Proc Indian Natn Sci Acad **86** No. 1 March 2020 pp. 365-368

DOI: 10.16943/ptinsa/2020/49798

Status Report 2016-2019

Geomorphology of the Indian Coast: Review of Recent Work (2016-19)

NILESH BHATT*
Department of Geology, Faculty of Science, The Maharaja Sayajirao University of Baroda, Vadodara 390 002, India

(Received on 19 September 2019; Accepted on 29 September 2019)

Coastal landscape is the net result of an equilibrium attained between large numbers of interacting variables over very small (daily) to large (millennial) time periods. The Indian coastline falls in humid (having two monsoons), semi-arid and arid climate with rocky, muddy and sandy segments. The local structural controls are also manifested by coastal configuration and geomorphology. Recent work published on the coastal geomorphology of India is mainly found focusing on the dynamic nature of shoreline addressing through various applications of remote sensing. Major emphasis has remained to evaluate the coastal changes in terms of coastal erosion and natural hazard potential. The review presents a highlight of the work published during the period of 2016-19.

Keywords: Coastline Change; Geomorphology; Coast; India

Introduction

Large landmass of India constitutes a peninsula having about 7500 km long coastline that obviously exhibits a variety of subdomains due to geological, climatic and ecological variations all throughout. The coastline of India consists of several segments with varied tidal range from less than 1 m to as high as 12 m. Based on geomorphological characteristics, it can be divided into (1) deltaic coast of west Bengal, (2) sandy beaches and lagoon coast of Orissa, (3) rocky coast of Andhra Pradesh, (4) Krishna-Godavari delta coast, (5) beach ridges and back water coast of Kerala, (6) sandy linear beaches of Karwar-Ratnagiri, (7) tidal flat coast of Gulf of Khambhat and Kachchh and (8) rocky coast of south Saurashtra (Figure 1). Studies on geomorphology of these coastal segments have been carried out by some earth scientists since a long time and its general characteristics were described by Mukhopadhyay and Karisiddaiah (2014). Accordingly, the western coast is comparatively narrow, having prominent presence of cliffs which are uncommon on wider eastern coastal zones. A strong control of subsurface tectonics and differential uplift of peninsular Indian landmass on the characteristics of western and eastern coastal geomorphological assemblage has been envisaged by Ramkumar *et al*. (2016). However, recent (2016-19) researches on Indian coastal geomorphology have largely focused morphological changes of the coastal configurations using remote sensing data.

East Coast

Much work is available on the Late Quaternary sea level changes on eastern and western coast using continental records and also sub-marine records in a series of publications during last two decades. A recent work by Loveson and Nigam (2019) present a more focused picture of the sea level changes during late Pleistocene to Holocene time from the east coast of India. Accordingly, there was a slow and steady rise in the sea level during 1488 to 10800 yr BP with an average rate of 0.88 m/100 years that was followed by rapid rate of about 2.06m/100 years during 1088 to 9200 yr BP. They also suggested that a major part of coastal plains on east coast were submerged under the sea during early Holocene as evident by relict occurrences of the delta in inland areas.

Ahammed and Pandey (2018) studied morphological changes on the coast of Andhra Pradesh using geospatial technology along with end

**Author for Correspondence: E-mail: nilesh_geol@yahoo.com*

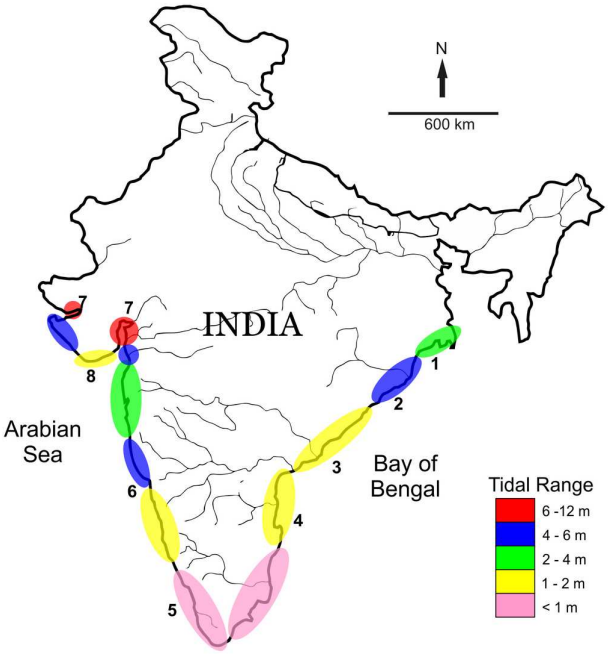

Fig. 1: Map showing tidal range and major geomorphological domain along the Indian coast. 1. deltaic coast of west Bengal, 2. sandy beaches and lagoon coast of Orissa, 3. rocky coast of Andhra Pradesh, 4. Krishna-Godavar i delta coast, 5. beach ridges and back water coast of Kerala, 6. sandy linear beaches of Karwar-Ratnagiri, 7. tidal flat coast of Gujarat and 8. rocky coast of south Saurashtra

point rate (EPR) statistics that involved a time span of AD 1973 to 2015 and inferred most prominent changes in the Krishna and Godavari delta shore having average erosion and accretion rate of 10.63 and 17.29 m per year, respectively. The fluctuations in hydrology of fluvial system, perhaps related with the climate change, have played a key role in delta front shore line changes, as they suggested.

Ghosh (2018) studied the estuarine interfluves of the Sunderban area in context of climate change. He analysed the effects of climate change in terms of change in rain fall and relative sea level during AD 1890 to 2012 and revealed that the flat sandy coastal belt in the extreme south have been severely affected by wave dash and seasonal storm surges which are mostly responsible for vigorous erosion. On the other hand, high tidal velocity was observed by them along the middle reaches that could intensify the hydraulic pressure along the marginal parts of the river bank which leads to erosion, whereas depositional activities were mostly observed along the sheltered inner reaches and convex river banks.

Ghosh and Mukhopadhyay (2017) attempted vulnerability assessment through index modelling in the same area i.e. Murinana-Saptamukhi estuarine interfluves of the Sundarban, considering the coastal vulnerability as "a system's openness to flood and erosion risk due to hydrogeomorphic exposures and socio-economic susceptibility in conjunction with its capacity/incapacity to be resilient and to cope, recover, or adopt to an extent". They worked out composite vulnerability index to delineate the magnitude and spatial extent of vulnerability with the help of quantitative techniques and geospatial tools. The study of Ghosh and Mukhopadhyay (2017) highlights the critical situation of the population under different potential risk classes residing in the study area with the intention of suggesting some proper courses of action of planning and management to conserve coastal communities in their original habitat.

Jangir *et al*. (2016) studied a part of Odisha coast using remote sensing and GIS technique and inferred that its geomorphology defined by lagoons, tidal flats and mangrove swamps is rapidly changing since a decade (1999-2009) due to tides, waves and currents and storm surges. They noted a significant change in the shore line at cyclone land fall areas of Odisha coast. An increase in accretion rate was also observed for the period 1999-2009 in comparison with that of 1990-1999. The study indicated that the swale complex, older and younger coastal plains, tidal flats and mangrove swamp are the dominant features.

Pramanik *et al*. (2016) used regional slope, coastal elevation, geomorphology, significant wave height, mean tidal range and relative sea level, developed coastal vulnerability index (CVI) to evaluate the effects of coastal hazards like cyclone and tsunami surges. Their study in the coastal zone of Krishna-Godavari delta region of Andhra Pradesh indicated that the coastal geomorphology plays a decisive role to CVI in terms of coastal flooding. However, Sheik Mujabar and Chandrasekar (2013) did similar work on the southern Tamil Nadu coast and developed a coastal vulnerability index (CVI) for its relative assessment. They concluded that in addition to the natural processes, human activities that affect on natural hydrological cycle play a significant role in

intensifying and affecting the coastal vulnerability to the natural hazards like cyclone and tsunami surges.

Rani *et al*. (2018) assessed coastal vulnerability using geospatial techniques along Vizianagaram-Srikakulam coast of Andhra Pradesh. They could establish that for a considerable length there occurs a landward shift of about 2.5 km due to coastal erosion, whereas some part shows accretion of about 1.82 km during 1997-2017.

Joevivek *et al*. (2018) studied variations in shoreline trend for 21 stations between Manuvai and Vijayapathi along the southern tip of India using multispectral satellite data. The rate of changes between AD 1973 and 2006 has shown that the average shoreline is accreted at 1.78 m/year. The study could also relate an unusual change (3.6 m/year to 15.6 m/year) in the rate between years 2001 and 2009 due to the impact of tsunami. The study further indicated that the littoral sediment movement with respect to the wave climate and anthropogenic activities are the predominant factors that affect the shoreline change and sediment drift prevailing on the coast.

West Coast

Rajawat *et al*. (2015) made shoreline change inventory for the entire coast of India using satellite data of AD 1989-1991 and AD 2004-2006 time windows. They could demonstrate that 3829 km (45.5%) of the coast is under erosion, 3004 km (35.7%) is getting accreted, while 1581 km (18.8%) of the coast is more or less stable. Highest percentage of shore under erosion is in the Nicobar Islands, while the percentage of accretion is highest on Tamil Nadu coast. Accordingly, the Indian coast has lost a net area of about 73 km^2 during the year 1989-1991 and 2004-2009 time frame. This study has been used to prepare a Shoreline Change Atlas of the Indian coast. However, similar studies are not published recently from the west coast of India. Mahapatra *et al*. (2015) studied coastal vulnerability of south Gujarat coast to sea level rise and estimated that about 45.67% i.e. 785 km length of the Gujarat coast is under high to very high-risk category due to an anticipated sea level rise.

Maya *et al*. (2017) attempted to understand the geomorphic response to sea level and climate change since late Pleistocene in coastal areas of south Kerala. They have attempted to build the history of coastal evolution in terms of late Quaternary sea level changes. Accordingly, the coastal plain of Kerala and associated beach ridges are suggestive of at least two phases of marine transgression and regression, one during late Pleistocene and another during the Holocene.

Although, coastal geomorphic assemblage such as raised tidal flats and beach ridges have been investigated for ancient high energy wave events like storm/tsunami on Gujarat coast by some workers recently (Bhatt *et al*., 2016; Prizomwala *et al*., 2018). Sediment dispersal system and resultant geomorphological changes along the west coast has not been investigated in detail. The Indian coast has a lot of potential for future work at much higher resolution to address the local scale geomorphological evolution to build better database on climate, tectonics and sediment routing systems that controls the geomorphic assemblage of any coast.

Acknowledgements

Encouragement and constant support from Professor D M Banerjee is thankfully acknowledged. Enough care was taken to include all possible works published during 2016-19. Any omission, however, is not deliberate and the author apologizes for missing out on important works, if any.

References

Ahammed K K B and Pandey A C (2018) Shoreline morphology changes along the Eastern coast of India, Andhra Pradesh by using geospatial technology *Journal of Coastal Conservation* Doi.org/10.1007/s11852-018-0662-5

Bhatt N, Murari M K, Ukey V, Prizomwala S P and Singhvi A K (2016) Geological evidences of extreme waves along the Gujarat coast of western India *Natural Hazards* **84** 1685-1704

Ghosh A (2018) Spatiotemporal changes of geomorphic environment in the Muriganga-Saptamukhi estuarine interfluves of Indian Sundarban in the context of climate change: a case study *Environment Development Sustainability* **20** 1153-1172

Ghosh A and Mukhopadhyay S (2017) Vulnerability assessment through index modelling: a case study in Muriganga-Saptamukhi estuarine interfluves, Sundarban, India *Arabian Journal Geosciences* **10** 408-418

Jangir B, Satyannarayana A N V, Swati S, Jayram C, Chowdary V M and Dadhwal V K (2016) Delineation of spatio-temporal changes of shoreline and geomorphological features of Odisha coast of India using remote sensing and GIS techniques *Natural Hazards* **82** 1437-1455

Joevivek V, Saravanan S and Chandrasekar N (2018) Assessing the shoreline trend changes in Southern tip of India *Journal of Coastal Conservation* Doi.org/10.1007/s11852-018-0657-2

Loveson V J and Nigam R (2019) Reconstruction of Late Pleistocene and Holocene sea level curve for the east coast of India *Journal of Geological Society of India* **98** 507-514

Mahapatra M, Ramkrishnan R and Rajawat A S (2015) Coastal vulnerability assessment using analytical hierarchical process for south Gujarat coast, India *Natural Hazards* **76** 139-159

Maya K, Vishnu Mohan S, Limaye R B, Padmalal D and Kumaran N K P (2017) Geomorphic response to sea level and climate changes during Late Quaternary in a humid tropical coastline: Terrain evolution model from Southwest India *PLoS ONE* **12** e0176775

Mukhopahdyay R and Karisiddaiah S M (2014) The Indian coastline: Processes and landforms. In V.S. Kale (ed.) *Landscapes and landforms of India* Springer 91-101

Pramanik M K, Biswas S S, Mondal B and Pal R (2016) Coastal vulnerability assessment of the predicted sea level rise in the coastal zone of Krishna-Godavari delta region, Andhra Pradesh, east coast of India *Environment Development Sustainability* **18** 1635-1655

Prizomwala S P, Gandhi D, Bhatt N, Wrinkler W, Ravikumar M, Makwana N and Bhatt N Y (2018) Geological evidence for AD 1008 tsunami along the Kachchh coast, western India: Implications for hazard along the Makran subduction zone *Scientific Reports* **8** 16816

Rajawat A S, Chauhan H B, Ratheesh R, Rode S, Bhandari R J, Mahapatra M, Kumar M, Yadav R, Abraham S P, Singh S S, Keshri K N and Ajai (2015) Assessment of coastal erosion along the Indian coast on 1:25,000 scale using satellite data of 1989-1991 and 2004-2006 time frames *Current Science* **109** 347-353

Rani M, Rehman S, Sajjad H, Chaudhary B S, Sharma J, Bhardwaj S and Kumar P (2018) Assessing coastal landscape vulnerability using geospatial techniques along Vizianagaram-Srikakulam coast of Andhra Pradesh, India *Natural Hazards* **94** 711-725

Ramkumar M, Menier D, Mathew M and Santhosh M (2016) Geological, Geophysical and inherited tectonic imprints on the climate and contrasting coastal geomorphology of the Indian Peninsula *Gondwana Research* **36** 52-80

Sheik Mujabar P and Chandrasekar N (2013) Coastal erosion hazard and vulnerability assessment for southern coastal Tamil Nadu of India by using remote sensing and GIS *Natural Hazards* **69** 1295-1314.