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Delineation of Coastal Regulation Zone of an Ecologically Sensitive Coastal Region in the Southern Indian Peninsula: A GIS Approach

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ABSTRACT

The coastal ecosystems in India are facing a large array of natural and anthropogenic stresses due to climate change and economic developments. Therefore, proper management of these sensitive regions towards a holistic sustainable development is the need of the hour. Coastal regulation zones (CRZ) are created for regulation of activities in the coastal area for the protection of coastal and sea resources under 1986 Environment Protection Act, of India. This research was carried out along the Eastern Ramanathapuram coast of Tamil Nadu in the Indian Peninsula to delineate the coastal regulation zone using GIS. To understand and categorize the most sensitive coastal region. Our analysis further splits CRZ region into CRZ-I A, CRZ-I B, CRZ II, III-A, and CRZ III B, CRZ-IV B in compliance with Regulation 2019. Here, aligned with the CRZ compliance, 500m buffer area is taken from HTL (High Tide Level) towards the landward side in the ecosensitive coastline, and 100 m buffer area is taken along creeks and estuaries, as per the guidelines of CRZ Notification, 2019. The output is integrated with land use/land cover map of 2020 and population density to analyseand categorize various coastal zones in the study area.

Key words : Coastal Regulation Zone, High Tide Line, Ramanathapuram, Gulf of Mannar, Palk Bay.

Introduction

Coastal regions are considered as vital resources to the world's national and global economies. These regions are under rising strain from a multitude of events, resulting in both land and assets demand (Kvalvik *et al.*, 2020). Like other coastal nations, India also has many coastal areas with fragile habitats, which tend to decline because of human activity (Ramachandran *et al.*, 2005).

Nowadays human domination in the coastal region increasing because of various resources. Consequently, the density of the population also rises (Joseph and Balchand, 2000). The usage of habitation in the coastal zone is increasing each day.

To regulate exploitation and track further degradation of coastal infrastructure, a notification was released by the Government of India in1990, based on the Environmental Protection Act (1986) and the 1986 Environmental Protection Rules. Which designate coastal regulatory zones and impose restrictions on factories, operations, in these sensitive Zones (Sahasranaman, 1996). On 19 February 1991, the Government of India released a notification entitled CRZ Notice 1991 to preserve the marine ecosystem and biodiversity. It will forbid new hazardous anthropogenic practices along the coast (Panigrahi and Mohanty, 2012).

Unscientific approaches by peoples will cause damages in coastal landforms, and it will damage the entire ecosystem. Accordingly, the stability of the region will lose. Hence the Government has taken certain rules to protect the coastal atmosphere by categorizing various zones. Government laws can help to determine the boundaries of the coastal region and it will make protection zones to lessen the anthropogenic pressure on the coastal ecosystem (Pérez-Cayeiro *et al.*, 2019).

Coastal regulations at the national and state levels control the Indian coastal zone to monitor physical and socioeconomic risk (Dhiman *et al.,* 2019). Coastal regulation zone studies were carried out periodically by the government to ensure safety along the beach of Ramanathapuram district.

Eastern parts of Ramanathapuram District of Tamil Nadu, India is taken for the Coastal Regulation Zone study. The study area geographically located at 9.38° N latitudes and 78. 83° E longitudes. The length of thestudy area shoreline stretch is 182 km. It has an average elevation of 2 m (6 ft). A large section of citizens focusses their efforts in the coastal area in the context of global tourism, industrialization, forestry, etc. (Joseph and Balchand, 2000). With human activities rapidly intensifying, environmental pollution in coastal regions is getting even more severe (Chen and Qian, 2020). The study area (Fig 1) is part of India's first marine reserve park, the Gulf of Mannar Marine National Park. Offshore islands, mangroves, Coral reefs, mudflats, dunes, sandy beaches and seagrass are some of the sensitive ecosystems found over this region. Well-developed beaches exist along the Gulf of Mannar coastal areas, which scale differs due to local geomorphology (Magesh and Krishnakumar, 2019).

The role of satellite data for mapping surface features is increasing day by day due to increasing spatial accuracy and availability of free data. CRZ assessment is mainly dependent on spatial data. GIS is the recent advanced technology that is connected to the surface of the earth (Longley *et al.*, 1999). GIS provides a platform for evaluating, overlaying, and integrating data from different sources, whereas remote sensing techniques can acquire large-scale high-quality datasets for earth surface analysis (Chapman and Thornes, 2003).

Materials and Method

Appropriate strategic preparedness and protection are important if environmental sustainability and



Fig. 1. Ramanathapuram coastal area, Tamil Nadu, India

economic growth are to stay in balance (Dhiman *et al.*, 2019). The thematic map of Ramanathapuram Coastal Zone Regulation is prepared using Survey of India (SOI) topographic maps along with remote sensing information. For the purposes of categorizing the coastal control zone, coastal sections within 500 meters of High Tide Level towards the landward side are categorized into 4 divisions. The identification and preparedness will forbid new hazardous anthropogenic practices along the coast (Velsamy *et al.*, 2020). The methodology implemented for this research is shown in Fig. 2 and the classification procedure is given in Table 1.

Mangroves arecategorize in CRZ-I A. The region between the Low and the High Tide Line is categorize for CRZ,IB. Built-up along the shoreline, within the current municipal borders or in other established constitutionally defined metropolitan areas catego-



Fig. 2. Methodology adopted for CRZ Mapping

Ta	ble	1.	Coastal	Regu	lation	Zone	cl	assification	l
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rize for the CRZ-II. Heavily populated areas of CRZ-III category, where-population density with more than 2161 /km² based on 2011 census is categorize for CRZ-III A. Population thickness under 2161 for each km² based on 2011 census and the region up to 200 meters from the HTL towards landward side will be reserved as the 'No Development Zone (NDZ) which is categorize for CRZ-III B.

The CRZ-IV region extends from the Low Tide Line to a distance of up to twelve nautical miles offshore. CRZ-IV B incorporates the region along with LTL and tidally affected water body, for example, estuaries or brook.

The High-Tide Line (HTL) was demarcated using SOI Topographical map. Here 500m buffer area is taken from HTL towards the landward side in the eco-sensitive coastline, and 100 m buffer area is taken along creeks and estuaries, as per the guidelines of CRZ Notification, 2019. Remote sensing technologies seem to have a significant effect on preparation and provide better identification of Land Surface (Deafalla et al., 2014). Analyzing the LULC of the study area is asignificant process to assess the causes and impacts of potential vegetation dynamics in various situations (Liu et al., 2017). For the present study, the study area has integrated with land use/land cover map of 2020 Fig. 3. The results are integrated as per the norm of CRZ Notification, 2019. Population growth and urbanization trends are human activity's most basic phenomena and may represent shifts in coastal bodies (Ma et al., 2017). To analyze and categorize the coastal regulation zones in the study area. The population density of the respective coastal region has analyzed. The village wise populationdata has taken and integrated from the District census handbook, census of India 2011.

CRZ classification	Features			
CRZ,I A	Mangrove area			
CRZ, B	The region is located between the Low Line and the High Tide region.			
CRZ,II	Built-up along shoreline, within the current municipal borders or in other			
	established constitutionally defined metropolitan areas.			
CRZ,III	Regions which are largely undisturbed			
CRZ,III A	Heavily populated areas, density of population- 2161/km ² .			
CRZ,III B	Area with a population thickness under 2161 for each square kilometre. As per the			
	2011 census, the zone up to 200 meters from the HTL towards landward side will			
	be reserved as the 'No Development Zone (NDZ)			
CRZ,IV A	The water territory which stretches up to twelve nautical miles towards offshore			
CRZ,IV B	CRZ-IV B incorporates the region along with LTL and tidally affected water body,			
	for example, estuaries or brook.			

Results

The studyareahaving a sensitive coastal zone 85.4 km²area. This is further classified into 5 categories as per the 2019 regulation which shown in (Fig. 4) and (Table 2). CRZ – I A, covered 12.52 km² area. CRZ-I B covers an area of 14.40 km². CRZ – II, occupies an area of 8.19 km². CRZ-III has split into two, which are CRZ III-A and CRZ III B.7.91 km² area comes under CRZ – III-A, and 42.27 km² area occupy in CRZ – III B category. CRZ – IV B covers an area of 0.11 km²

Discussion

The Mangroves region of devipattinam village is comes under CRZ-I A. It is the most eco sensitive place under coastal regulation zone. CRZ-I B categories between high and low tide line. In the study area lagoon and delta region of rameswaram island falls in between this low and high tide line. CRZ – II, isin the well-developed areas which are rameswaram town and mandapam regions.

CRZ-III is relatively populated, undeveloped regions. This has split into two, which are CRZ III-A and CRZ III B according to Regulation 2019. The Pamban and Sattakkonvalsai villages are under CRZ - III A where 50 m from HTL is NO development Zone and the population density is above 2161/m², as per population report. The CRZ – III B is categorized based on the population density of less than 2161 per square Kilometre, as per the 2011 census. In this region 50 m from HTL is NO development Zone. The coastal villages Kalimankund, Periapattinam, Rettaiyurani, Pudumadam, Nochiyurani, Sattakonvalsai, Pirappanvalsai, Enmanamkondan, Nagachi, Attangarai, Kanjirangudi, Tiruppulani, Alagankulam, Terbhogi,

Table 2. Coastal Regulation Zones Extension of Ramanathapuram

CRZ, I A(km²)	CRZ, I B(km ²)	CRZ,II(km ²)	CRZ,III A(km ²)	CRZ,III B(km ²)	CRZ,IV B(km ²)
12.52	14.40	8.19	7.91	42.27	0.11



Fig. 3. Landuse/ Landcover classes of study area _Year 2020



Fig. 4. Coastal Regulation Zone Map of Ramanathapuram coast

Athyuthu, Chitrakkottai, Pathanendal Keelakarai, Karan Mayakulam, and Ervadi are under this category. CRZ - IV B are the intertidal zones that are adjacent to estuaries in kanjirangudi village and the creeks of pamban village in the study area.

Conclusion

The study area has been categorized into six zones based on the Coastal Regulation Notification (CRZ) 2019.CRZ-I A is located in an ecologically sensitive location that includes mangroves in Pathanengal village and the Pamban region's tidal flats. The deltaic zone of Sattankonvalsai village and the lagoon region of Dhanushkodi are inhabited to CRZ-I B. CRZ-II is located in Mandapam village and Rameswaram town, both of which have experienced rapid development. CRZ-III-A is located in the Sattakovasaivillage settlement, with a population density of 2161 inhabitants per square kilometre. CRZ-III-B covers the western coastal villages where the density of population is less than 2161 per square Kilometer. In this region 50 m from HTL is NO development Zone. The CRZ-IV B is situated between the intertidal zones. This part consists Tiruppulani's estuary and Nagachi's Vaigai deltaic region.

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