Chapter 9
The Degradation of Coastal Habitats in Andhra Pradesh and Tamil Nadu: An Environmental Approach

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9.1 Introduction

The geographical habitats of Andhra Pradesh coast and Tamil Nadu coast are supported by four major deltas (Godavari, Krishna Cauvery delta and Penna R. delta), bay fringed shores of Kakinada, Machilipatnam (Masulipatnam), Chirala, Palk Bay, Mandapam Bay and other embayed shores, rocky shores of hill ridges, river systems, various lakes and backwaters, and beach dune fringed shorelines. They harbour mangrove ecosystems, coral reef ecosystems, sea grass ecosystems, beach dune ecosystems, and other wetland ecosystems along the coastal stretches of the region. The purpose of this chapter is to investigate the types of coastal habitat degradation and their causes in the regional settings of the long coast. For this study, the entire coast is categorised into ten different types of geographical sections, from Kanyakumari to Ichchapuram. The geospatial techniques helped to identify the specific coastal habitats in the region. The nature of habitat degradations in the coastal stretch was revealed by geospatial changes in the coastal habitat. The assemblage of plants and animals together with the abiotic environment of the tropical coast represented productive ecosystems in the transition between land and sea. They are categorised as (i) rock intertidal shore platform ecosystems, (ii) mangrove ecosystems of the deltaic shores, (iii) coral reef ecosystems at the shore fringe shelf banks, (iv)

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beach dune ecosystems along the sandy shores, (v) sea grass ecosystems along the bay fringed shores, (vi) riverine ecosystems along the coastal drainage channels, (vii) other wetland ecosystems of the coastal zones, and (viii) marine aquatic ecosystems of the shallow seas. The natural drainage flows into the coast, along with favourable sea conditions that harbour such diverse ecosystems, but human factors and climate change-induced physical factors are causing the degradation in quality of coastal habitats. Earlier studies (Das, 2021, Das et al., 2022, Mukhopadhyay, 2007, Ramkumar et al., 2016, Paul, 2005; Paul et al., 2018, 2023b; Jagtap, 1996; Jagtap et al., 2003, Thangaradjou & Kannan, 2005; Nageswara et al., 2015; Manikandan et al., 2011; Murty et al., 2022; Sengupta & Ghosal, 2017) demonstrated the reduction in sediment discharges and stream flows of the east flowing river systems of the peninsular and extra peninsular India. So far as, 17 factors (11 human factors and 6 physical factors) are considered to assess the habitat quality index in the present study. The study highlighted that beach dune ecosystems, mangrove ecosystems, riverine ecosystems, and other wetland habitats of the Coromandel coast (Andhra Pradesh and Tamil Nadu coasts) are degraded in comparison to the other habitats.

9.2 Study Area

The present study areas are extended in Andhra Pradesh and Tamil Nadu coast along the shorelines of 1030 km-long sections in the Bay of Bengal fringe areas. The south-eastern coast of the subcontinent represents the most diverse coastal habitats in India. Human encroachment on coastal processes and resource exploitation have increased significantly in the region. The study area is divided into 17 sections to identify the 8 types of coastal habitats and also for assessing their quality (Fig. 9.1). There are five major shipping ports and seven major cities located on the shore fringe coasts of Andhra Pradesh and Tamil Nadu. The southeast coast is also drained by a number of major (Godavari, Krishna, Cauvery, and Penner) and minor river systems (Vamshadhara, Nagavali, Gosthani, Sarada, Vaigai, Gundar, Vaipar, Thamirabarani, Manimutthar, Vellar, Vellaru, Gadilam, Palar, Penar, Varagali, Swarnamukhi, and Kondurpalem, etc.).

9.3 Materials and Methods

The current study investigates coastal habitat degradation on temporal and spatial scales using Sentinel-2A and Landsat 8 (multispectral data). Environmental data of fresh water flows and sediment discharges by the river systems, cyclone landfalls into the coastal zones, sea level rise rates, shoreline erosion-accretion rates, salt water encroachments into the coastal aquifers, 2004 tsunami impacts, and other human factors are considered from different reports and published papers for the

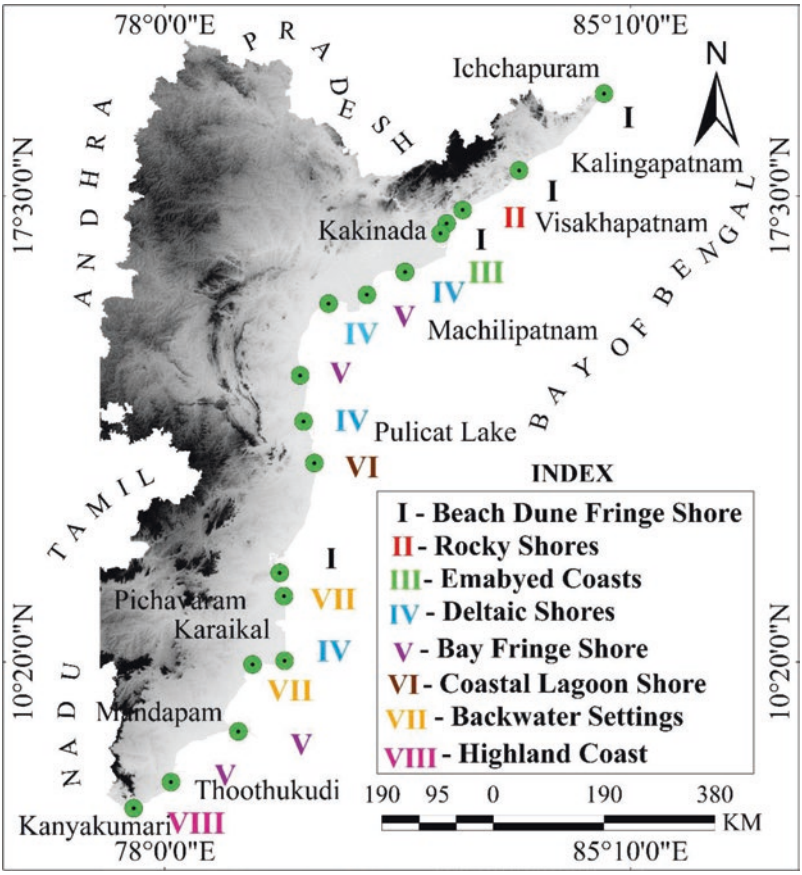

Fig. 9.1 The diversity in coastal habitats along the Coromandel Coast (Andhra Pradesh, Puducherry and Tamil Nadu, India)

study. Multicriteria decision analysis (MCDA) is conducted using the weighted sum method for assessing the habitat quality index for the coastal sections of Andhra Pradesh and Tamil Nadu. Considering the MCDA for each section, a final map is prepared to represent the habitat diversity and quality along the coasts. Finally, the validation is done through field studies in site-specific areas and through the Google Earth image of the coastal belts.

9.4 Results and Discussion

The following sections will demonstrate the coastal habitat types and their locations, the temporal changes of the coastal habitats and degradation trends, the identification of multiple factors causing the degradation of coastal habitats, the

estimation method of the habitat quality index, and an attempt to conserve the degraded habitats of the sensitive coastal environment (Ghorai et al., 2016, 2017a, b). The southeast coast of India will suffer from climate change impacts and resource use conflicts due to the alarming rate of population density in the coastal districts of Andhra Pradesh and Tamil Nadu.

9.4.1 Coastal Habitat Diversity in Andhra Pradesh and Tamil Nadu

The south-east coast is extended from Kanyakumari in Tamil Nadu to Ichchapuram in Andhra Pradesh along the Bay of Bengal across 27 coastal districts. A significant number of major and minor rivers are crossing the coastal districts from west to east and debouching into the Bay of Bengal. A few of them have built up wide and extensive deltas at their mouths with sedimentary depositional landforms. Such deltaic and marine alluvium plains harbour freshwater wetlands and coastal wetlands in the region. The fertile alluviums are also cultivated for growing crops, inhabited by population, and provided the space for urbanisation along the coastal zones. The inland coasts, the shorelines, and the shallow offshores supported eight types of coastal habitats, which are sensitive and fragile in consideration of their environmental significance under fluvial, tidal, and marine processes (Paul et al., 2023a). Southern Tamil Nadu and southern Andhra Pradesh harbour multiple habitats in the coastal sections (Table 9.1, Fig. 9.2).

Table 9.1 The location of habitat types and their characters in the Coromandel coast along the south-eastern shoreline of India

Habitat types	Geographical location	Characters
River mouth ecosystems along the drainage channels	Coastal drainage systems	Freshwater ecosystems
Other wetland types	Inland floodplains	Wetland ecosystem
Rocky intertidal shores	Shore platforms of the rocky coasts	Intertidal organisms
Beach dune habitat of the sandy shores	Sandy shorelines	Dune plants and benthic fauna
Tidal flat wetland system	River delta, estuaries, backwaters, lagoons	Mangrove ecosystem
Sea grass patches	Subtidal shores	Seagrass colony
Coral reefs	Shore fringe tidal banks	Coral reef ecosystem
Marine habitats	Open marine offshores	Aquatic ecosystem

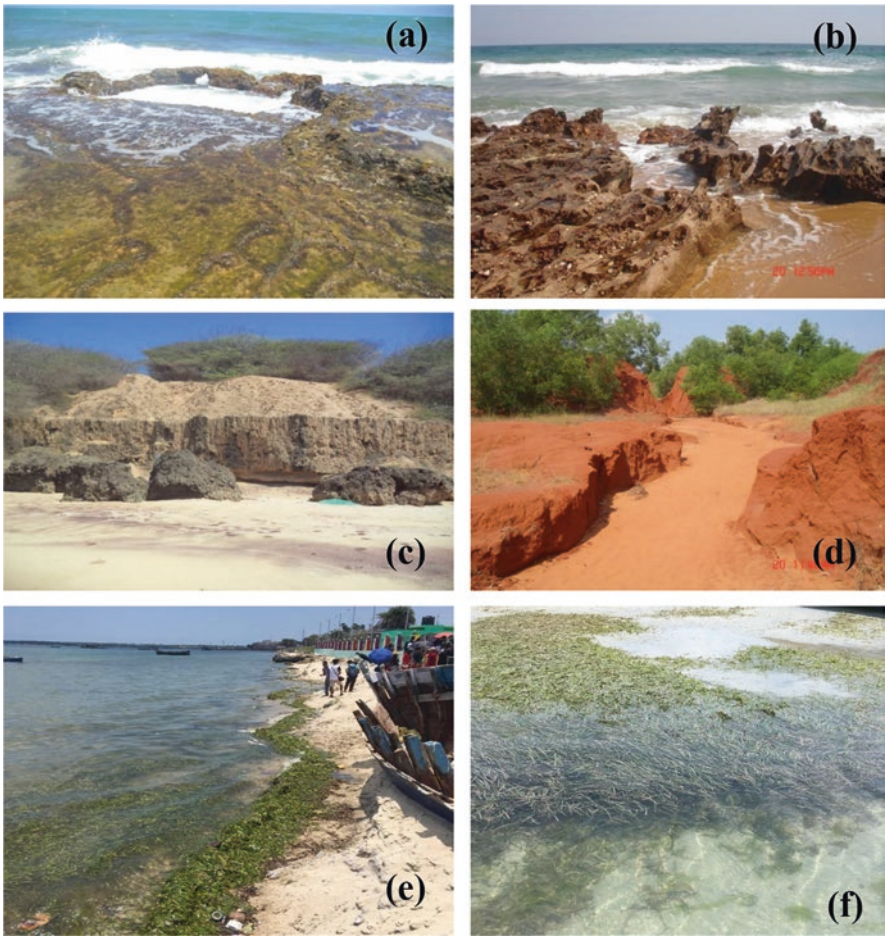

Fig. 9.2 A few habitat types in Coromandel coast of India: (**a**, **b**) Rocky intertidal shores in Manapad and Vishakhapatnam; (**c**, **d**) Beach dune habitats at Cape Comoran and Red hills of Vishakhapatnam; and (**e**, **f**) Sea grass patches along the Palk Bay fringe shorelines of Rameswaram

9.4.2 Temporal Changes in Coastal Habitats and Trends of Degradation

Coastal habitats are changing temporarily in different sections due to the impacts of multiple human factors (11 factors) and physical factors (6 factors). Land use and land cover changes, beach placer mining, cropping intensity, reductions in sediment and freshwater discharges by the river systems, and coastal urbanisation rates are major human factors causing habitat degradation in the coastal belts of Andhra Pradesh and Tamil Nadu (Fig. 9.4). The temporal changes of coastal habitats are recorded through satellite remote sensing studies. Mangrove ecosystems of the tidal

flat habitats are affected due to the conversion and spread of fish farm plots and salt processing ponds along the coastal belts. The distribution of such coastal wetland habitats was recorded and documented in the coastal districts through the geospatial techniques in 2011 by MOEF, Government of India for Andhra Pradesh and Tamil Nadu (NWIA, 2011). The study reveals that total 28.22% coastal wetlands are represented in the coastal districts of Andhra Pradesh, and total 13.56% coastal wetlands are distributed in the coastal districts of Tamil Nadu in India (Fig. 9.3). However, most of the wetlands are distributed in 4 coastal districts of Andhra Pradesh (east Godavari, west Godavari, Krishna, and Nellore) and only 3 coastal districts of Tamil Nadu (Kanchipuram, Pudukkottai, and Ramanathapuram) as per the previous estimation by MOEF.

All the river systems at their lower courses in Andhra Pradesh (Vamshadhara, Nagavali, Gosthani, Krishna, and Penneru) and in Tamil Nadu (Cauvery, Palar, Vaigai, Pennaiyar R., and Tammrabarani R.) demonstrated depositional features by extensive channel bars and less discharges of water and sediments into the coastal zones. Human activities in the catchment areas of the rivers and climate change impacts are mainly responsible for such reductions of fresh water and sediment discharges into the coastal zones. During the past five decades, a significant decrease in stream flow has been found in the Krishna and Cauvery rivers, and there has been

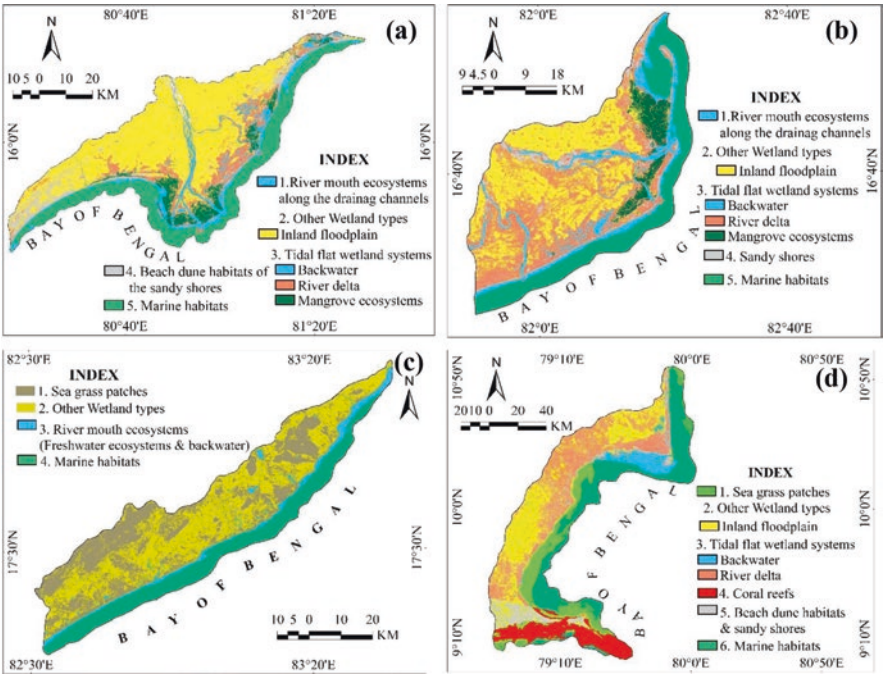

Fig. 9.3 Spatial diversity of coastal habitats in (**a**) Krishna delta, (**b**) Godavari delta, (**c**) Vishakhapatnam shoreline, and (**d**) Gulf of Mannar

a variation in precipitation in the peninsular river basins (Das et al., 2022). Hypersalinity in the tidal flats of the deltaic mangroves ecosystems resulted from shortage of fresh water and sediment accretion levels. The Palk Bay and Gulf of Manner sections of Tamil Nadu coast are noted for extensive patches of sea grasses and shelf fringe coral reefs. They were affected by erosion with dynamic marine processes, illegal coral mining activities, and various shore fringe activities by humans with placer mining, urbanisation processes, tourism recreation pressures, marine fishing, and port activities during the previous decades. The sandy shores of beaches, bars, and sand dunes are severely affected by placer mining activities on the Andhra Pradesh and Tamil Nadu coasts. Land use and land cover changes and tourism-related recreational activities along the seashore cause the degradation of sand dunes by diminishing the habitat areas with dune floral structures. Marine waves and currents have accelerated shoreline erosion along alluvial coasts in recent decades (Fig. 9.4).

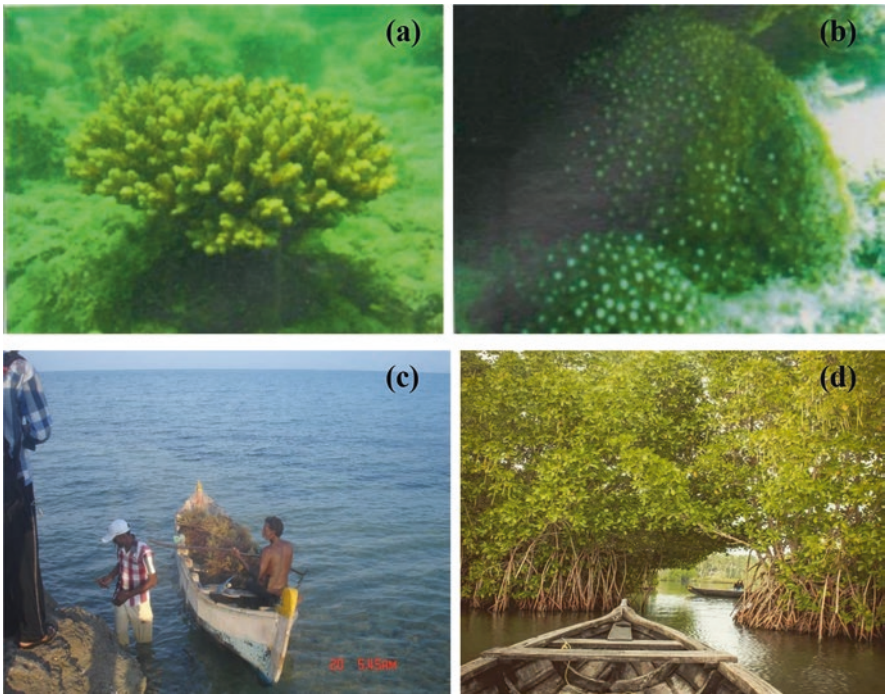

Fig. 9.4 Coral reefs and mangroves: (**a**, **b**) Living corals on the bank of shallow seas in the Palk Bay and Gulf of Mannar (*Acropora Valida and Goniopora Stutchburyi*); (**c**) Coral mining by the poor people in Rameswaram Island; and (**d**) Recreation and tourism activities in Pichavaram mangroves

9.4.3 Selection of Multicriterion Factors for Assessing Habitat Degradation

This part of the study reveals the identification of reasons for habitat degradation with the help of temporal change detection and repeated field observations during the previous decades in the coastal sections under study. So far as, multiple human factors (11 numbers) and various types of physical factors (6 numbers) have been selected as major reasons for the degradation of coastal habitats in the two eastern coastal states of Peninsular India. During the field survey, these reasons were considered in the questionnaire schedule to ask the selected number of locals to justify the factors playing a significant role in habitat degradation. However, it is validated that coastal urbanisation, land use and land cover changes, marine fishing, tourism and recreation activities, and the reduction of stream flows and sediment transport played the most significant role as human factors compared to others. Among the physical factors affecting cyclone landfalls, shoreline erosion accretion rates and saltwater encroachment into the coastal aquifers played the most significant roles in the region (CGWB, 2014). On the basis of habitat types and their diversity, the entire coastal stretch is classified into 17 coastal sections from Srikakulam to Kanyakumari for assessment of habitat degradation (Table 9.2).

9.4.4 Assessment of the Habitat Quality Index

For assessing the status of coastal habitats, the total 17 factors are applied for the each section of the coastal districts with 10 point assigned values by estimating the roles played by them in a regional framework of the coastal system. Thus, after giving the assigned values for 17 factors to the 17 coastal sections, a total value for each section will be estimated to compare the regional variation in stressors along the coastal system. Similarly, the separate rate values for human factors and physical factors out of the total assigned values of the coastal section will come out of the assessment to identify the dominance of group factors over others for each section in the coastal framework. The final ranking is given after the summation of total scores for each section of the coastal system in the study. However, the coastal habitats are ranked as very high, high, moderate, and low in terms of stressors by the integrated scores estimated by the study. The two sections of very high stressed habitats are located in northern Andhra Pradesh and southern Tamil Nadu coasts of the Peninsular India. Similarly, high-stress habitats are also located in four sections along the northern Andhra Pradesh and southern Tamil Nadu coasts. The low- and moderately stressed sections of coastal habitats are represented as better-quality habitat in the regional framework of coastal systems (Fig. 9.5).

Another observation is made by the study when the dominance of factors is estimated separately for human and physical factors. In three cases, the physical factors are dominating over the human factors in the degradation of coastal habitats in the coastal sections. Among them, two sections are located in Andhra Pradesh and only

Table 9.2 Assessment of habitat quality by the weighted sum method with 11 human factors and 6 physical factors applied in 17 coastal sections of the Coromandel Coast

Sl No	**Human Factors**	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16	S-17
1	Coastal Urbanization processes	0.7	1.2	0.1	1	0.1	0.1	0.1	0.4	0.3	0.4	1.3	0.9	0.5	0.1	0.9	0.9	1
2	Land Use and Land Cover changes in the coast	0.1	0.1	0.1	0.1	1.1	1	1.1	0.65	0.65	0.5	0.7	0.2	1.1	0.1	0.5	1	1
3	Coastal tourism recreation activities	0.5	1.7	0.5	1	0.1	0.1	0.1	0.1	0.1	0.5	1.2	1	0.1	0.1	0.5	1	1.4
4	Shipping ports and harbours	1.2	1.2	0.2	1	0.2	0.2	0.2	0.2	0.2	0.7	1.5	0.2	0.2	0.2	0.5	1.5	0.6
5	Marine fishing ventures into the sea	1.5	0.2	0.2	1.4	1.5	1.5	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.1	1	1	0.4
6	Fish farming and salt processing in the coast	1.3	0.1	0.2	1.2	0.6	1.2	0.5	0.4	0.4	1.2	0.2	0.5	0.5	0.5	0.5	0.5	0.2
7	Beach placer mining in the shore	1.5	1.2	0.2	0.2	0.2	0.2	0.2	0.6	0.6	0.2	0.5	0.5	0.2	0.2	0.5	1.5	1.5
8	Coral mining activities in the near shores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.2	3.8	3
9	Thermal power station and Atomic power station in the coastal site	0	1.5	1.5	0	0	0	0	0	0	1.5	0.5	0	0	0	0.5	0.5	4
10	Intensive cropping in the coastal zones	0.1	0	0.5	1.5	1.9	1.5	0.5	0.1	0.5	0	0	1.5	1.9	0	0	0	0
11	Reduction in sediment discharges and stream flows into the coastal zones	1	0	0	1.5	2	0	1.5	0	0.5	0	0.5	0.7	1.5	0	0.8	0	0
	Physical Factors	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16	S-17
12	cyclone landfalls and impacts	0.5	0.5	1.5	0.5	1.75	1.75	0.4	0.5	0.5	0.3	0.2	0.4	0.3	0.3	0.2	0.2	0.2
13	Sea level rise rates	2	1.5	0.9	0.9	0.9	0.9	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.1	0.1
14	Shoreline erosion and accretion rates	1	1	0.9	1	0.7	0.4	1	0.3	0.4	0.2	0.5	0.5	0.5	0.5	0.2	0.2	0.7
15	Sediment deposition in the river beds	1	1	0.5	0.5	2	0.2	0.8	0.5	0.5	0.2	0.4	0.4	0.4	0.3	0.2	0.6	0.5
16	Salt water encroachments into the aquifers	0.2	0.2	0.2	0.2	1	1	0.7	0.7	0.7	0.7	0.4	0.4	1	1	0.8	0.4	0.4
17	Tsunami waves impacts (2004)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	1.3	1.3	0.5	0.7	0.7
Integrated scores of habitat quality index		13	11.8	7.9	12.4	14.5	10.5	8	5.35	6.25	7.3	8.8	8.2	9.9	5	11.1	14	15.7
Habitat degradation ranking		VH	H	M	VH	VH	H	M	L	L	M	M	M	H	L	H	VH	VH

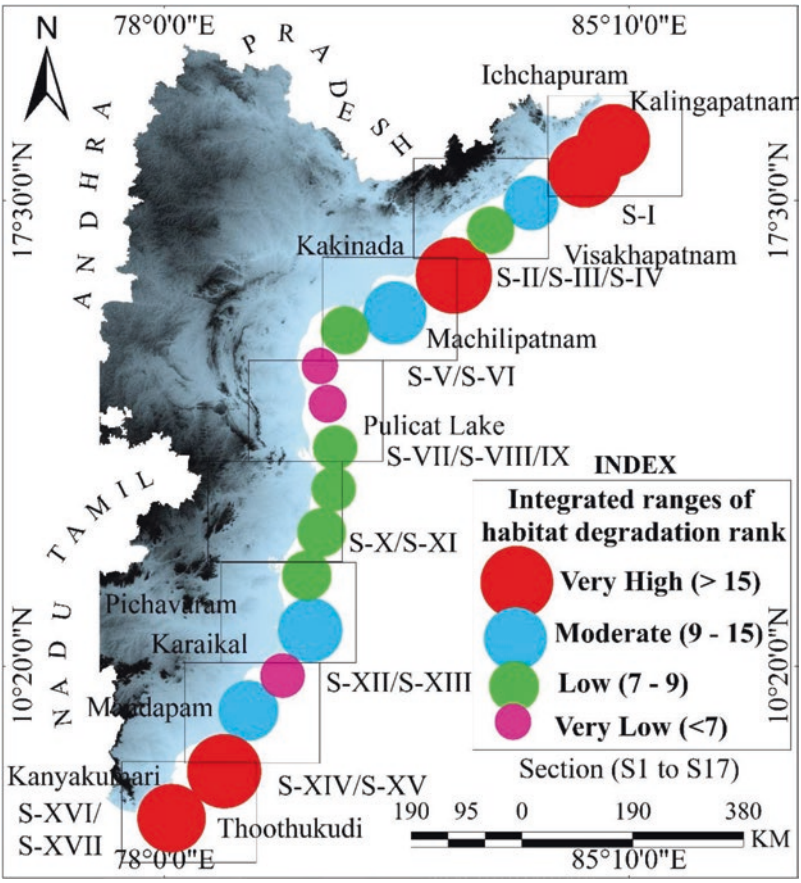

Fig. 9.5 The rate of habitat degradations assessed by integrated scores of habitat quality in seventeen coastal sections of the study area

one section in Tamil Nadu coasts under study. However, in fourteen sections of coastal habitats, human factors are playing the most significant role in the degradation of the habitat quality. Types of multiple habitats are distributed all along the coastal sections, except in five places where a single habitat is extended. The current database will help to find out the quality of coastal habitats for appropriate management practises in marine and coastal environments.

9.4.5 Management Approaches for the Habitat Conservation in the Coastal Areas

The Gulf of Mannar and Palk Bay coasts of Tamil Nadu were declared as Marine National Parks in 1988 for the location of two significant habitats as the coral reef ecosystem and the seagrass ecosystem, in the regional settings of the coasts.

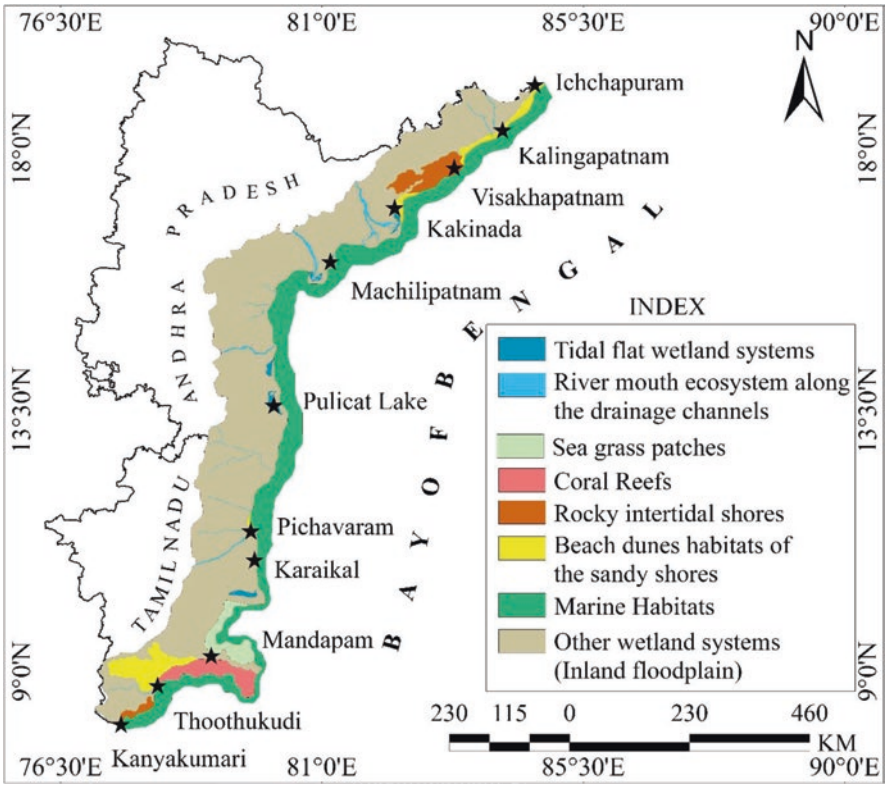

Fig. 9.6 Proposed coastal habitat management and conservation sites to meet the demand for the long-term goal in environmental crises

Significant environmental regulations are in place to limit tourist visits to the areas in order to conserve the region's sensitive coastal habitats. During the previous decades, overexploitation of marine resources resulted in the vast destruction of marine flora and fauna in the coastal marine sections. The coral reef areas that once thrived have been exploited for industrial uses, and only a few sections remain today, particularly from Tuticorin to the Krusadai Islands of the Tamil Nadu coast. Earlier studies (Patterson et al., 2004; Edward et al., 2008; Mohanraj et al., 2010) also demonstrated that the Tuticorin section of the Gulf of Manner coast is the most environmentally stressed area, mainly due to various human activities such as destructive trawl fishing, coral mining, and pollution from industries along the coastal belt. The mangrove forests were replaced along the estuary fringe coasts and backwater fringes by the extension of aquaculture ponds and salt processing ponds along the coastal sections of Andhra Pradesh and parts of Tamil Nadu. Since 2006, ecological engineering methods have been used in the Godavari, Krishna, Cauvery delta, and Pichavaram coast to increase mangrove cover areas and to restore habitat from hypersalinity in coastal sections (Fig. 9.6).

The Ministry of Water Resources (2014) has prepared a report on the status of ground water quality in coastal aquifers, which reveals that the alluvial coasts of Andhra Pradesh and Tamil Nadu are significantly affected by the encroachment of salt waters into the aquifers. Kakinada in Andhra Pradesh and Rameswaram Island in Tamil Nadu suffer mostly due to the degradation of groundwater quality. Human factors in terms of overextraction of ground waters due to rapid urbanisation in the coastal parts, sea level rise impacts, and salt water inundations due to the impacts of storm surges and tsunami waves in 2004 are primarily responsible for the degradation of ground water quality in coastal aquifers. However, such a groundwater quality status report will serve as a database for future management of water resources in coastal zones.

A national wetland atlas on the district level was also prepared by MOEF, Government of India, in 2011 with the help of ISRO, Ahmedabad, for understanding the current status of various wetlands. The coastal wetlands of Andhra Pradesh and Tamil Nadu are well represented at the district level in the status report. As per the report, the coastal wetlands include saltpans (inland), lagoons, creeks, sand bars, intertidal mudflats, saltmarshes (coastal), mangroves, coral reefs, saltpans (coastal), aquaculture ponds, etc., as components in the region. The report also demonstrated that a total of 28.22% of areas in Andhra Pradesh and 13.56% of areas in Tamil Nadu occupy coastal wetlands of different types. However, the present study includes more other types, for example, riverine wetlands, sea grasses, shallow marine water spaces, islands, barriers, and coastal sand dunes, including with the coastal wetlands types considered in the MOEF report. Human overexploitation of such natural resources, particularly through changing LULC activities along the coasts, untreated waste dumping through urban drainage outlets, coastal aquaculture ponds, tourism-recreational pressures, expanding port cities, agricultural runoff, and other industrial centres, created stress factors in coastal habitats. For management and conservation of coastal habitats, such reports and research activities are needed to meet the demands of the sustainable goal in the sensitive coastal environment of the region.

9.5 Conclusion

The present study indicated that the degradation of habitat quality in the coastal belts or coastal sections indicated a significant environmental crisis. The majority of the coastal habitats are highly stressed due to human factors and physical factors at present in Andhra Pradesh and Tamil Nadu. The coral reefs and sea grasses attenuated wave energies in the past to protect the coasts from a high-energy marine environment and harbour a wide variety of assemblages of marine animals in the coastal sections of the Gulf of Mannar and Palk Bay. Now they are restricted only to a few islands and coastal sections after overexploitation of these natural resources by the local people. Mangrove ecosystems of deltaic, estuarine, and lagoonal habitats, on the other hand, were acting as a very good buffer against wind waves and storm

surges in coastal resiliencies while also supporting a rich biodiversity in the swampy forests of Peninsular India's south eastern mega deltas. The ecosystem services are affected due to the reduction of freshwater and sediment discharges into the deltaic coasts, as well as land use and land cover conservation efforts in the wetlands, and also by emerging threats from sea level rise impacts and growing hypersalinity patches in the tidal flats of tropical coastal environments. Coastal sand dunes and sandy beaches are highly exploited for placer mining activities in many coastal sections of Andhra Pradesh and Tamil Nadu as they are the sources of rare earth minerals. The habitat supported a specific community of plants and animals on the seashores, but they are seriously affected by overexploitation of natural resources, particularly in the Vishakhapatnam, Vimlipatnam, Ramanathapuram, and Srikakulam districts of the region.

Coastal wetlands habitats are highly stressed in the northern Andhra Pradesh and southern Tamil Nadu coasts. Immediate attempts are needed to restore the habitats of mangrove ecosystems, coral reefs, sea grasses, and coastal sand dunes to save the people and their livelihoods from the threat of coastal risk associated with cyclones, tsunamis, and sea level rise impacts on the low-lying coasts of India.

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