A Critical Literature Review on

The Effect of Coastal Processes and Hydrodynamics Changes along Coastal Region of India

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Abstract: The coastal zone is exposed to different cyclic and random processes that continuously undergo changing the region. It is essential to understand the coastal processes of erosion, transport, and deposition of sediments for sustainable development of the property and natural habitat. The coastline on either side of the Indian peninsula is subjected to varied coastal processes and anthropogenic pressures. Accurate prediction of the sediment transport, caused by waves and tidal or wave-induced currents, is of great importance in predicting coastal morphological changes. In the present paper, the land-ocean interaction processes and regional coastal issues such as erosion, suspended sediment transportation, etc are studied and reviewed with the synergetic application of in situ, remote sensing, and numerical simulation methods.

Key Words:

Coastal Zone, Delft 3D-FLOW, Erosion, MIKE, Sediment transportation.

INTRODUCTION

Coastal zones are the most fragile, dynamic and productive ecosystem and area unit quite typically stressed from each phylogeny activities and natural processes. Total coast line of the world is around 35, 6000 km and the coastal region covers over 10 percent of the planet surface. Coastal zones in India assumes importance as a result of high productivity of its ecosystems, concentration of population, exploitation of renewable and non- renewable natural resources, discharge of waste effluents and municipal sewage, industrialization and spurt in recreational activities. Coastal zones are ceaselessly dynamical as a result of the dynamic interactions between the ocean and land. Erosion and accretion, inundation due to water level rise and storm surge, shifting of shoreline caused by natural or human activities, such as construction of artificial structure, port and harbors leads to changes within the coastal zone and its environment. Integrated Coastal Management (ICM) is a process that goes beyond the traditional approach of planning and managing activities on an individual scheme basis. The **"Dynamics of Coastal Zone"** is defined on the basis of interactions between the coastal process like tide, waves, currents, etc. with the coastal land forms like beach, mudflats, wetlands etc. Coastal Zone Management" (CZM) is a part of Integrated Coastal Management (ICM), which is associate in nursing combining more fields of study

and sectoral approach to drawback definition and solutions in the coastal zone. Figure 1 shows the classified coastal sectors of India.

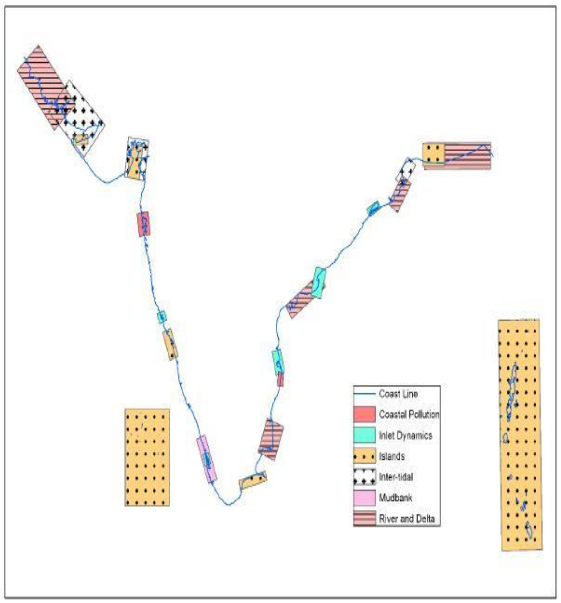

Figure 1: Classified Sectors along the Coast of India (Source: SAC, Ahmedabad)

The Indian coastal region is bestowed with varying natural resources and is relentlessly modified under natural and anthropogenic activities. The coastal processes and the coastal geomorphology along the Indian coast are varied in nature, where the coastal processes also show high seasonal variability (Rajawat et al, 2015). The three major marine processes that influence coasts are Erosion, Transportation and Deposition. Every year, 20 billion tons of sediments are brought to the oceans by the rivers (Milliman and Syvitski 1992). There are several hydrodynamic changes observed near the Gulf region such as tidal elevation, composition of sediment input, the rate or volume of sediment input/output, waves and currents formation and the bathymetry. The tides and tidal currents, waves – generation and types, wind and currents, fluvial-deltaic systems and sea level are the major factors influencing the coastal processes. Because of said factors, the impacts on region are siltation of harbours, accumulation of sand bars, seasonal blockage of estuaries, sedimentation and erosion around coastal structures and shoreline changes.

Spatial information on the coastal land use and land forms along with high tide and low tide lines, the inventory and status of coastal habitats and information on ESA (Ecologically Sensitive Areas) are required for the preparation of a suitable coastal zone management plan as well as implementation of regulations in the coastal zone. The coastal issues are of regional specific, which acts in varying degrees, dynamics and durations independently and in conjunction with each other, which induces changes through construction or destruction through various assemblages of land and water/wetland system along the coasts.

LITERATURE REVIEW

A large number of studies pertaining to different aspects of Indian coastal environment have been carried out using RS & GIS technology. Some of the organizations in India have been using satellite data operationally to create information on coastal zones of the country. Forest Survey of India has been using satellite data to regularly monitor the mangroves of the Indian coast. Institute for Ocean Management (IOM), Anna University; ICMAM Project Directorate of MoES; M.S. Swaminathan Research Foundation; Centre for Earth Science Studies, Thiruvananthapuram; Institute of Wetland Management and Ecological Design, Kolkata; State Remote Sensing Centre of Gujarat, Maharashtra, Karnataka and Orissa; National Remote Sensing Centre, Hyderabad, etc. have worked on the Indian coast using RS data in studying the existing land use and changes in the land use/landcover pattern, shoreline management studies, coastal processes and mapping of critical habitats such as coral reefs, sea grass, mangrove. IOM and ICMAM have generated models for coastal zone management using RS & GIS technologies. Space Applications Centre (ISRO), Ahmedabad has carried out extensive studies for the entire Indian coastal zone. (Dr. Ajay et al, 2012). Conventional methods of monitoring the coastal parameters through in-situ measurements are difficult, expensive and are point observations whereas remote sensing-based data provide large area coverage and are repetitive observations which are more reliable and quicker to obtain (Quillon et al, 2004). Remote sensing techniques have been extensively used in inventory, monitoring and management of natural resources in the coastal areas. Due to its repetitive, multispectral and synoptic nature, satellite Remote Sensing (RS) has proved to be extremely useful in providing information on various aspects of the coastal environment, viz.

coastal wetlands, coastal landforms, shoreline changes, tidal boundaries (high/low), brackish water areas, suspended sediment dynamics, coastal currents, vital coastal habitats etc. RS has also proved itself as one of the powerful tools in studying the coastal ecosystems, resources and their time series modifications, especially owing to the repetitive data collection by the polar orbiting remote sensing satellites and the satellite invitation capabilities to the coasts in the event of disasters. Development of new techniques and improvements of the existing methodologies in deriving coastal and oceanographic parameters from space born missions are cardinal research activities (Ratheesh et al, 2013; Cippolini et al, 2017). Multi-sensor approach and use of multi-temporal space born data have been providing valuable data base along the coastal region in deciphering the complex coastal processes.

The temporal observations, especially from polar orbiting satellites are inadequate to resolve the dynamics along the coastal region, especially the tidal and diurnal dynamics (Ratheesh and Rajawat 2012). Numerical simulation methods find its applicability in solving the existing lacuna. Integration of satellite derived parameters in numerical simulation methods have been used to resolve the data gaps from in situ measurements and the temporal gap from remote sensing observations (Kurapov et, 2011; Traon et al, 2015). Bhatti et al (2018) studied the problem of extensive erosion of high tidal mudflat along the northern parts of Gulf of Khambhat (GoK) was observed from the analysis of time series satellite images during the time period from March 2014 to September 2017 and found around 28.66 sq. km area of high tidal mudflat eroded within this time period. The results showed the importance of assessing the stability of mudflats along the GoK, where large development activities are proposed. Jun Tang et al (2018) developed an efficient numerical model consisting of adaptive multilevel quadtree meshes for coastal waves and nearshore currents. In the model, coastal waves were modeled using the elliptic mild-slope equation that accounts for wave refraction, diffraction, reflection, and breaking-induced energy-dissipation effects, and nearshore currents are modeled using two-dimensional horizontal (2DH) depth-integrated shallow-water equations for which the wave radiation stresses for driving currents are provided by the wave model. Ramakrishnan et al (2017) carried out the simulation of coastal morphological changes that occurred under normal and extreme wave conditions using Xbeach, a process-based numerical model to simulate the morphological changes by forcing the model with buoy observed wave parameters. The results highlight the importance of modelling studies for conceptual understanding of the beach response to normal and extreme conditions, and for identifying vulnerable sectors of a beach so that appropriate measures can be taken to prevent coastal erosion and loss of land. The improvements in orbit models, radar processing, atmospheric and geophysical effect corrections that have emerged over the years, altimetry gives very accurate estimation of the rate of sea level rise and its geographical variability (Paolo et al, 2017). Wang et al (2017) used large amounts of in situ data accumulated in the Changjiang estuarine and coastal waters to verify and calibrate the QAA Algorithm. Furthermore, the QAA is remodified for CDOM retrieval by employing a CDOM algorithm (QAA_CDOM). Based on the QAA and the QAA_CDOM, a new version of algorithm, named QAA_cj was developed, which is more suitable for highly turbid waters to decompose ag from adg (CDOM and non-pigmented particles absorption coefficient). His study showed that by comparison of matchups between Geostationary Ocean Color Imager (GOCI) retrievals and in situ data, it revealed that the accuracy of retrievals from calibrated QAA is significantly improved. CDOM products from the improved QAA_cj can be used in advancing our understanding of the land-ocean interaction process by earth observations in monitoring spatial-temporal distribution of the river plume into sea.

Kobayashi et al (2016) had made effort to improve quantitative understanding of beach morphology and stone structural damage progression and to develop a simple and robust model that is suited for engineering applications by producing cross-shore numerical model CSHORE. Efforts have been made to integrate coastal hydrodynamics, sediments, and structures for practical applications. Satellites provide key essential variables to constrain ocean models and/or serve downstream applications (Traon et al, 2015). Estimation of tidal levels and associated currents in Gulf of Khambhat is challenging due to the amplification of tides and intense current magnitudes (Kumar et al, 2015). Kumar et al, (2015) used Delft3D-FLOW and Ramakrishanan et al (2015) used sediment transport model - MIKE 21 Mud Transport

(MT) to understand the sediment transport in Gulf of Khambhat region & along the central Kerala coast, respectively. MIKE MT is interrelated with the other modules of MIKE 21 Hydrodynamics (HD) module. The HD module simulates the water level variations and flows in response to a variety of forcing functions in coastal areas. From past studies, it was observed that tides, winds and currents are the important physical factors that control the dispersal patterns (Kumar et al, 2015). Remote Sensing and GIS techniques were used for assessing vulnerability of the Gujarat coast due to predicted sea level rise was studied by Mahapatra et al (2015). In the study, synergetic use of satellite remote sensing, numerical simulations and filed observations had been done to generate coastal thematic information considering five physical parameters: coastal geomorphology, coastal slope, shoreline change rate, mean spring tidal range, and significant wave height. Ocean color remote sensing had been shown to be a useful tool to map turbidity (T) and suspended particulate matter (SPM) concentration in turbid coastal waters (Dogliotti et al, 2015). Ramakrishnan et al, (2014) studied the morphological changes in the estuary of the Narmada river by means of remote sensing satellite images. The study revealed that human activity in the form of salt pans, industrial and settlement built up had consistently increased during past three to four decades which affects the hydrodynamics of oceans. The eustatic sea level rise due to global warming is predicted to be about 26–82 cm by the 2100 (5th IPCC 2013), which necessitates identification and protection of vulnerable sections of coasts. Mahapatra,et al, (2014) developed an integrated coastal vulnerability index (ICVI) for the South Gujarat coast using both physical and socioeconomic variables. In the model study, physical variables, namely coastal slope, Coastal landforms/features, Shoreline change rate, Mean spring tidal range, and Significant wave height, are used for the calculation of the physical vulnerability index (PVI), whereas four variables such as population density of adjacent coastal villages, land use/land cover, proximity to road network and settlement were used to assess the social vulnerability index (SVI). Ramakrishnan at al (2012, 2013) estimated vertical suspended sediment concentration (SSC) profiles in Gulf of Kachchh, from the sediment concentration values derived from synoptic observations of Ocean Color Monitor (OCM) and application of MIKE-21 Mud Transport model. Sinha P.C. (2010) studied tidal circulation and suspended sediment transport in the gulf of Khambhat along the west coast of India.
Yan Ding et al (2006) developed a Quasi-Three-Dimensional Coastal Area Morphological (Q3DCAM) Model confirmed that the Q3DCAM model consisting of the diffraction effects and the surface roller affects which is capable of predicting waves, currents, and morpho-dynamic changes more accurately than before.

CONCLUSIONS

A large number of studies pertaining to different aspects of Indian coastal environment have been carried out using RS & GIS technology. SAC-ISRO, Ahmedabad has carried out extensive studies for the entire Indian coastal zone. (Ajay et al, 2012). Conventional methods of monitoring the coastal parameters through in-situ measurements are difficult, expensive and are point observations whereas remote sensing-based data provide large area coverage and are repetitive observations which are more reliable and quicker to obtain. (Quillon et al, 2004). The temporal observations, especially from polar orbiting satellites are inadequate to resolve the dynamics along the coastal region, especially the tidal and diurnal dynamics (Ratheesh and Rajawat 2012). Numerical simulation methods find its applicability in solving the existing lacuna. Integration of satellite derived parameters in numerical simulation methods have been used to resolve the data gaps from in situ measurements and the temporal gap from remote sensing observations (Kurapov et, 2011; Traon et al, 2015). The Management plans with proper understanding of the coastal processes and coastal dynamics are needed to achieve sustainable development along the coastal region. From past studies it can be concluded that study of regional coastal processes using in situ and satellite observations integrated with numerical models along the Coastal region is needed for sustainable development under climatic variability.

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