Assessing Anthropogenic Impacts in Coastal Areas Through Landuse and Land Cover Changes from 1980 to 2019 Using Remote Sensing and GIS Techniques: A Case Study of Southern Coastal Gujarat, India

Ritika Prasad[1,✉]

[1] University of Lucknow, India
✉ prasad.ritika24@gmail.com

Keywords: land use, land cover, coastal areas, degradation, human impact

1. Introduction

Coastal regions are areas that offer vital ecosystem services to mankind in direct and indirect ways. These areas are valuable environments, which signify a very important resource base for society, economy, and human culture. These significant resources have gathered huge population and development activities around coastal regions that have imposed stresses on the coastal environment, inducing wide-ranging and rapid changes.

Coastal regions accommodate more than 60 % of the world's population in less than 15 % of the earth's land surface (Kubiszewski and Cleveland, 2012). It is projected that by 2025 this number could climb up to 75 % of humanity living on coastal areas and most of the world's coastal ecosystems will possibly be threatened by unsustainable development activities (EEA, 1999). In the current situation, this threat continues and even accelerates because of the lack of planning and management.

Human pressures on coastal regions are varied and consist of the manufacturing sector, the residential development sector, leisure and recreation, the transport sector, agriculture, and fishing (Mimura, 2008). The degree of impact of human actions in coastal areas and communities is different, subject to local conditions. The distinguishing factors that cause pressure on coastal zones are demographic change, socio-economic development, and land use policy. Among these, population growth and economic development are considered the utmost dominant cause of pressure on coastal regions (Clark, 1982, Jaiswal et al., 1999, Chilar, 2000, Yuan et al., 2005, Joshi et al., 2011, Rawat et al., 2013). India is one such example in the world where the population is centralized in coastal areas.

The southern coastal region of Gujarat, India, is an area that faces stresses from various human activities that have been occurring for a long time (Misra and Balaji, 2015). Land alteration is not in accordance with the objective of sustainable development and gives pressure to both biophysical conditions and the community that depends on the coastal resources. As land use is not compatible with the carrying capacity of the land, this causes the degradation of coastal ecosystems and results in adverse impacts such as coastal erosion, increased relative sea-level rise, and marine pollution. Relative sea-level rise is one of the impacts that accelerates pressure and affects coastal destruction. Lack of appropriate management and guidelines aggravates the current scenario of coastal degradation which requires urgent spatial planning on resource utilization in such areas.

To back up the coastal management, access to land cover information is essential (Dahdouh-Guebas, 2002). The land cover turns out to be a core indicator because the processes of human activity development directly impact its changing conditions. Besides, land cover change can be used as an indicator to define the extent of pressure from human activities and development in coastal zones, and what form of management could be undertaken to achieve stable future conditions.

2. Statement of the Problem

Coastal areas are regions that have huge prospects of environmental services and resources related to social, economic, and cultural activities. The concern nowadays is that human activities and physical development in coastal areas haphazardly increase without control. They expand and change the existing coastal ecosystem without considering the suitability and capacity of the coastal land.

Coastal areas of southern Gujarat are subject to development pressure that will have lasting effects for a long time (Chauhan and Nayak, 2005). The pressures are aggravated by sea-level rise that can be seen as a primary factor in coastal degradation. This situation poses a risk to the resilience of both human and environmental coastal systems. One of the impacts can be seen in land cover change conditions in coastal areas. Dealing with the above problem, this study will analyse land cover change in coastal areas and identify changing trends.

Coastal planning processes are conducted with a consensus-building that depends on local knowledge

DOI: 10.2312/yes19.05

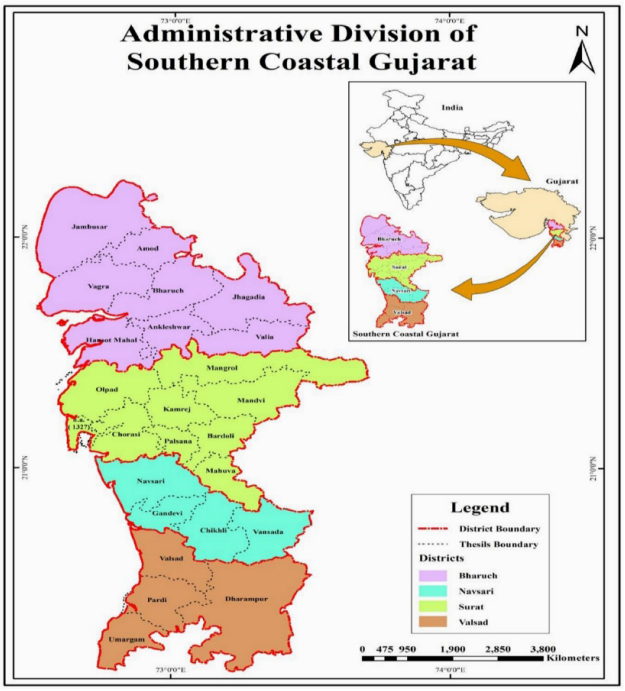

Figure 1: Administrative divisions of Southern Gujarat.

and stakeholder preferences to make informed choices about equitable resource allocation. Coastal planning and management in Gujarat is constrained by a dearth of data about interaction between development activities and coastal environment conditions. Information relating to causes of land use change will allow more cautious preparation and organisation in the area. It will provide us with an understanding of cause and effect relationships between interacting social, economic, and environmental components.

3. Study Area

The coastline of about 200 km in South Gujarat, forming a part of four districts of Gujarat such as Bharuch, Surat, Navsari, and Valsad, has been investigated in the present study (Fig. 1).

The geographical area extends from 20°49' N to 21°41' N in latitudes and 73°01' E to 73°3' E in longitudes. The coastline of the study area is comparatively uniform and broken by a few indentions. Sandy beaches are present along most of the coast of the study area. Mudflats, marsh, and mangrove vegetation are also found along the coast of the study area. The major rivers of the area are Damanganga, Kolak, Par, Purna, Auranga, Ambica and Mindhola, etc which are comparatively smaller and rise within the boundaries of the state from the eastern highlands.

The Bharuch district has a population of 1,550,822 in the southern part of the Gujarat peninsula on the west coast of the state of Gujarat (Census of India, 2011a). The Narmada River flows into the Gulf of Khambat through its lands. The district of Surat with a total population of 6,079,231 covers an area of 7657 km² and is bordered by the districts of Bharuch and Narmada in the North, Navsari and Dangs in the South and the Gulf of Khambat in the West (Census of India, 2011b). The town of Hazira is located in this district, which is an important transhipment port and is popularly known as the "industrial hub" of India due to the presence of major industrial facilities. The district of Navsari covers an area of 2211 km² with a population of 1,329,672 and is bordered by the districts of Surat in the North, and Dangs in the East (Census of India, 2011c). The district of Valsad is surrounded by the district of Navsari in the North, Dang in the East, and Maharashtra in the South. The population of Valsad is 1,705,678 persons for an area of 3034 km². (Census of India, 2011d).

4. Objectives

- To identify the changes in land use and land cover that influence the coastal zone in southern Gujarat from 1980 to 2019.
- To determine the causes which affect the change of land use in the study area.

5. Data Sources and Methodology

The study uses both primary information and secondary information available at various levels. Multitemporal analysis has been done in this study by us-

Data Source: https://earthexplorer.usgs.gov/

S. No.	Sensor	Year	Date of Passing	Resolution
1	Landsat - 3	1980	08.04.1980	30 Meter
2	Landsat - 5	1990	25.03.1990	30 Meter
4	Landsat - 7	2000	23.11.2000	30 Meter
5	Landsat – 5 (Landsat 7 images after 2002 black spot and liner so does not useable)	2010	12.05.2010	30 Meter
5	Landsat – 8	2019	28.05.2019	30 Meter

Software :
1. ArcGIS 10.1
2. ERDAS 2014

Method:
Supervised Classification (ERDAS)

Figure 2: Description of satellite images used in the study.

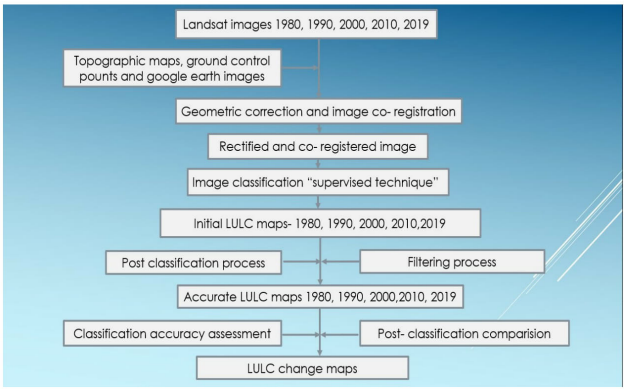

Figure 3: Datasource and methodology,

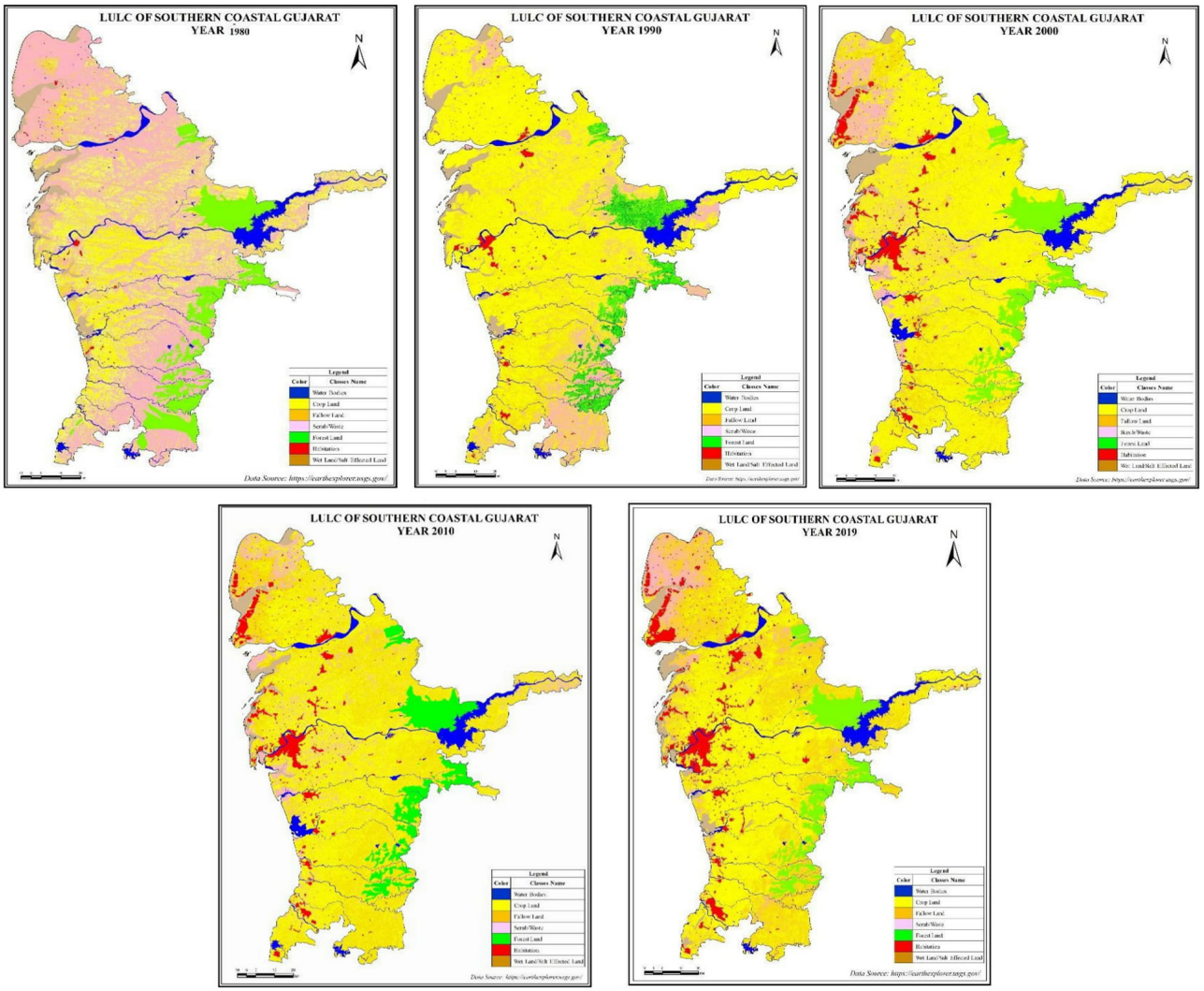

Figure 4: Maps showing land use and land cover from 1980 to 2019.

ing Landsat images from 1980 to 2019 (Fig. 2). To obtain land cover data, each image is classified by using supervised classification. Change detection of land cover in the study area is done in five stages from 1980 to 1990, 1990 to 2000, 2000 to 2001, 2001 to 2010, and 2010 to 2019 (Fig. 3).

6. Results and Discussion

In the study, the images are classified based on the land conditions of the area. According to the classification, the following categories could be identified: forest land, crop land, fallow land, scrub land, habitation and water bodies, and rivers.

Based on the findings, land use changes in 1980, 1990, 2000, 2010, and 2019 (Fig. 4), the fallow land has experienced the most significant increase, followed by urban areas. Agricultural area and wasteland tend to decrease over time. Rivers, wetlands, and forest land remained more stable during the 1980-2019 periods.

The primary factors influencing the coastal areas are mainly human activities which include economic development, population growth, demographic growth, infrastructure development policy, topography, and climate change. In this study, the primary factors are determined by interpreting the interaction between the social-economic and ecological systems in the area and their relevance to the coastal degradation.

As it has already been noted that there has been a significant increase in urban areas, the population is the most important underlying factor because with population growth there is the corresponding need for urban land. The growth of population increases various human activities in the area, including resi-

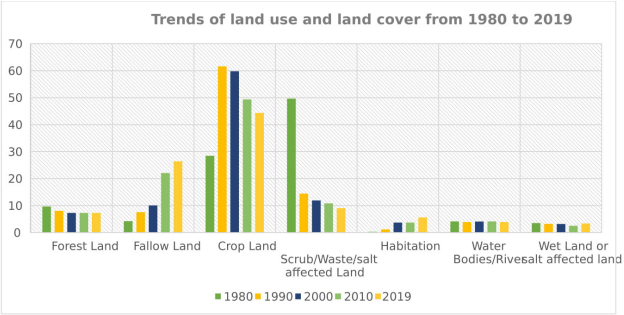

Figure 5: Trends of land use and land cover changes from 1980 to 2019.

dential, industrial, and commercial development, and aquaculture development. With the rising demand for residential, industrial, and commercial growth and the limit of land availability, land use change occurs in this area. The early development process of urban built-up area in this location is influenced by river and coastline patterns, including Narmada River and Tapti River. These patterns relate to the general livelihood of the community that correlates with fisheries and agriculture. Rivers are amongst the major contributors to the pattern of urban built-up area expansion because fisherman communities use the river for transportation from their house to the sea. This results in emerging urban development patterns along the river and coastline.

The increase in fallow land can be attributed to the growing population that has placed a great deal of stress on the topsoil resources of this region. Much of the land used for agriculture is decreasing in the state. The increase in fallow land can be due to land getting affected by salinity in the region.

On the other hand, there is a decline in the crop land which is mainly due to the scarcity of water and declining water quality. Since the study area is also dominated by industrial activities migration of the human population to urban centres is also leading to a decline in agriculture.

Wasteland is also on decline mainly because of expansion in urban activities like an increase in commercial and residential buildings (Fig. 5).

6.1. Impact of land use changes

In southern Gujarat, the development of activities along the coastal area does not consider the physical condition of the existing land. Consequently, this area is incapable to accommodate all of these activities and causes various impacts. Impacts describe the effects of changes in coastal states on measures of ecosystem function.

In southern Gujarat the impacts of these uncontrolled activities could be seen in recent years, including relative sea-level rise. In addition, it has also been noted through the primary survey that the intensity of floods over the years has risen especially in the monsoon season. The degradation of coastal zones is the main impact of land use conversion that is caused by the pressures in this area. This phenomenon is mainly caused by land utilization that is incompatible with the capacity and suitability of land. Along with the degradation of the coastal zone, other impacts emerge in the study area, including coastal flooding and decreasing productivity in many sectors such as agriculture and aquaculture fisheries. Over the next few years, it could lead to the socio-economic impoverishment of the coastal community.

7. Conclusions

This study is conducted to examine the land use change in the coastal zone of southern Gujarat and the primary factors that underlie these changes can be taken into consideration to assess the future land use configuration in the coastal zone. Information about land use change is particularly important to understand the behaviour of land uses related to human activities in the study area. Moreover, information on future land use change and distribution obtained from this research can be used in supporting the arrangement of coastal zone management plan, charting future activities, and guiding the steps required to achieve coastal planning aims. Appropriate coastal land use planning to attain a sustainable future is important in the coastal zone because the region still encounters several problems, including the implementation of regulations and the arrangement process of a coastal management plan.

Land use/land cover (LULC) maps demonstrate that the study area covers a fragile ecosystem including mudflats, and salt marshes, and hence future environmental degradation along this coast could disrupt the natural functioning of the environment. Therefore, improved remote sensing tools (high-resolution data) and GIS accompanied by field surveys and numerical modelling can enable a better understanding of these regions to develop a sound strategy for the conservation and restorations of these natural systems. Finally, the present research pertaining to the mapping of LULC will enable decision-makers to identify the susceptible zones and find better solutions to the existing coast problems in these locations.

8. REFERENCES:

Census of India 2011a, Gujarat: District Census Handbook Bharuch: Village and Town Directory. Series 25, Part-XII-A. Directorate of Census Operations Gujarat. 372 pp. [Online] https://censusindia.gov.in/2011census/dchb/DCHB_A/24/2421_PART_A_DCHB_BHARUCH.pdf [Accessed 22.08.2020].

Census of India 2011b, Gujarat: District Census Handbook Surat: Village and Town Directory. Series 25, Part-XII-A. Directorate of Census Operations Gujarat. 372 pp. [Online] https://censusindia.gov.in/2011census/dchb/DCHB_A/24/2425_PART_A_DCHB_SURAT.pdf [Accessed 22.08.2020].

Census of India 2011c, Gujarat: District Census Handbook Navsari: Village and Town Directory. Series 25, Part-XII-A. Directorate of Census Operations Gujarat. 372 pp. [Online] https://censusindia.gov.in/2011census/dchb/DCHB_A/24/2423_PART_A_DCHB_NAVSARI.pdf [Accessed 22.08.2020].

Census of India 2011d, Gujarat: District Census Handbook Valsad: Village and Town Directory. Series 25, Part-XII-A. Directorate of Census Operations Gujarat. 372 pp. [Online] https://censusindia.gov.in/2011census/dchb/DCHB_A/24/2424_PART_A_DCHB_VALSAD.pdf [Accessed 22.08.2020].

Chauhan, H.B., Nayak, S. 2005. Land use/land cover changes

near HAzira Region, Gujarat using remote sensing satellite data. Journal of the Indian Society of Remote Sensing 33, 413–420. https://doi.org/10.1007/BF02990012

Chilar, J. 2000. Land cover mapping of large areas from satellites: status and research priorities. International Journal of Remote Sensing. 21(67). pp. 1093–1114. https://doi.org/10.1080/014311600210092

Clark, D. 1982. Urban Geography: an Introductory Guide, Croom Helm, London. 231 pp.

Dahdouh-Guebas, F. 2002. The use of remote sensing and GIS in the sustainable management of tropical coastal ecosystems. Environment, Development and Sustainability. 4. pp. 93–112. https://doi.org/10.1023/A:1020887204285

Kristensen, P., Anderson, Ö., Denisov, N., 1999. A checklist for state of environment reporting. Technical report No. 15. European Evironmental Agency, Copenhagen. 24 pp. [Online] https://www.eea.europa.eu/publications/TEC15/ [Accessed 22.08.2020].

Kubiszewski, I., Cleveland, C. (2012). United Nations Conference on Environment and Development (UNCED), Rio de Janeiro, Brazil. [Online] http://editors.eol.org/eoearth/wiki/United_Nations_Conference_on_Environment_and_Development_(UNCED),_Rio_de_Janeiro,_Brazil [Accessed 22.08.2020].

Jaiswal, R. K., Saxena,R., Mukherjee, S. 1999. Application of remote sensing technology for land use/land cover change analysis Journal of the Indian Society of Remote Sensing. 27(2). pp. 123–128. https://doi.org/10.1007/BF02990808

Joshi, R.R., Warthe, M., Dwivedi, S., Vijay, R., Chakrabarty, T. 2011. Monitoring changes in land use land cover of Yamuna riverbed in Delhi: a multi temporal analysis. International Journal of Remote Sensing. 32(24). pp. 9547–9558. https://doi.org/10.1080/01431161.2011.565377

Mimura, N. 2008. Conclusions: The Rapidly Changing Environment of the Asia and Pacific Region and its Implications for Sustainability of the Coastal Zones. In: Mimura, N. (ed.), Asia-Pacific Coasts and Their Management. States of Environment. Springer, Amsterdam. pp. 345–358. https://doi.org/10.1007/978-1-4020-3625-5_6

Misra A, Balaji R. 2015. Decadal changes in the land use/land cover and shoreline along the coastal districts of southern Gujarat. India. Environmental Monitoring and Assessment. 187(7). 461. https://doi.org/10.1007/s10661-015-4684-2

Rawat, J.S., Biswas, V., Kumar, M. 2013. Changes in land use/cover using geospatial techniques: a case study of Ramnagar town area, district Nainital, Uttarakhand, India. Egyptian Journal of Remote Sensing and Space Sciences. 16. pp. 111–117. https://doi.org/10.1016/j.ejrs.2013.04.002

Yuan, F., Sawaya, K. E., Loeffelholz, B. C., Bauer, M. E. 2005. Land cover classification and change analysis of the twin cities (Minnesota) metropolitan area by multi temporal Landsat remote sensing. Remote Sensing of Environment. 98. pp. 317–328. https://doi.org/10.1016/j.rse.2005.08.006