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Coastal Vegetation Change Detection Using Remote Sensing Approach †

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Abstract: The coastal zone represents 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 on the coastal areas putting these ecosystems under high pressure. This, in turn, has lead to the loss of valuable vegetation along the coastal areas of the world. This study was taken up to detect the change occurring in coastal vegetation of Daman district of India. Daman is one of the Union territories of India which have shown a good development in recent years. As a result, area under the mangrove vegetation has changed at and near the coast of the district. Remote sensing approach was utilized in this study to detect the changes occurred in the vegetation between the years 2016 to 2021. Landsat ETM+ data was used to derive NDVI images of the study period using ERDAS imagine 2014. Field work covering the entire study area was carried out for classifying and accuracy assessment 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. Results indicated that area under the no vegetation decreased during the study period whereas rest all categories, i.e., low vegetation, moderate vegetation and dense vegetation showed increase. The increase in the vegetation can be attributed to efforts taken up by the Daman official authorities for conserving the coastal areas. This will lead to enhanced ecosystem services provided by these ecosystems.

Keywords: NDVI; vegetation maps; mangroves; India

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1. Introduction

The coastal regions of the world are facing growing pressures 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 coastal and marine biodiversity and productivity [5,6]. The majority of the world's population resides within 60 km of the coast, a number expected to increase to nearly three-quarters by 2020 [7,8], making them vulnerable to episodic events like the depletion of green cover 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].

The coastal zone encompasses 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, 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 the remote-sensing derived information, the state and central agencies responsible for the conservation of these ecosystems are increasingly adopting remote sensing data for their 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 identify the change of vegetation pattern and abolition of green coverage of the area through NDVI technique within the Daman district of India, which is one of the country's Union territories 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 Figures 3 and 4). 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 at approximately 20°24′51.52″ N latitude and 72°49′56.50″ E longitude.

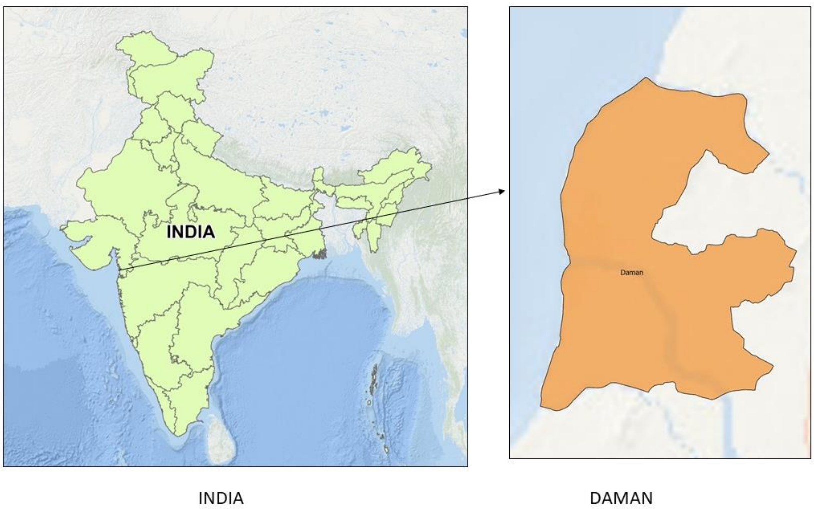

Figure 1. Map showing Daman district.

3. Material and Methods

The 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 study are to analyze the various vegetation types. GCP were taken to locate the different patch on the study area.

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

Pre-processing-The acquired satellite imagery underwent 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 an effective indicator of vegetation health and density. These classes were defined as follows:

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

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

Change Detection-Comparative analysis of vegetation maps enabled the identification of changes in the 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 change in coastal vegetation in Daman District using spatial approach. Satellite data downloaded for the study area aided in analyzing the vegetation of the study area. ArcGIS software was 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 to determine the presence of live green vegetation [12]. NDVI is particularly effective in efficiently measuring coastal vegetation. Any alterations in these ecosystems have far-reaching consequences, affecting the balance not only at the local, regional, but also at the national and global levels. The current study was initiated to scrutinize changes in the vegetation of Daman district and yielded highly promising results.

In the present study vegetation types of Daman were mapped using Landsat data and 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). The 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 km² and 0.15 km², respectively (refer to Figure 3). While the change in dense vegetation was substantial, it can be seen as a potential positive development.

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

Sr. No.	Vegetation Class	Year 2016 (km²)	Year 2021 (km²)	Change (km²)
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	

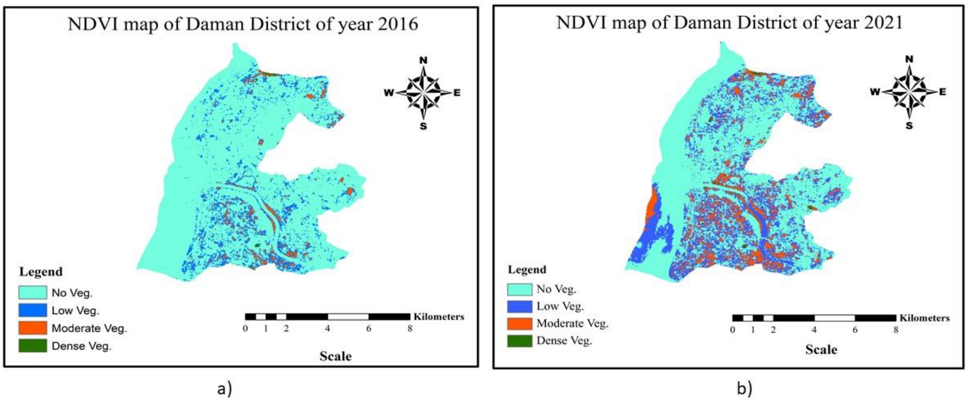

Figure 2. Vegetation map of Daman district (**a**) 2016 (**b**) 2021.

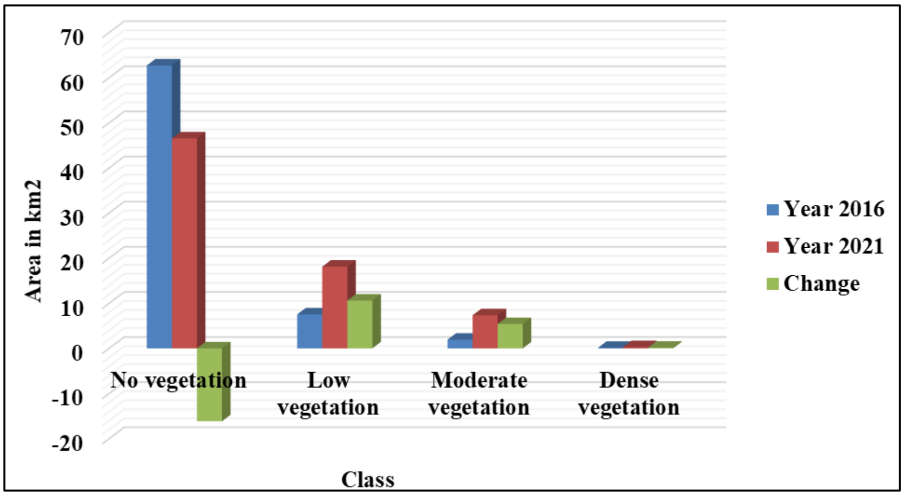

Figure 3. Chart showing the vegetation of the study area.

5. Conclusions

The multispectral remote sensing images are very efficient for obtaining a better understanding of earth environment. It is the science and arts of acquiring information and features in form of spectral, spatial and temporal about some object, area or phenomenon such as vegetation, land cover classification, urban area, agriculture land and water resources without coming into physical contact of this object. In this study, the multispectral image of Daman district was used to detect in Daman from the year 2016 to 2021. Area under vegetation has increased in the study area during the study period which can be attributed to efforts taken up by the Daman official authorities.

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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 conflict of interest.

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