environmental sciences proceedings

MDPI

Proceeding Paper

Coastal Vegetation Change Detection Using a Remote Sensing Approach †

Usha Pandya [1,*], Ashwini N. Mudaliar [2] and Switi Alvi [1]

1 Department of Botany, Government College Daman, Nani Daman, Daman 396210, India
2 Department of Botany, Faculty of Science, The Maharaja Sayajirao University of Baroda, Vadodara 390002, India; ashwini144@gmail.com
* Correspondence: ushajosh12@gmail.com

† Presented at the 5th International Electronic Conference on Remote Sensing, 7–21 November 2023; Available online: https://ecrs2023.sciforum.net/.

Abstract: Coastal zones represent varied and highly productive ecosystems such as mangroves, coral reefs, sea grasses, and sand dunes. However, as a result of globalization, anthropological activities have increased in coastal areas, putting these ecosystems under high pressure. This, in turn, has led to the loss of valuable vegetation in the coastal areas of the world. This study was conducted to detect the changes occurring in the coastal vegetation in the Daman district of India. Daman is one of the Union territories of India, which have shown good development in recent years. As a result, the area covered by mangrove vegetation has changed at and near the coast of this district. A remote sensing approach was utilized in this study to detect the changes in vegetation that occurred between the years 2016 and 2021. Landsat ETM+ data were used to derive NDVI images of the study period using ERDAS imagine 2014. Field work covering the entire study area was carried out to classify and assess the accuracy of the vegetation categories, i.e., no vegetation, low vegetation, moderate vegetation, and dense vegetation. Vegetation maps for both the years were prepared using ArcGIS software 10.5. The results indicated that the area with no vegetation decreased during the study period, whereas the rest of the categories, i.e., low vegetation, moderate vegetation, and dense vegetation, showed an increase. This increase in vegetation can be attributed to the Daman official authorities' efforts to conserve these coastal areas. This will lead to enhanced ecosystem services provided by these ecosystems.

Keywords: NDVI; vegetation maps; mangroves; India

check for updates

Citation: Pandya, U.; Mudaliar, A.N.; Alvi, S. Coastal Vegetation Change Detection Using a Remote Sensing Approach. *Environ. Sci. Proc.* **2024**, *29*, 17. https://doi.org/10.3390/ECRS2023-15853

Academic Editor: Xin Wang

Published: 6 November 2023

Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

The coastal regions of the world are facing growing pressure due to the expansion of industries, increased trade and commerce, booming tourism, population growth, and migration. These areas, known for their high biological productivity, are crucial components of the global ecosystem. Coastal ecosystems host a rich diversity of species and genes, perform essential functions like nutrient cycling and pollutant filtration, and act as protective barriers against erosion and storms [1,2]. Furthermore, marine ecosystems play a pivotal role in climate regulation, serving as significant carbon sinks and oxygen sources [3,4]. Unfortunately, industrial development along the coast has led to the degradation of these ecosystems and a decline in the living resources found within the Exclusive Economic Zone (EEZ), including in relation to coastal and marine biodiversity and productivity [5,6]. The majority of the world's population resides within 60 km of a coast, a number expected to increase by nearly three quarters by 2020 [7,8], making coasts vulnerable to episodic events like the depletion of green cover, which has been an ongoing issue since the dawn of human civilization and continues to threaten the environment. Human activities have accelerated the loss of natural forests due to development projects [9].

Coastal zones encompass a diverse range of highly productive ecosystems such as mangroves, coral reefs, sea grasses, and sand dunes [10]. These ecosystems are under significant pressure due to increased human activity along the coast, and this is driven by globalization. It is imperative to protect these coastal ecosystems to ensure sustainable development. Therefore, there is an urgent need to conserve coastal ecosystems, including individual plant species and communities, to support settlements, recreation, environmental preservation, and agriculture. To achieve sustainable development, it is crucial to establish accurate, up-to-date, and comprehensive scientific databases covering habitats, protected areas, water quality, environmental indicators, and periodic assessments of the overall system's health [11]. This requires consistent monitoring of habitats, landforms, coastal processes, water quality, and natural hazards.

Realizing the value of remote-sensing-derived information, the state and central agencies responsible for the conservation of these ecosystems are increasingly adopting remote sensing data for routine use. Remote sensing technology allows for the systematic and comprehensive assessment of changes in coastal vegetation, facilitating informed decision making for sustainable resource management.

In this context, this study focuses on detecting changes in coastal vegetation, especially Mangroves, and identifying changes in vegetation patterns and the reduction in green coverage in these areas through an NDVI technique within the Daman district of India, which is one of the country's Union territories that has been experiencing significant development in recent years. The coastal region of Daman has witnessed alterations in its mangrove vegetation cover and surrounding areas, necessitating a thorough examination of these transformations.

2. Study Area

Daman is located on the mainland in the southern part of the Gujarat state in India. It is situated approximately 200 km north of Mumbai and is bordered by the Valsad District of Gujarat State to the north, east, and south (see Figure 1). The Daman Ganga River, originating from Nasik, flows through the center of the Daman District, effectively dividing it into two distinct parts known as Moti Daman and Nani Daman. The total area of the Daman district is 72 km^2, with geographical coordinates of approximately 20°24′51.52″ N in latitude and 72°49′56.50″ E in longitude.

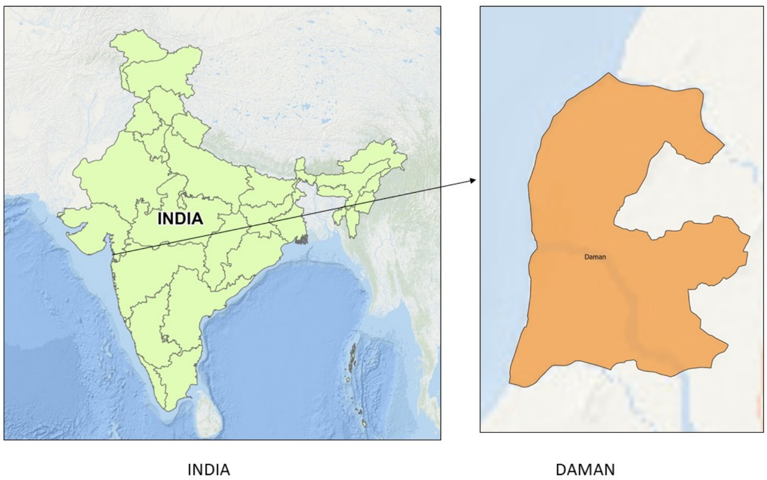

Figure 1. Map showing Daman district.

3. Material and Methods

This study made use of data from various sources. Satellite imagery from Landsat ETM+ for the years 2016 and 2021 was utilized to analyze alterations in vegetation cover.

Methodology

Field work was carried out in different parts of the study area to analyze the various vegetation types. GCP were taken to locate the different patches in the study area.

Data Acquisition—Landsat ETM+ satellite imagery for the years 2016 and 2021 was obtained to gain a multi-temporal perspective of the study area.

Pre-processing—The acquired satellite imagery was subjected to pre-processing steps, including radiometric and geometric corrections, to ensure data accuracy and consistency.

Vegetation Index Calculation—The Normalized Difference Vegetation Index (NDVI) was computed from Landsat imagery using ERDAS Imagine 2014. NDVI serves as a reliable indicator of vegetation health and density.

Field Work and Ground Truthing—Extensive fieldwork was conducted to collect ground truth data across the entire study area. Field surveys allowed for the classification of vegetation categories, including no vegetation, low vegetation, moderate vegetation, and dense vegetation.

Image Classification—The NDVI images were used to classify the coastal vegetation into different categories, integrating the field data for accuracy assessment. The study area was categorized into four distinct classes based on the NDVI values, which serve as effective indicators of vegetation health and density. These classes were defined as follows:

- No Vegetation: NDVI values less than or equal to 0.
- Low Vegetation: NDVI values greater than 0 and less than or equal to 0.1.
- Moderate Vegetation: NDVI values greater than 0.1 and less than or equal to 0.2.
- Dense Vegetation: NDVI values greater than 0.2.

Spatial Analysis—Geographic Information System (GIS) tools, particularly ArcGIS software 10.5, were employed to create vegetation maps for both 2016 and 2021.

Change Detection—Comparative analysis of vegetation maps enabled the identification of changes in coastal vegetation over the study period. The study focused on quantifying the changes in the extent of each vegetation category.

4. Results

This study was undertaken to analyze the changes in coastal vegetation in Daman District using a spatial approach. Satellite data downloaded for the study area aided in analyzing its vegetation. The ArcGIS software utilized for the study helped in preparing the latest map of Daman district, which can be further utilized for future reference.

Satellite-based vegetation maps provide a comprehensive view of plant density across the entire globe. The Normalized Difference Vegetation Index (NDVI) serves as a straightforward indicator for determining the presence of live green vegetation [12]. The NDVI is particularly effective in efficiently measuring coastal vegetation. Any alterations in these ecosystems have far-reaching consequences, affecting balance not only at the local and regional but also the national and global levels. The current study was initiated to scrutinize changes in the vegetation of Daman district, and it yielded highly promising results.

In the present study, the vegetation types of Daman were mapped using Landsat data and an NDVI technique. Figure 2a,b illustrate the vegetation status of the study area for the years 2016 and 2021, respectively. NDVI values below 0.1 are indicative of barren areas such as rock, sand, or snow. This category exhibited a significant decrease in area, amounting to 16.16 km^2, which is a positive sign for the ecosystem's health (refer to Table 1). This region experienced an increase in vegetation cover from 2016 to 2021, attributed to the concerted efforts of Daman's official authorities. The "Low vegetation" category displayed a notable increase, expanding by 10.59 km^2, signifying a transition from the "No vegetation" category. Additionally, both the "Moderate vegetation" and "Dense vegetation" categories exhibited growth, increasing by 5.39 km^2 and 0.15 km^2, respectively (refer to Figure 3). While the change in dense vegetation was substantial, it can be seen as a potential positive development.

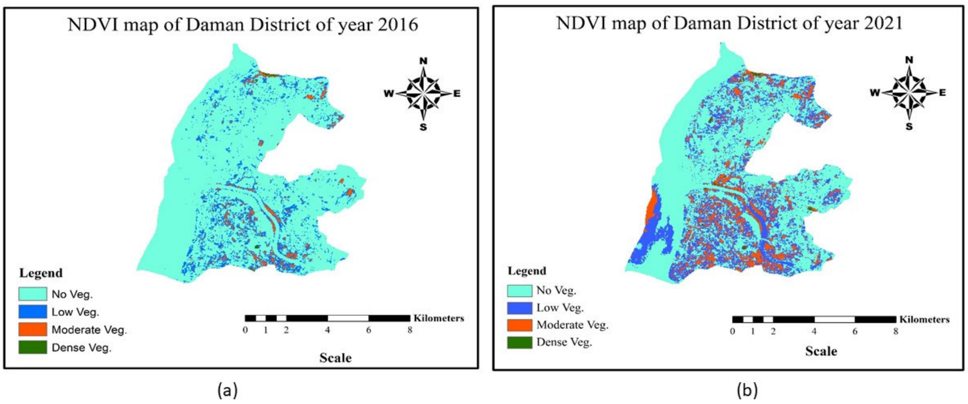

Figure 2. Vegetation map of Daman district: (**a**) 2016; (**b**) 2021.

Table 1. Table showing the area under different vegetation classes along with change detection.

Sr. No.	Vegetation Class	Year 2016 (km^2)	Year 2021 (km^2)	Change (km^2)
1	No vegetation	62.70	46.54	−16.16
2	Low vegetation	7.51	18.11	10.59
3	Moderate vegetation	1.94	7.33	5.39
4	Dense vegetation	0.11	0.27	0.15
	Total	72.00	72.00	

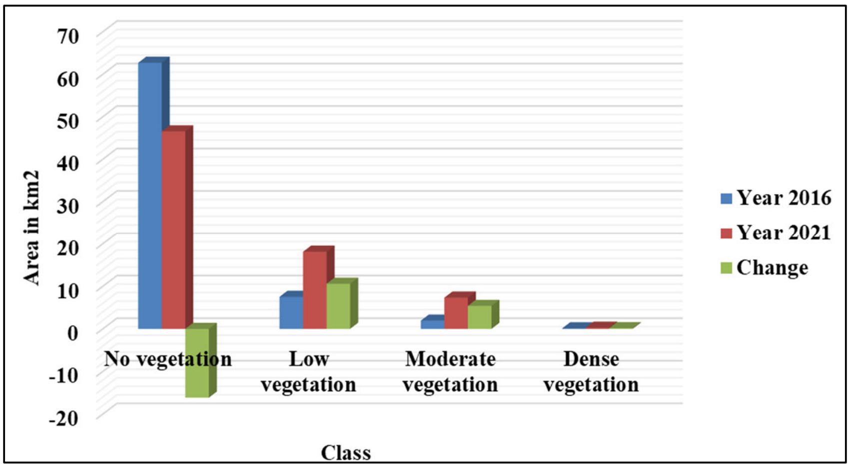

Figure 3. Chart showing the vegetation in the study area.

5. Conclusions

Multispectral remote sensing images are very useful for obtaining a better understanding of earth's environments. Their use constitutes the science and art of acquiring information and features in spectral, spatial, and temporal forms about a given object, area, or phenomenon, such as vegetation, land cover classification, urban area, agriculture land, and water resources, without coming into physical contact with this object. In this study, multispectral images of Daman district were used to detect vegetation changes in Daman from 2016 to 2021. The area under vegetation increased in the study area during the study period, which can be attributed to the efforts of the Daman official authorities.

Author Contributions: Conceptualization, U.P.; methodology, S.A.; software, A.N.M.; validation, U.P., S.A. and A.N.M.; formal analysis, U.P.; investigation, U.P.; resources, S.A.; data curation, S.A.; writing—original draft preparation, A.N.M.; writing—review and editing, A.N.M.; visualization, S.A.; supervision, U.P.; project administration, U.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: This study used Landsat-8 multispectral imagery that is publicly available at http://earthexplorer.usgs.gov (accessed on 22 January 2022).

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Barbier, E.B.; Hacker, S.D.; Kennedy, C.; Koch, E.W.; Stier, A.C.; Silliman, B.R. The value of estuarine and coastal ecosystem services. *Ecol. Monogr.* **2011**, *81*, 169–193. [CrossRef]
2. Elisha, O.D.; Felix, M.J. Destruction of coastal ecosystems and the vicious cycle of poverty in Niger Delta Region. *J. Glob. Agric. Ecol.* **2021**, *11*, 7–24.
3. Heinze, C.; Meyer, S.; Goris, N.; Anderson, L.; Steinfeldt, R.; Chang, N.; Le Quéré, C.; Bakker, D.C.E. The ocean carbon sink–impacts, vulnerabilities and challenges. *Earth Syst. Dyn.* **2015**, *6*, 327–358. [CrossRef]
4. DeVries, T. The ocean carbon cycle. *Annu. Rev. Environ. Resour.* **2022**, *47*, 317–341. [CrossRef]
5. Burke, L.; Kura, Y.; Kassem, K.; Revenga, C.; Spalding, M.; McAllister, D.; Caddy, J. *Coastal Ecosystems*; World Resources Institute: Washington, DC, USA, 2001.
6. Sahavacharin, A.; Sompongchaiyakul, P.; Thaitakoo, D. The effects of land-based change on coastal ecosystems. *Landsc. Ecol. Eng.* **2022**, *18*, 351–366. [CrossRef]
7. McCammon, A.L.T. United Nations Conference on Environment and Development, held in Rio de Janeiro, Brazil, during 3–14 June 1992, and the '92 Global Forum, Rio de Janeiro, Brazil, 1–14 June 1992. *Environ. Conserv.* **1992**, *19*, 372–373. [CrossRef]
8. Hinrichsen, D. The coastal population explosion. In Proceedings of the Trends and Future Challenges for US National Ocean and Coastal Policy: Proceedings of a Workshop, Washington, DC, USA, 22 January 1999; NOAA: Washington, DC, USA, 1999.
9. Nayak, S. Role of remote sensing to integrated coastal zone management. In Proceedings of the XXth Congress of the International Society for Photogrammetry and Remote Sensin, Istanbul, Turkey, 12–23 July 2004.
10. Crossland, C.J.; Kremer, H.H.; Lindeboom, H.J.; Crossland, J.I.M.; Tissier, M.D.A. *Coastal Fluxes in the Anthropocene: The Land-Ocean Interactions in the Coastal Zone Project of the International Geosphere-Biosphere Programme*; Springer Science & Business Media: Berlin/Heidelberg, Germany, 2005.
11. Nayak, S. Coastal zone management in India—Present status and future needs. *Geo-Spatial Inf. Sci.* **2017**, *20*, 174–183. [CrossRef]
12. Ng'andwe, P.; Mwitwa, J.; Muimba-Kankolongo, A.; Ratnasingam, J. An Overview of the Forestry Sector in Zambia. In *Forest Policy, Economics, and Markets in Zambia*; Ng'andwe, P., Mwitwa, J., Muimba-Kankolongo, A., Eds.; Academic Press: Boston, MA, USA, 2015; pp. 1–26.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.