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Research Article

Land Cover Change Analysis Using Normalized Difference Vegetation Index (NDVI) in the Coastal Area of Jambusar, Gujarat, India

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Abstract

Envisaging the changes in the land cover is very important for integrated coastal zone management and a tough task too due to the large scale measurement and monitoring of the area. Remote sensing and GIS have been found the convenient way to investigate the changes in the coastal areas using multi-date satellite and Google Earth images in detecting and mapping changes in coastal land cover.

In the present study, we have selected part of the Jambusar lower coastal area near the Dhadhar River in the Bharuch District, Gujarat, India for the change analysis. The Normalized Difference Vegetation Index (NDVI) one of the most simple and popular classification techniques have been used in the present study for the land cover change analysis. For this satellite images: Landsat 5 of 1989 and Landsat 8 of 2021 were used to study changes in land cover in about 32 year's period.

The result shows a major reduction in sparse vegetation area (34%) which has been occupied by mainly increased Salt pan areas and partly by changes of vegetation pattern to moderate (13.68 %) and dense (8.55%) vegetation within 32 years period. There has been a sizeable increase of around 34 Sq. Km in the salt pan-industrial area in the span of 32 years (1989 -2021).

Keywords: Remote Sensing; NDVI; Landsat; Land Cover Change

Introduction

Gujarat state has the longest coastline (1600 Km) with respect to all the maritime states of India, which is divided into 4 major sections: Saurashtra coast, South Coast,Gulf of Kutch and Gulf of Khambhat. The Gulf of Khambhat also known as Gulf of Cambay covers approximately 3120 Sq. km area having high tidal amplitude and different hydrodynamics in view of the opening of gulf in Arabian sea and a number of major rivers (Tapi, Sabarmati, Mahi and Dhadhar) draining in this area (Gujarat Ecology Commission, 2011) [7].

The study of Coastal geomorphology is important as the tides, waves and currents provide energy that is constantly working to change the landforms. (Shaikh., *et al*. 1989) [1]. The shoreline computation is one of the most important parameters in the detection of coastal erosion and deposition as well as the study of coastal morphodynamics (Armenio., *et al*. 2019) [2]. In view of this in the present study changes in the coastal land cover in part of Jambusar area located in the Gulf of Khambhat has been analysed for proper land use planning and management.

Study area

Study area lies between 21°45' and 22°15' N latitudes and 72°30' and 72°45' E Longitudes, on the coastal segment of Jambusar Taluka,

Bharuch District of Central Gujarat, India. Jambusar is a city in Bharuch district having approximately a stretch of 60 Km coastline. The upper region of the Jambusar coastline has the drainage basin of Mahi River and the lower region has Dhadhar River. Mahi is a perennial river while Dhadhar is seasonal. All the estuaries are funnel-shaped and are macro-tidal estuaries [6]. In the funnel-shaped or trumpet-shaped estuaries width decrease drastically upstream. Such a decrease in width produces a concentration of the energy of the tidal wave (Langbein 1963) [3]. This concentration of energy might dissipate on the banks and river bed. Thus deposition occurs mainly at the mouth. This has given rise to wide mudflats along the estuaries (Shaikh., *et al*. 1989) [1].

The coast around the gulf is indented by estuaries and consists of extensive mudflats and the sporadic presence of beaches. Mangroves are found growing on the intertidal mudflats in a very stunted and sparse form, near the Mahi, the Dhadhar. The coastal area of Jambusar has prominent Mangrove patches mostly in the southern region. The dominant area under mangroves is seen in Devla in Bharuch (Misra., *et al*. 2014) [4]. *Avicennia marina* is the prevailing species found in the Gulf of the Khambhat region.

The salt pans are predominantly seen in the coastal belt of Jambusar right from the upper boundary of the coast to the lower boundary. The Disaster management plan of the Bharuch in its 2019-2020 report states that there are around 43 salt Industries on the Jambusar coast with approximately 2700 workers involved in this functioning.

This paper primarily aims to determine the change in land cover in the lower belt of the coastal area of Jambusar.

Figure 1: Study area Location.

Materials and Methodology

Time series Google Earth and Landsat 5 and 8 (Figure 3 and Figure 4) have been used in this study. Landsat images of the year 1989 and 2021 were downloaded from USGS site (https://earthexplorer.usgs.gov/). The coordinate system used in the remote sensing study is WGS_1984_UTM_zone_43N. Other details of the images is mentioned in the table 1.

Sr.no	Satellite	Resolution	DATE_ACQUIRED	Spectral Bands	Path/Row
1	LANDSAT_5	30m	1989-05-09	7	148/045
4	LANDSAT_8	30m	2021-04-15	11	148/045

Table 1: Details of Landsat 5 and 8 images of the year 1989 and 2021.

Methodology flow chart is presented in the figure 2.

NDVI calculation from Landsat image

In this study Normalized Difference Vegetation Index (NDVI) was computed from Landsat 5 and 8 images for the classification of land cover. Initially NDVI was developed for the classification of vegetation but it is also very good in the classification of land features. NDVI value ranges between -1 to +1. On the scale of -1 to +1 in NDVI the higher value indicated the healthier vegetation and

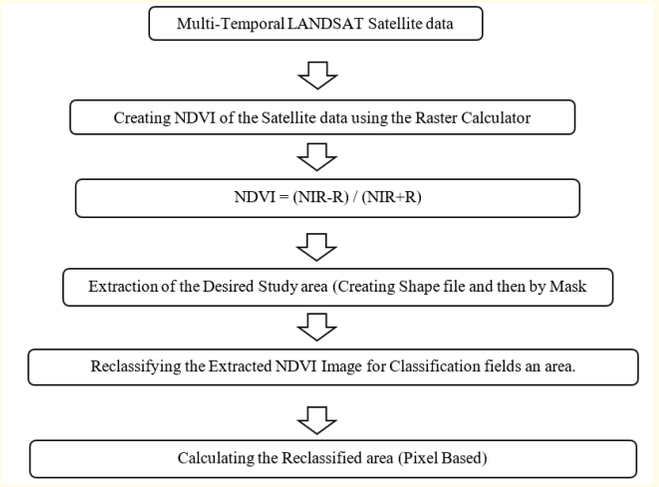

Figure 2: Methodology of Image processing.

the scale towards the lower value indicates the lesser vegetation to barren land to the water body in decreasing manner. Formula for the calculation of NDVI is given in Equation 1.

NDVI = (NIR - R)/(NIR + R) ----------(1)

Where NIR is Near Infra Red Band and R is Red band.

Formula for the calculation of NDVI from Landsat 5 image is given in Equation 2.

NDVI = (Band 4 - Band 3)/(Band 4 + Band 3)---------- (2)

Formula for the calculation of NDVI from Landsat 8 image is given in Equation 3.

NDVI = (Band 5 - Band 4)/(Band 5 + Band 4) ----------(3)

NDVI results of the 1989 and 2021 satellite images of study area are shown in figure 4 and figure 5, respectively.

Figure 3: NDVI of 1989.

Figure 4: NDVI of 2021.

Table 2 and table 3 Provide the information of the NDVI values. Table 3 indicated the NDVI value of different classes.

NDVI	Highest	Lowest
1989	0.346405	-0.376344
2021	0.335047	-0.30719

Table 2: NDVI Values Obtained.

NDVI Value	Range
Salt Pan	-0.42 to -0.05
Mud flats	-0.05 to 0.10
Sparse Vegetation	0.10 to 0.135
Moderate Vegetation	0.135 to 0.190
Dense Vegetation	0.190 to 0.393

Table 3: NDVI Value for the different classes.

Results and Discussions

NDVI images were generated using Eq.2 and Eq.3 from Landsat 5 and 8 images of 1989 and 2021, respectively, in GIS environment (Figure 3 and Figure 4). NDVI values were extracted from these images for land cover classification (Table 3 and Table 4). These images were reclassified using NDVI values of different classes. Reclassified maps were generated showing five major classes namely present in the study area (Figure 5 and Figure 6). The classified images were verified from the Google Earth images (Figure 8 and Figure 9).

Figure 5: Reclassified NDVI of 1989.

Figure 6: Reclassified NDVI of 2021.

Figure 7: Google Earth image of the year 2020 of Gulf area showing study area boundary.

Figure 8: Google Earth Image of 1989.

Figure 9: Google Earth Image of 2020.

The validation of the area classification created from NDVI values using Google Earth images (Figure 7) is a normal process and sometime more appropriate than field check in difficult terrain such as coastal areas(Pham and Prakash 2018) [5] (Figure 8 and Figure 9). Land use and land cover changes were observed during the study period from 1989 to 2021. The major changes is noticed in the area covered by sparse vegetation which is reduced from 184.91 Sq. Km (1989) to 102.15 Sq. Km (2021) (Figure 5 and Figure 6) (Table 4). The decrease of the sparse vegetation area of around 82 Sq. Km is compensated by increase in Salt pan area (34.43 Sq. Km), moderately vegetated area (32.82 Sq. Km) and densely vegetated area (20.51 Sq. Km) (Table 4). Slight reduction in mud flat area (4.99 Sq. Km) has also been observed. The Satellite data clearly depicts the increase in the salt pans in this region (Figure 3 and Figure 4). There are 43 salt industries operating in ten coastal villages of the region with more than 2700 salt workers involved (Disaster Management plan 2017 and 2018).

		1989 NDVI Classes Area			2021 NDVI Class Area			Change Between 1989 and 2021	
	Land Cover	Count	Area (Sq.Km)	%	Count	Area (Sq.Km)	%	Area (Sq.Km)	%
1	Salt Pan	1908	1.72	0.72	40163	36.15	15.07	34.43	14.35
2	Mud flats	52210	46.99	19.58	46662	42.00	17.50	-4.99	-2.08
3	Sparse Vegetation	205458	184.91	77.07	113499	102.15	42.57	-82.76	-34.49
4	Moderate Vegetation	5490	4.94	2.06	41954	37.76	15.74	32.82	13.68
5	Dense Vegetation	1527	1.37	0.57	24315	21.88	9.12	20.51	8.55
Total		266593	239.93	100.00	266593	239.93	100.00	0.00	0.00

Table 4: Changes in the NDVI densities of the 1989 and 2021 areas.

Concluding Remarks

The study demonstrates that the most prominent change noticed in the study area is decrease of sparse vegetation area (34.49%) which has been changed to Salt pan area (14.35%), Moderately vegetated area (13.68%) and Densely vegetated area (8.55%) during the period 1989-2021.

Slight decrease in the area of mud flat (2.08%) can also be attributed to the increase in the area of Salt pan due to increase in industrial activities in this coastal region. Increase in the Salt pan area in this region is posing the problem of salt water intrusion affecting quality of the groundwater and land. Thus with the help of simple NDVI technique we can do the change analysis study of coastal area in conjunction with remote sensing and GIS for proper planning and management of Land Cover and Land Use pattern.

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Disclosure Statement

The authors declare that they have no conflict of interest.

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