology of the ancient port city of Poompuhar, South India. Curr. Sci., 2017, 112, 1112–1115.
20. Ramasamy, S. M. and Saravanavel, J., Remote sensing revealed geomorphic anomalies and recent earth movements in Cauvery Delta, Tamil Nadu, India. J. Indian Soc. Remote Sensing, 2020, 48, 1809–1827.