iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** XI **Month of publication:** November 2017

DOI:

www.ijraset.com

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue XI November 2017- Available at www.ijraset.com

Monitoring Shoreline Changes of the Puducherry Coast, South India: A Review and a Case Study

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Abstract: In this study an attempt has been made for an appropriate management strategy regarding the shoreline changes with the help of site specific real time field data collected from the Coastal Zone of Puducherry region. Field data's such as wave climate data, collected from the buoy recorder and suspended sediment collected from the sand trap can be used for the numerical model study. Comparison of the numerical model study can be made from the observation of real time shoreline changes using GPS and total station survey. This study is time consuming but trustworthy with other method and will help to resolve the issues related to site condition and could enable the field engineers to adopt a suitable method for any coastal related developmental works.

Keywords*: *Wave data, GPS, Total station, Numerical model etc.

I. INTRODUCTION

The management of a coast and its resources are an integral part of every countries economy. In most of the developed countries the coast are thrived by economic desire in the expense of ecological imbalance, coastal damages such as beach disappearance which has considerably reduced the tourism development.

A coast with sandy beaches is dynamic in nature which constantly changes with seasonal variation (Kumar et. al., 2010). The shoreline changes have become unpredictable these days due to various abnormal calamities such as human intervention, climatic changes and sea level rise making the situation more vital, severe, unstable and complicated (Kim IH and Lee J.L2009). In order to reach a state of equilibrium due to the above phenomenon, the shoreline changes it configuration (Pandian et al., 2004) by means of its sediment budget. This situation drives the coast towards unremitting erosion on one side, and accretion on the other thereby tagging the coast as vulnerably risk zone destroying the coastal environment. **(**Kannan R., Anand KV, Sundar V, Sannasiraj SA, Rangarao V (2013))

Accordingly a long-term and time-series monitoring of the shoreline change is indispensable for an effective coast management. Several studies were conducted on shoreline changes such as long term and short term shore line observation with the help of satellite images(Elraey et al., 1999) and (Maiti and Bhattacharya, 2009; Ford, 2013). Traditional ground surveying techniques by using surveying instruments and GPS (Hwesik Jang and two others, 2003: Seonho Choi, et al., 1996), Analysis on the beach profile (Thom and Hall, 1991; Dora et al., 2012) by observing aerial photographs (Anders and Byrnes, 1991; Jimenez et al., 1997; Kurosawa and Tanaka, 2001; Ford, 2013) taken on the location will improve in predicting shoreline changes.

The quantification of shoreline changes using remote sensing (Nayak 2002; Zuzek et al., 2003; Thieler et al., 2009) and GIS (Dolan et al. (1991), (Kana 2003) and (Cracknell, 1999) . Selvavinayagam (2008); Chand and Acharya (2010); Kumaravel et al. (2013); Usha and Subramaniam (1994); Usha et al. (2013); Anitha and Usha (2014a,b). Image overlay technique in predicting and forecasting shore line changes. in monitoring and understanding the long-term, seasonal and short-term shoreline changes (Chen and Rau 1998) and Gainau (2011).

For short term assessment study on shore line change, non-aeronautical cameras were used (Cheryl et al., 2000), (Noaa, 2003). Recently for continuous and long-term observation of shoreline changes, the study adopting a video monitoring system has been tried (Yoon, 2008).

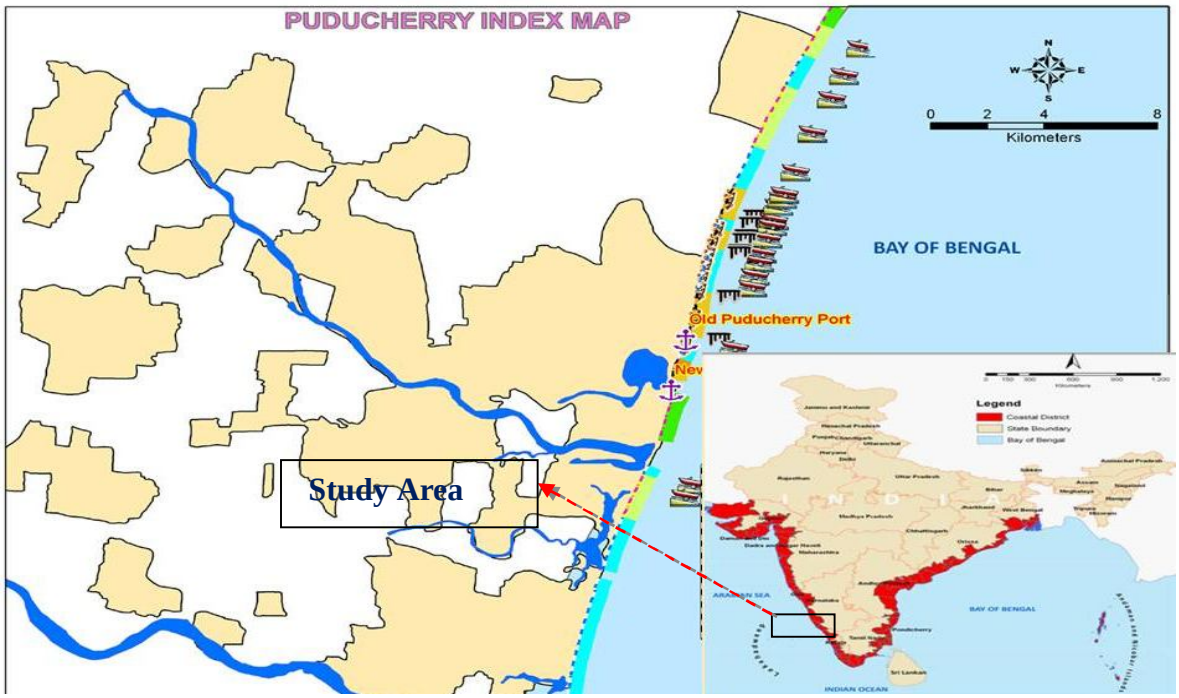

Fig. 1 Study Area of Pondicherry (Puducherry) Map

II. METHODS FOR MONITORING SHORT TERM AND LONG TERM SHORELINES CHANGES

A. Remote Sensing and GIS technique

Remote sensing and GIS techniques are used for short term (Dora G.U., Kumar V.S., Johnson G., Philip C.S., Vinayaraj P., 2012) and long term shoreline monitoring. Long term shore line changes can be better acknowledged using satellite imageries covering seasonal variation and calamities pertaining to the coast as a database in GIS with well defined Ground Control Points (GCPs) as coordinates. This method is extended to generate a simulated "shoreline proxy" model (R. S. Kankaraa, S. Chenthamil Selvana, Vipin J. Markosea, B. Rajana, S. Arockiaraja 2014), by compiling the shoreline position in digital format (Thieler *et al*., 2009) . Estimation of shoreline change using high resolution satellite images are used for the extraction of shoreline (Elraey et al., 1999) and its short term variability during seasonal changes. High-resolution stereo imagery techniques are used for results analysis and accurate resolution of coordinates. (Cheryl hapke, Bruce Richmond (2000), Eom, Jin-Ah, Choi, Jong-Kuk, Ryu, Joo-Hyung, Won, Joong-Sun,). Prediction of shoreline changes by the above methods are confidently used in calibrating and verifying numerical model developed for forecasting the long-term evolution of coastal changes.

B. Real time kinematic (RTK) Global Positioning System (GPS), fixed camera and video based technology

Real time kinematic (RTK) Global Positioning System (GPS) surveying technique are used for the assessment of real time coastal geomorphological changes and the patterns of shoreline accretion and retreat. This technique is used for predicting the dune inundation and erosion during storm events (Jaeger et al., 2010&11). The fixed camera observation technique were used for the assessment of spatial consistency in the behavior of shoreline changes with response to the wave action on the near shore (Rink,W., &Forrest, B.(2005), are used as an yardstick for the development of nearshore (subtidal) record on morphologic change of the study region. Seasonal signal in shoreline position (beach width) either accrete or erode can be forecasted by this technique. Video-based technology (Yoon, Han-Sam, Ryu, Seung-Woo, Kang, Tae-Soon) are used for monitoring short term shoreline changes pertaining to a coast and for the development of data base in predicting the long-term shoreline changes in terms of timescale from seconds to years and spatial scale from meters to kilometers.

C. Aerial photography

The method provides the current pictorial view of the shoreline which can be mapped based on the recent situation which are more acceptable than a topographic map prepared many years ago which is now obsolete Anders, F.J., Byrnes, M.R., 1991.. A recent aerial photograph can reveal the changes that have taken place since the map was made along the shoreline Ford, M., 2013. The

aerial photographic technique can provide a day –to – day comparison of the selected area and also the changes that has instated in that the area Jiménez J.A., Sánchez-Arcilla A., Bou J., Ortiz M.A., 1997. Since maps and aerial photographs complement each other, more information can be achieved using the two together than by using either alone. The aerial photographic method has its own disadvantage such as position location and scale are only approximate and detailed variation in the shoreline features are not readily apparent without overlapping photography and a stereoscopic viewing instrument and also requires more training to interpret the map data's.

III. A CASE STUDY ON THE ABNORMAL COASTAL MODIFICATION OF THE PUDUCHERRY REGION, SOUTH EAST INDIA

The union territory of Pondicherry situated on the East Coast of South India in front of Bay of Bengal is Considered as a standing example for the above case .This coast experiences an average of 2 to 3 cyclones annually. The significant wave height and wave period ranges between 0.7m to 1.5m and 6sec to 8sec (Vijayakumar et.al). The severity of wave climate is experienced during cyclone with significant wave heights ranging from 4.0 to 6.0 m and peak periods from 10.0 sec to 15.0 sec (Neelamani,S. and Sundaravadivelu,R., 2006) . Pondicherry coast and its upland are under a threat of shoreline erosion for the past thirty years and the severity has increased in the recent years (Neelamani, S. and Sundaravadivelu,R., 2006) mainly due to human interference.

Fig 2: Aerial view of Puducherry

The Puducherry coastal stretch had sand dunes and beaches once upon a time which are evident from the relics of the geomorphologic features and the signatures present on some part of the coast(fig.3&4). The natural sand dunes and beaches had disappeared way back few decades ago and the entire coast and uplands are now sheltered by sea walls.

Fig 3: Pondicherry (Puducherry) sandy beach

Fig 4: Pondicherry (Puducherry) sandy beach

The deterioration of sandy beach initiated after the interference of coastal activities such as construction of pier in the year 1961 for the development of the Puducherry port (Fig.5). To protect the coast, rubble mound sea wall was constructed along the coastal stretch of nearly 1.7Km(fig:6). The problem was still aggravated after the construction of the new fishing harbour in the year 1988 which are witnessed from the satellite imageries showing the beach on the Northern side of the Northern groin completely vanished (fig7)

Fig 5. New pier at Pondicherry

Figure 6: Rubbled Mound Construction At Puducherry Sandy Beach

To protect the white town from getting damaged from the aggressively eroding coast ,the rubble mound sea wall was again extended up to a distance of nearly 25 m including walk way(fig 9) in the year 2006 which has now defaced the sediment movement alongshore and extended the eroding beach still further on the Northern direction of the Puducherry coast till Periya Mudaliyar chavadi around 7Km from the North of Puducherry coast (fig8**)**.

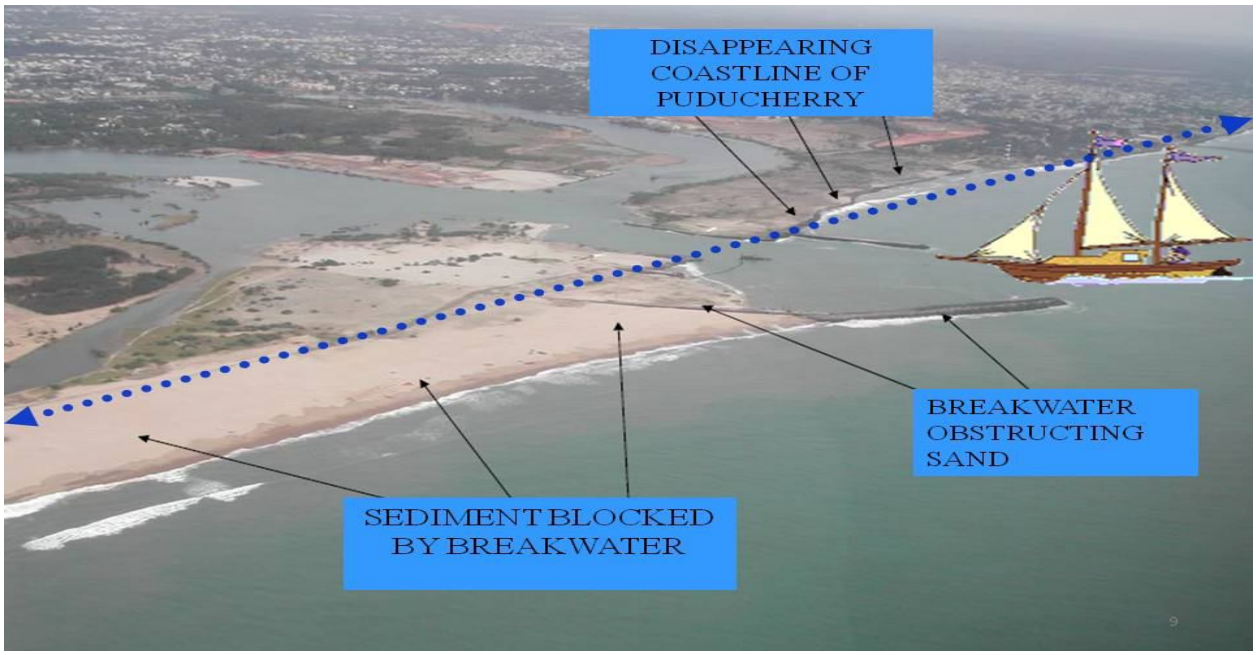

Fig 7: Fishing Harbour Entrance of Puducherry

The major cause for the addressed coastal deterioration along the Puducherry coast are mainly due to improper coastal management in the past also implementation of coastal related projects without considering the dynamic behavior of the coast which has laid the coast under pressure such as abnormal land modification, and creating a distress within the coastal community. Hence, before embarking on any coastal related activities it is very much essential for a coastal engineer to acknowledge the possible issues and its aftermath before implementation of the projects. This is possible only with a sound site specific study and adopting scrupulous management strategies.

Fig 8: Coastal Erosion of Puducherry

IV. METHODOLOGY SUGGESTED FOR THE PUDUCHERRY COAST

The Puducherry Government has decided to win back the beach in front of the white town. A reef structure was suggested in order to trap the sediments in the littoral zone and to form an artificial beach. For the project, a detailed investigation study has to be performed on the coastal stretch of Puducherry region based on the wave climatic factor, cartographic and satellite imagery which can reveal the past and present condition of the coast which will be useful in predicting the shore line changes and the retention of the beaches. To assess the present and to fore cast and monitor the future changes in the coastal stretch, satellite imagery, remote sensing and GIS platform will be more appropriate. This technique is found to be cost effective and available at any frequency.

Fig 9 : Rubbled Mound seawall with walk way -2006

V. CONCLUSION

From the studies observed from various literatures with similar problems, the following conclusion was drawn which pertains to the Puducherry coast. The periodical shoreline changes are to be observed in real time using physical instruments such as total station

and GPS and compared with satellite data's, in order to monitor the coastal profile changes. The modification of the coast after the implementation of the coastal project are to be compared with the historical , satellite , map and aerial photography data's in the lag of physically observed data during the time of project implementation. Hence, before implementation of any coastal related project it is obligatory to have a sound knowledge on the historical behavior of the site in order to anticipate the response of the coast during the progress of any coastal related project and its lateral consequences. The above management strategy will be helpful for the engineers as a decision support system in order to have a control over the issues related to the coast during the progress, completion and serviceability of any coastal related project.

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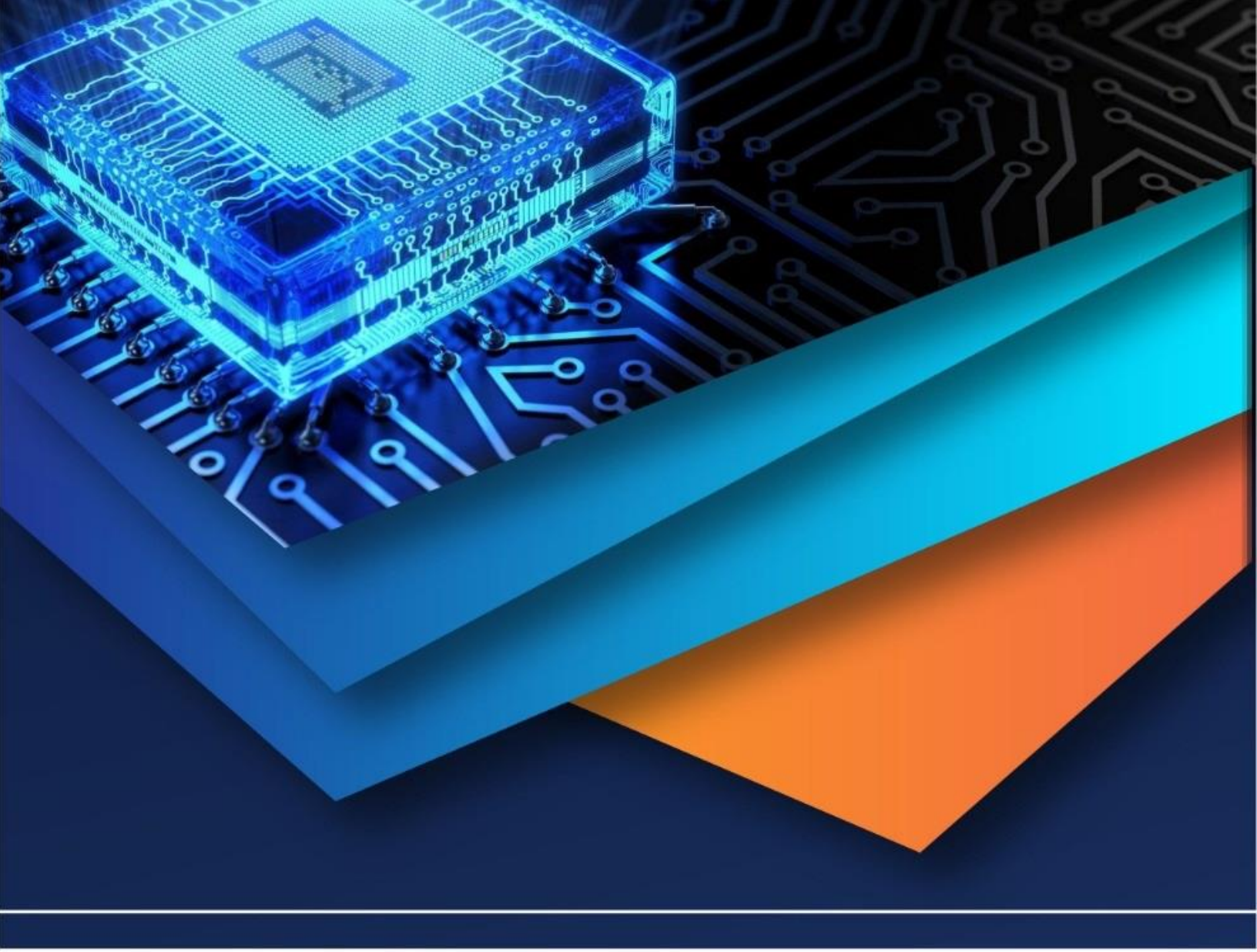

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