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Assessing Spatio-Temporal Land Cover Changes in Dhund River Basin, Eastern Rajasthan (India), Using Multi-Temporal Landsat Data

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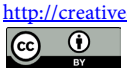


Abstract

Land cover is an impression of natural cover on surface of earth such as bare soil, river, grass etc. and utilization of these natural covers for various human needs and purposes by mankind is defined as land use. Land cover identification, delineation and mapping is important for planning activities, resource management and global monitoring studies while baseline mapping and subsequent monitoring is done by application of land use to get timely information about quantity of land that has been used. The present study has been carried out in Dhund river watershed of Jaipur, Rajasthan which covers an area of about 1828 sq·km. The minimum and maximum elevation of the area is found to be 214 m and 603 m respectively. Land use and land cover changes of three decades from 1991 to 2021 have been interpreted by using remotes sensing and GIS techniques. ArcGIS software (Arc map 10.2), SOI topographic map, Cartosat-1 DEM and satellite data of Landsat 5 and Landsat 8 have been used for interpretation of eleven classes. The study shows an increase in cultivated land, settlement, waterbody, open forest, plantation and mining due to urbanization because of increasing demands of food, shelter and water while a decrease in dense forest, river, open scrub, wasteland and uncultivated land has also been marked due to destruction of aforementioned by anthropogenic activities such as industrialization resulting in environmental degradation that leads to air, soil and water pollution.

Keywords

Dhund River, Landsat, Land Use/Land Cover, Change Detection Analysis, Rajasthan

1. Introduction

Land use can be referred as human's activities which are carried on over land,

usually with emphasis on the functional role of land in economic activity. Land use deals with the use of land surface and describes how a parcel of land is involved in forest, agriculture crops, grazing ground, water resources, waste disposal sites, habitation etc. In contrast, land cover is the assemblage of biotic and abiotic component on the earth's surface which describes the material that is present on the earth's surface [1]. Land use/land cover (LU/LC) is one of the most important aspects in managing the earth's resources and hence acquired much attention from the planners and decision makers [2]. Land use pattern of any terrain is a reflection of the complex physical process acting upon the surface of the Earth. These processes include impact of climatic, geologic and topographic conditions on the distribution of natural resources [3]. LU/LC keeps changing due to some natural and, more significantly through anthropogenic activities [4].

Change analysis acquires effective information in the form of maps and statistical data which becomes the central component in spatial planning, monitoring environmental changes, management and utilization of land [2]. Change detection analyses describe and quantify differences between images of the same scene at different times [5]. Land use/Land cover change detection has acquired immense significance as part of global environmental change [6]. Change detection in land use/land cover due to natural and human activities can be monitored by using multidate images to evaluate differences in land cover [7].

Remote sensing and GIS have emerged as one of the most powerful tools for classifying, mapping, monitoring, evaluating and assessing the natural resources in less time, with low cost and better accuracy. Satellite image pixels can be classified in LULC categories either by automatic extraction or by visual interpretation method [8].

The objective of the study is to assess spatio-temporal land use/land cover changes using multi-temporal satellite data. Land use/land cover change indicate rapid development in industrialization of chemical, textile, food and jewelry industry etc. that remarkably shows economic growth and better employment opportunities in the region which is subsequently leading to increasing urbanization during last three decades (1991 to 2021).

One of the recent studies is carried out in Selangor, Malaysia which suggests that human activities, exacerbated by climate change and population growth, have substantially altered land use/land cover in the region [9].

A case study was conducted on a watershed in Iran, using Landsat images of 2001, 2014, 2021 and 2040 predicted the changes that may occur in 2040 [10].

2. Study Area

Dhund river basin lies in Jaipur district of Rajasthan state in India and is bounded between 75˚40'E to 76˚10'E longitudes and 26˚30'N to 27˚10'N latitudes covering a geographical area of 1828 km^2 (**Figure 1**). Dhund river originates from Achrol in the northern part of the basin and flows towards south for

approximately for 98.95 km in a largely gentle plain and alluvial surface before confluence with Morel River in adjoining Sawai Madhopur district. The basin experiences semi-arid climate with an average annual rainfall of 536 mm and annual and annual average temperature of about 25.1˚C. The state capital Jaipur lies at the western periphery of the watershed, and is surrounded by hillocks and linear ridges of the Delhi Super Group. The watershed has residual, structural and denudational linear ridges with ravenous land and alluvial plains. The maximum and minimum elevation encountered in the basin are 603 m and 214 m above mean sea level respectively. The general slope of the watershed is from NW to SE, as defined by the course of the Dhund river.

Primary land use in the watershed is cultivation, which is largely rainfed, though a small dam has been constructed on the upstream of Dhund river which supports irrigation in nearby villages. Stone quarry activity has been observed in the eastern part of the basin.

Natural vegetative cover in the basin is confined to the linear ridges and hillocks which surrounds the city of Jaipur in the north and east. The city of Jaipur is popularly known as "Pink city" and a very important tourist center of north India.

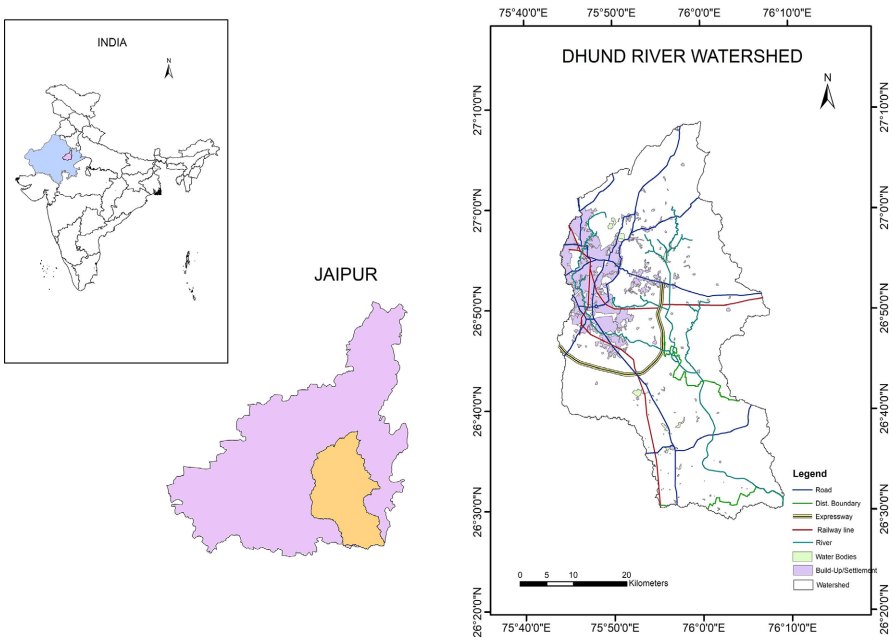


Figure 1. Location map of Dhund river watershed.

3. Data Sources and Methodology

3.1. Data Sources

The study has utilized multi-temporal Landsat data corresponding to Landsat 5 TM data of 1991, 2001 and 2011 and Landsat 8 OLI data of 2021 (row and path 147 and 42) for LULC mapping Landsat 5 consists of seven spectral bands with a spatial resolution of 30 meters of bands 1 to 5 and 7 while band 6 (thermal

infrared) has a resolution of 120 meters, but is resampled to 30-meter pixels. Approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi). Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images consist of nine spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 and 9. New band 1 (ultra-blue) is useful for coastal and aerosol studies. New band 9 is useful for cirrus cloud detection.

SOI (Survey of India) topographic map numbers *i.e.*, 45M/16, 45N/9, 45N/10, 45N/13, 45N/14, 54A/4, 54B/1, 54B/2 and 54B/3 on 1:50,000 scale have been downloaded from SOI website (soinakshe.uk.gov.in) and utilized for preparing base map with village/town, drainage network, major roads and railways etc. Cartosat-1 DEM data has been downloaded from NRSC-ISRO website (bhuvan.nrsc.gov.in) is used for demarcating watershed and assessing topography.

For Land use/Land cover mapping and change detection analysis, False Color Composite (FCC) of Landsat 5 satellite data of 1991, 2001, 2011 and Landsat 8 satellite data of 2021 has been downloaded from USGS Earth Explorer (https://earthexplorer.usgs.gov/) (**Figure 2**). To carry out study viz. geo-referencing of topographic maps and satellite data, demarcation of watershed, preparation of DEM, slope, base map and Land use/Land cover map, ArcGIS software (Arc Map 10.2) has been utilized.

3.2. Method

SOI toposheets were mosaiced, georeferenced, and area of interest extracted, a base map of the area was created. It contained information about roads, district boundary, expressway, railway line, river, water bodies and built-up/settlement. Base map was placed over the FCC in order to visually grasp the different LU/LC classifications. Categories of land use and land cover were identified using the visual interpretation of satellite data utilizing photographic and geotechnical aspects, with ground truth verification in strategic locations. Land use/land cover categories such as cultivated land, dense forest, built-up/settlement, river/dry river, water bodies, open forest, open scrub, quarry, waste land, uncultivated land and plantation were identified and delineated using visual interpretation of satellite data. LU/LC maps were created using several Arc-GIS modules for the satellite data corresponding to 1991, 2001, 2011 and 2021. An individual label/polygon id was given to each LU/LC category, and a database was later created for change detection.

Broadly there are two methods for detecting change:

1) Image to image comparison.

2) Map to map comparison [4].

Map to map comparison has been used in this study because it shows detailed changes in a specific land use category.

For GIS analysis, the following procedures have been followed:

1) Each polygon representing a land use category was created and given a unique ID.

2) List and label the polygons belonging to the same category.

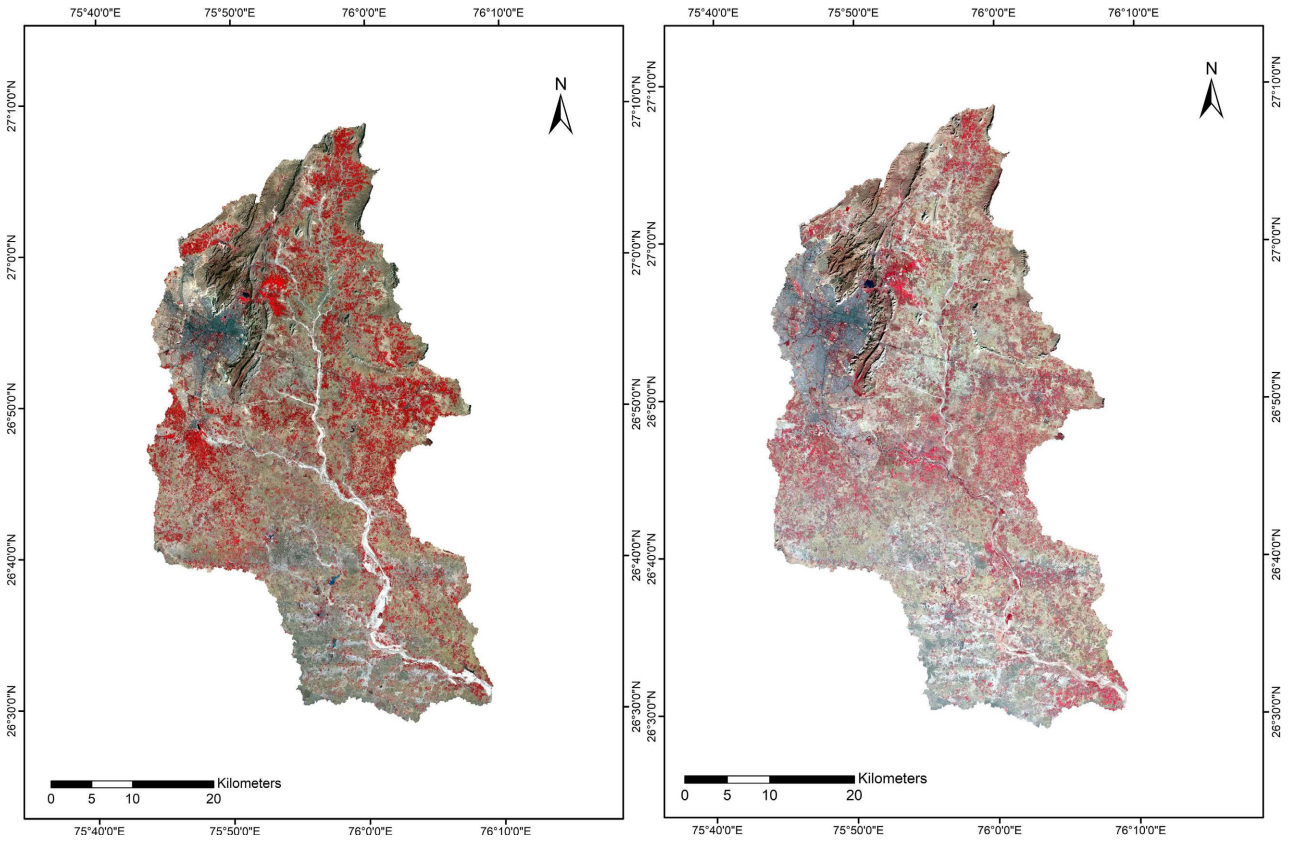
3) Determined the area of each type of land use.

For the years 1991, 2001, 2011 and 2021, the area for each land use/land cover category has been computed in square km and percentage as well. A review of each LU/LC category's changes between 1991 and 2001, 2001 and 2011, 2011 and 2021 has been conducted. Data generation, integration, compilation, analysis, and computing have all been carried out in GIS domain.

Limitations:

In the present study, we did not attempt any accuracy of the classes as it is associated with human error therefore, chances of mixing pixels are high which might be challenging in differentiating different classes with similar tone and texture.

Since the vegetation cover of land use/land cover did not discriminate among three vegetation classes *i.e.* cultivated land, open scrub and open forest in certain areas, subsequently the digital classification on satellite data were attempted to map land use/land cover classes with emphasis to delineate the cultivated land, open scrub and open forest but the supervised classification over data sets did not provide the desired accuracy and proper delineation of these classes. Eventually, we adopted a visual classification approach on fused data. This second step with detailed classification system resulted into better classification accuracy within the vegetation cover of land use/land cover of study area.



(a) (b)

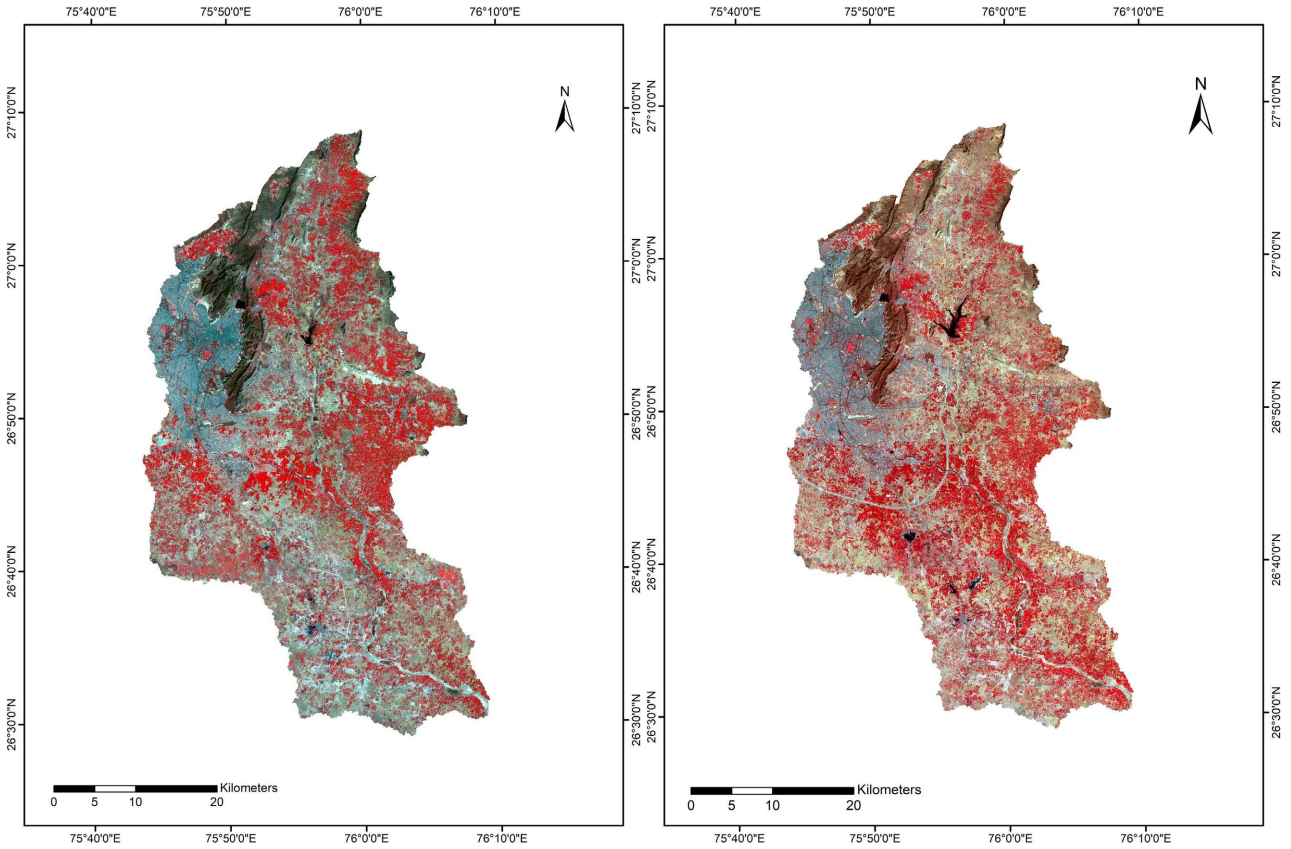


Figure 2. Dhund river watershed clipped from LANDSAT TM 5 data (a) 1991, (b) 2001, (c) 2011 and (d) LANDSAT 8 OLI data of 2021.

4. Results and Discussion

LU/LC mapping using Landsat data sets of 1991, 2001, 2011 and 2021 suggests significant changes at the landscape level. The study area has been transformed into a big urban center over the three decades. LU/LC details under each year of analysis are discussed here in **Table 1**.

4.1. Land Use/Land Cover (1991)

The first data set corresponds to LANDSAT 5, 1991 which has been used for land use/land cover mapping. It suggests that the most extensive and ubiquitous LULC category is cultivated land which covers an area of about 756.77 km^2 (41.37%) of the watershed. It is stretched across the whole watershed but primarily in the north and southern part. Second dominant category is open scrub which occupies 394.93 km^2 (21.59%) and is found mostly in north-west, north-east and south-east parts of the watershed especially along with river channel and its tributaries. In north-western part of watershed, it is found in association with open forest and in outer edges of built-up area. Uncultivated land occupies 256.99 km^2 (14.05%) area and is found in association with cultivated land, open scrub and waste land. Waste land occupies 115.61 km^2 (6.32%) area and it is as-

sociated with open scrub, uncultivated land and cultivated land. Other LU/LC categories that are demarcated are open forest, built-up/settlement, dense forest and river/dry river. Among these, 97.39 km^2 (5.32%) of the study area is occupied by open forest, 81.32 km^2 (4.45%) by built-up/settlement, 64.31 km^2 (3.52%) by dense forest and 52.27 km^2 (2.86%) by river/dry river. Open forest surrounding dense forest are mainly present in north western part of watershed and a very little area of open forest is found in north-eastern boundary of watershed. Built-up/settlement is mainly confined to western part of watershed, as Jaipur city and its peri-urban areas. Plantation and water bodies occupy 5.29 km^2 (0.29%) and 3.75 km^2 (0.21%) area respectively. Stone quarry covers a very small area that is 0.55 km^2 (0.03%) in north-eastern part of the watershed (**Figure 3**).

4.2. Land Use/Land Cover (2001)

LANDSAT TM 5 (2001) data set has been used as a next data for land use/land cover mapping. The statistics derived from LU/LC map of 2001 data shows that the major LULC categories are cultivated land, open scrub and uncultivated land. Categories which are found in significant amount are built-up/settlement, open forest, waste land, dense forest and river/dry river while categories like plantation, water bodies and quarry are present in small amounts.

Among these, 794.34 km^2 (43.42%) of the study area is occupied by cultivated land, 360.21 km^2 (19.69%) by open scrub which has been decreased in north-west, north-east and south-east part of the watershed whereas it has been increased in south-west part of the watershed, 238.72 km^2 (13.05%) by uncultivated land, 132.66 km^2 (7.25%) by built-up/settlement which is spreading in all the directions mainly towards south-west, 103.09 km^2 (5.64%) by open forest, 84.74 km^2 (4.63%) by waste land, 54.94 km^2 (3%) by dense forest, 45.14 km^2 (2.47%) by river/dry river, 7.4 km^2 (0.40%) by plantation, 4.66 km^2 (0.25%) by water bodies and 3.49 km^2 (0.19%) by quarry.

4.3. Land Use/Land Cover (2011)

The third data set stand for LANDSAT 5, 2011 and it is utilized for land use/land cover mapping propose that the main LULC categories are cultivated land, open scrub, built up/settlement, uncultivated land and open forest. Waste land, dense forest and river/dry river are also present in significant amount whereas plantation, water bodies and quarry are found in small amount.

Among these, 815.54 km^2 (44.59%) of the study area is occupied by cultivated land, 338.34 km^2 (18.50%) by open scrub which has been decreased and scattered all over the watershed, 200.56 km^2 (10.97%) by built-up/settlement which is increasing in all the directions mainly towards the south-west part of the area, 189.46 km^2 (10.36%) by uncultivated land, 106.99 km^2 (5.85%) by open forest, 77.00 km^2 (4.21%) by waste land, 47.67 km^2 (2.61%) by dense forest, 30.62 km^2 (1.67%) by river/dry river, 10.27 km^2 (0.56%) by plantation, 7.48 km^2 (0.41%) by water bodies and 5.06 km^2 (0.28%) by quarry which exists in both north-eastern and north-western part of watershed.

4.4. Land Use/Land Cover (2021)

The latest data corresponds to 2021, the analysis of the LULC map of 2021 data suggests that the dominant LULC categories are cultivated land, open scrub, built up/settlement, uncultivated land and open forest.

Out of 1828 km^2, 848.21 km^2 (46.37%) is occupied by cultivated land. The next dominant LULC category is open scrub which covers an area of 284.37 km^2 (15.55%). An area of about 258.69 km^2 (14.14%) is covered by built-up/settlement which is dominant in the north-western part of the watershed, 158.91 km^2 (8.69%) is occupied by uncultivated land, 113.17 km^2 (6.19%) by open forest, 65.62 km^2 (3.59%) by waste land, 43.56 km^2 (2.38%) by dense forest, 25.58 km^2 (1.4%) by river/dry river, 14.41 km^2 (0.79%) by plantation, 11.6 km^2 (0.63%) by water bodies which are very few in numbers which are present in northern and south-west part of the watershed and 5.06 km^2 (0.28%) by quarry.

Few field photographs with their corresponding spectral signatures are shown in Figure 4.

Table 1. Land use/land cover details of the study area.

LULC Categories	1991		2001		2011		2021		Change							
									2001-1991		2011-2001		2021-2011		2021-1991	
	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)
Cultivated Land	756.77	41.37	794.34	43.42	815.54	44.59	850.05	46.46	37.57	2.05	21.20	1.16	34.51	1.89	93.28	5.10
Dense Forest	64.31	3.52	54.94	3.00	47.67	2.61	43.56	2.38	−9.37	−0.51	−7.27	−0.40	−4.11	−0.22	−20.76	−1.13
Built-up/Settlement	81.32	4.45	132.66	7.25	200.56	10.97	261.24	14.28	51.34	2.81	67.90	3.71	60.68	3.32	179.92	9.84
River/Dry River	52.27	2.86	45.14	2.47	30.62	1.67	25.58	1.40	−7.12	−0.39	−14.52	−0.79	−5.04	−0.28	−26.68	−1.46
Water Bodies	3.75	0.21	4.66	0.25	7.48	0.41	11.60	0.63	0.90	0.05	2.82	0.15	4.12	0.23	7.84	0.43
Open Forest	97.39	5.32	103.09	5.64	106.99	5.85	111.82	6.11	5.70	0.31	3.90	0.21	4.82	0.26	14.42	0.79
Open Scrub	394.93	21.59	360.21	19.69	338.34	18.50	273.19	14.93	−34.72	−1.90	−21.87	−1.20	−65.15	−3.56	−121.74	−6.66
Quarry	0.55	0.03	3.49	0.19	5.06	0.28	5.06	0.28	2.94	0.16	1.57	0.09	0.00	0.00	4.51	0.25
Waste Land	115.61	6.32	84.74	4.63	77.00	4.21	68.87	3.76	−30.87	−1.69	−7.74	−0.42	−8.13	−0.44	−46.74	−2.56
Uncultivated Land	256.99	14.05	238.72	13.05	189.46	10.36	160.71	8.78	−18.27	−1.00	−49.25	−2.69	−28.76	−1.57	−96.28	−5.26
Plantation	5.29	0.29	7.41	0.40	10.27	0.56	17.87	0.98	2.11	0.12	2.87	0.16	7.59	0.42	12.58	0.69
Total Area	**1829.18**		**1829.41**		**1829.00**		**1829.54**									

4.5. Key Spatio-Temporal Changes

The LU/LC analysis of the multi-temporal satellite data suggests that there are significant changes in some LULC categories, such as:

- Cultivated land
- Built-up land/Settlement
- Uncultivated land
- Wasteland
- Open scrub

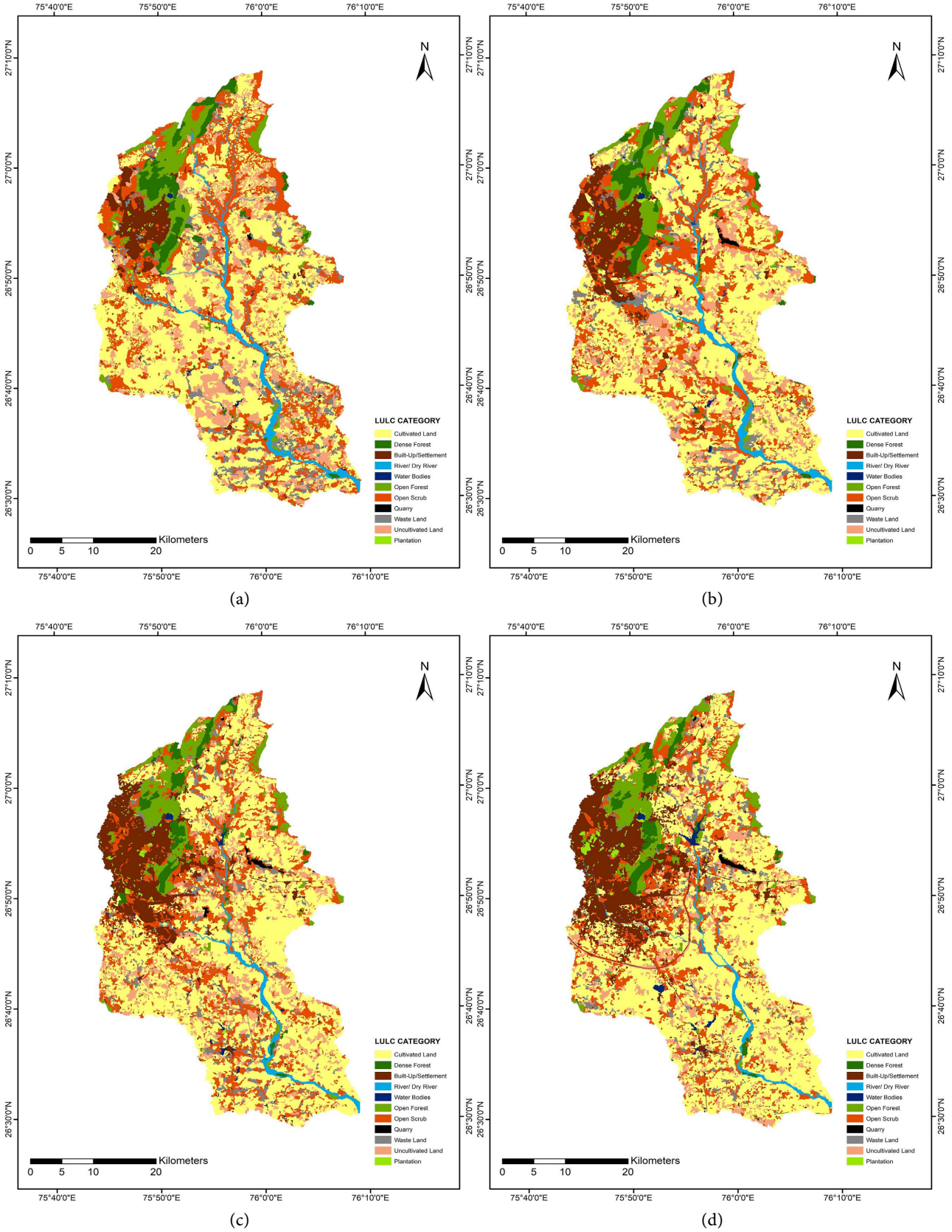


Figure 3. Land use/Land cover maps derived from LANDSAT 5 data of (a) 1991, (b) 2001, (c) 2011 and (d) LANDSAT 8 data of 2021.

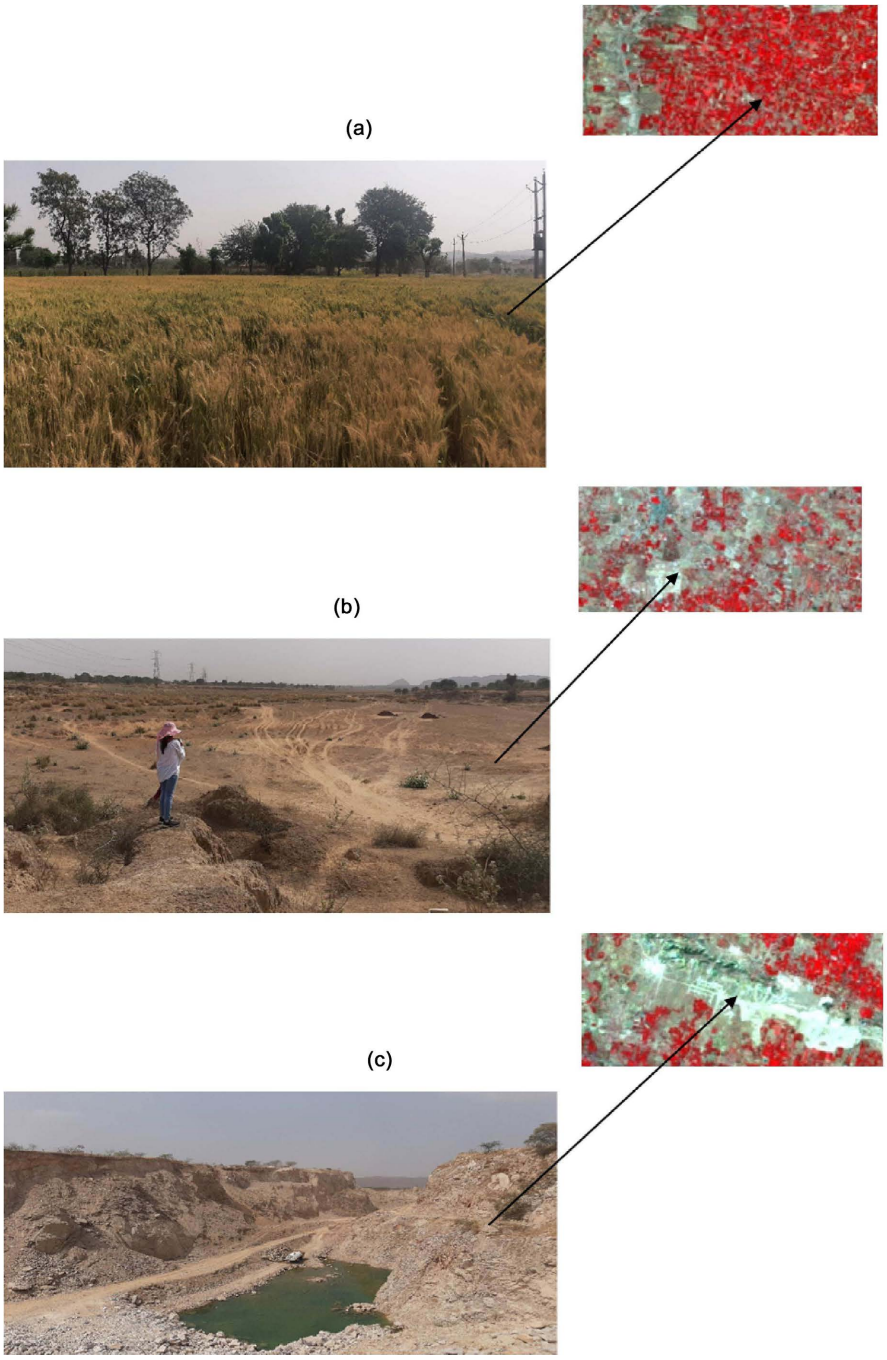


Figure 4. Field photographs and their corresponding spectral signatures (a) Cultivated land, (b) Wasteland and (c) Stone Quarry.

Cultivated land:

It is the most dominant land use/land cover category of the watershed across four time period. It covers an area of 756.77 km^2 in 1991, 794.34 km^2 in 2001, 815.54 km^2 in 2011 and 850.05 km^2 in 2021. Cultivated land is predominant in the southern half of the watershed, defined by alluvium and gentle slope with productive soil cover. There has been a steady increase in area under cultivated land. The area under cultivation has increased by 37.57 km^2, 21.2 km^2 and 34.51

km^2 from 1991 to 2001, 2001 to 2011 and 2011 to 2021 respectively. During the last thirty years it has increased in its extent by about 93.28 km^2, possibly due to the availability of water for irrigation after the construction of Kanota dam in the northern part of the watershed, and reclamation of watershed and uncultivated land. The increase in area in cultivated land is attributed to the corresponding decrease in area under uncultivated land (Table 2).

Built-up land/Settlement:

This land use/land cover category is dominant in western part of the watershed as Jaipur urban area and its extensions. It covers an area of 81.32 km^2 in 1991, 132.66 km^2 in 2001, 200.56 km^2 in 2011 and 261.24 km^2 in 2021. The area under settlement/built-up has increased by 51.34 km^2, 67.9 km^2 and 60.68 km^2 from 1991 to 2001, 2001 to 2011 and 2011 to 2021 respectively. The growth of Jaipur has been tremendous which saw an increase in built-up by 179.92 km^2. Better employment opportunities and livelihood has led to the development of this LU category. Open scrub, waste land and uncultivated land, has been converted into settlement/built-up category over the past three decades.

Uncultivated land:

Uncultivated land is scattered across the whole watershed and covers an area of 256.99 km^2 in 1991, 238.72 km^2 in 2001, 189.46 km^2 in 2011 and 160.71 km^2 in 2021. This land use/land cover category has been decreased from year 1991 to 2021 by about 96.28km^2 as it has been converted into cultivated land and built-up land. The area under uncultivated land has decreased in its arial extent by 18.27 km^2, 49.26 km^2 and 28.75 km^2 from 1991 to 2001, 2001 to 2011 and 2011 to 2021 respectively.

Wasteland:

Wasteland is found in association with cultivated land, uncultivated land and open scrub and covers an area of 115.61 km^2 in 1991, 84.74 km^2 in 2001, 77.00 km^2 in 2011 and 68.87 km^2 in 2021. The area under wasteland has decreased in its arial extent by 30.87 km^2, 7.74 km^2 and 8.13 km^2 from 1991 to 2001, 2001 to 2011 and 2011 to 2021 respectively. It has reduced in area by about 46.74 km^2 during the last three decades possibly due to conversion into cultivated land, built-up land and open scrub.

Open scrub:

This is the second most dominant land use/land cover category seen scattered throughout the watershed. It covers an area of 394.93 km^2 in 1991, 360.21 km^2 in 2001, 338.34 km^2 in 2011 and 273.19 km^2 in 2021. The area under open scrub has decreased in its arial extent by 34.72 km^2, 21.87 km^2 and 65.15 km^2 from 1991 to 2001, 2001 to 2011 and 2011 to 2021 respectively. It shows a decreasing trend during the last three decades and has lost about 121.74 km^2. Open scrub has been converted into built-up land and cultivated land.

The comparative study of change detection analysis shows that cultivated land has increased due to various reasons viz. increase in seasonal rain, increasing level of groundwater near dam and other water related initiatives taken by the government such as water supply schemes. Similarly, built-up land has been in-

creased due to migration of people from rural areas for better livelihood. Dense forest, river, open scrub, waste land and uncultivated land has been decreased due to encroachment by humans for food and shelter whereas water bodies, open forest and plantation has been increased because of human awareness for natural resources. Quarry has also been increased. Table 2 presents the key changes in LU/LC in the study area. Figure 5 and Figure 6 depicts the spatio-temporal changes in key LU/LC categories.

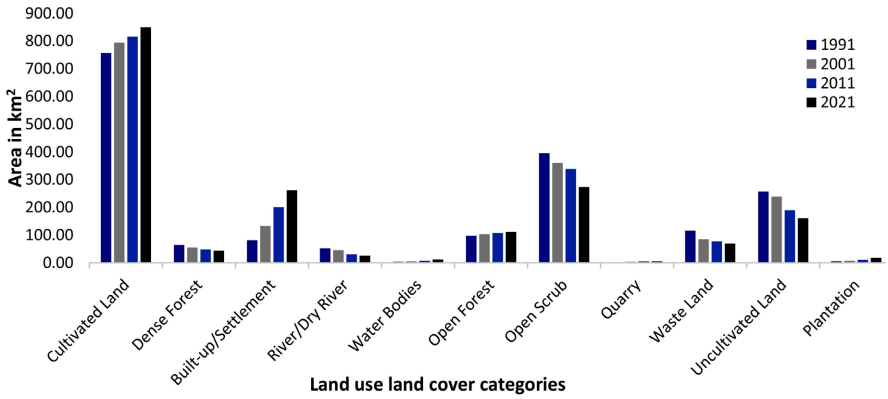


Figure 5. Spatio-temporal Changes in LULC categories.

4.6. Key Changes in LULC Cover from 1991 to 2021

Key changes can be noticed in major LULC categories namely cultivated land, built-up/settlement, open scrub, waste land and uncultivated land in last three decades.

Key changes in LUCL cover from 1991 to 2001:

A significant change from 1991 to 2001 in cultivated area has been noticed mainly in the east side of the basin as it has consumed the area under open scrub and wasteland. While the area under built-up land has been increased by consuming open scrub and uncultivated land. On the other hand, open scrub has been increased in west side of the basin which has consumed the area under uncultivated land and wasteland (Table 2) and (Figure 6).

Key changes in LUCL cover from 2001 to 2011:

During a period of 10 years from 2001 to 2011, a prominent change in cultivated area has been observed throughout the basin except in north west region where it occupied waste land and uncultivated land while settlement has been significantly increased by replacing area under cultivated land, open scrub, waste land and uncultivated land. Open scrub mainly used up the area under waste land and uncultivated land.

Key changes in LUCL cover from 2011 to 2021:

From 2011 to 2021, a remarkable change can be seen in area under cultivation as it has eaten up mostly area under open scrub, waste land and uncultivated land excluding north west region of the basin. A considerable development has been seen in settlement across the north west region of the basin.

Table 2. Key changes in LULC from 1991-2021.

LULC Categories	1991		2001		2011		2021		Change							
									2001-1991		2011-2001		2021-2011		2021-1991	
	Area (km²)	Area (%)	Area (km²)	Area (%)	Area (km²)	Area (%)	Area (km²)	Area (%)	Area (km²)	Area (%)	Area (km²)	Area (%)	Area (km²)	Area (%)	Area (km²)	Area (%)
Cultivated Land	756.77	41.37	794.34	43.42	815.54	44.59	850.05	46.46	37.57	2.05	21.20	1.16	34.51	1.89	93.28	5.10
Built-up/Settlement	81.32	4.45	132.66	7.25	200.56	10.97	261.24	14.28	51.34	2.81	67.90	3.71	60.68	3.32	179.92	9.84
Open Scrub	394.93	21.59	360.21	19.69	338.34	18.50	273.19	14.93	−34.72	−1.90	−21.87	−1.20	−65.15	−3.56	−121.74	−6.66
Waste Land	115.61	6.32	84.74	4.63	77.00	4.21	68.87	3.76	−30.87	−1.69	−7.74	−0.42	−8.13	−0.44	−46.74	−2.56
Uncultivated Land	256.99	14.05	238.72	13.05	189.46	10.36	160.71	8.78	−18.27	−1.00	−49.25	−2.69	−28.76	−1.57	−96.28	−5.26

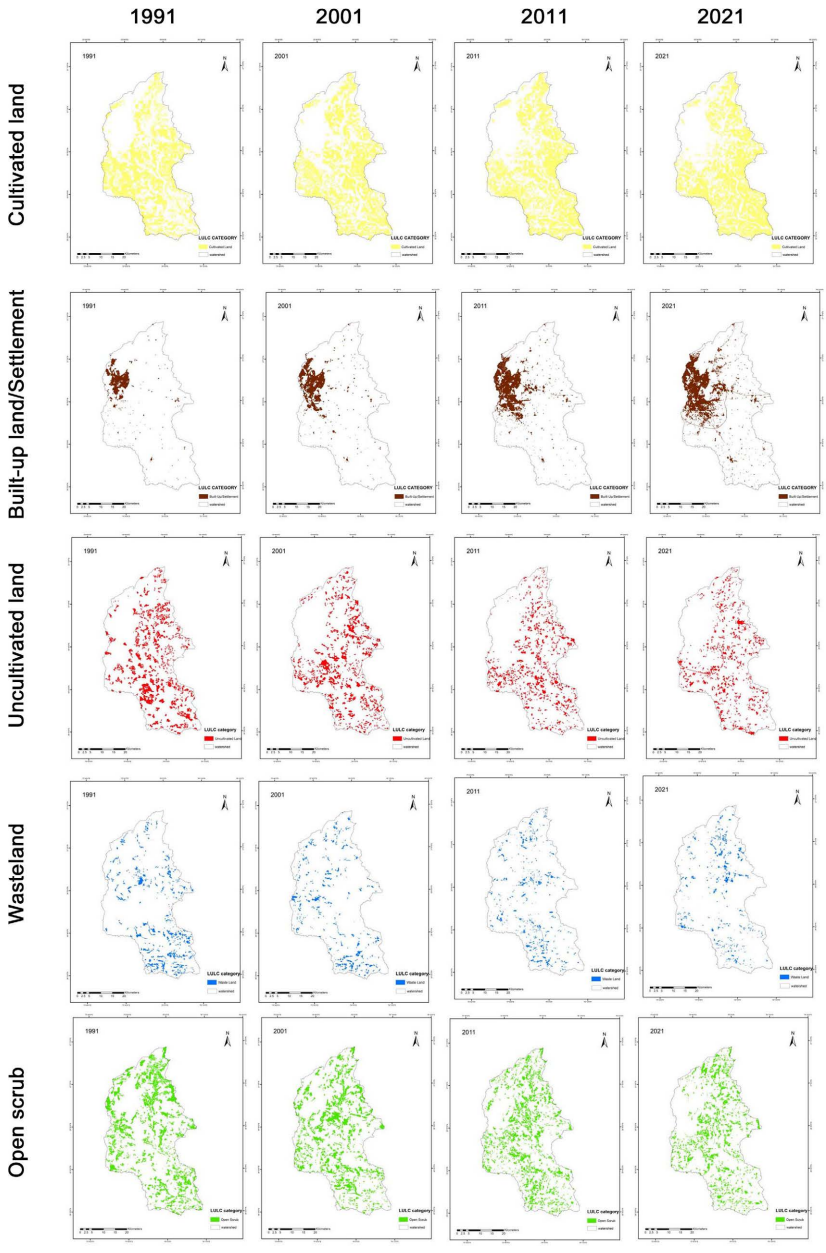


Figure 6. Spatio-temporal changes in Land use/Land cover categories in 1991, 2001, 2011 and 2021.

Urban and Rural changes in LULC cover:

Major urban LULC cover change has been observed in the north-west section of the basin where built-up land has been increased significantly by replacing open scrub and waste land due to steep increase of industrialization, population growth and migration for better employment opportunities. Rural LULC cover changes have been observed across the basin area mainly in the south-east portion of the basin where cultivated land is increased by replacing uncultivated land, open scrub, and waste land.

5. Conclusion

The present study provides a detailed insight into the LU/LC status of the watershed. The study shows significant changes under various LU/LC categories over the past three decades. The land use/land cover analysis reveals a wide variety of eleven categories of land cover as well as land use present in Dhund river watershed. The watershed is mainly dominated by cultivated land, built-up/settlement, open scrub and uncultivated land. The major part of the study area is occupied by cultivated land. LULC changes by LULC analysis of 1991, 2001, 2011 and 2021 suggested that cultivated land, built-up/settlement, water bodies, open forest, quarry and plantation have been increased from year 1991 to 2021 while dense forest, river/dry river, open scrub, waste land and uncultivated land have been decreased from year 1991 to 2021. The study shows that settlement, cultivated land and water bodies have been increased due to expansion of built-up area because of increasing demands of food, shelter and water while a decrease in dense forest and open scrub has been marked due to deforestation by anthropogenic activities resulting in degradation of natural resources. Key changes can be noticed in cultivated land and settlement as these two classes have increased by 93.28 km^2 and 179.92 km^2 respectively. These two classes have consumed area under categories such as open scrub, waste land and uncultivated land which has decreased by 121.74 km^2, 46.74 km^2 and 96.28 km^2 respectively. LULC changes of the watershed show both positive and negative changes. Positive change is noticed in cultivated land, water bodies, open forest, open scrub, plantation, waste land and uncultivated land while negative change is seen in built-up/settlement, quarry, dense forest and river/dry river. The findings have revealed that the study area has undergone notable changes in terms of land use and land cover for the period 1991 to 2021. The cultivation areas were found to be highly impacted, and might be due to the increased anthropogenic activities. The built-up land was found to be increased consistently between the two periods investigated. The present study helps us to monitor natural resources for sustainable development of local people in Dhund river watershed for three decades.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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