SSRG International Journal of Geo-informatics and Geological Science
ISSN: 2393–9206 / https://doi.org/10.14445/23939206/IJGGS-V11I1P104

Volume 11 Issue 1, 28-33, Jan-Apr 2024

Original Article

Measuring Land Use Change and Sprawl Using Geospatial Techniques: A Study Around Mandore, Jodhpur (Rajasthan)

Hemant Prakash[1*], Nikhil Jodhawat[2], Vijay Athwani[1], Vinita Chouhan[1]

[1]*Image Processing Expert, State Remote Sensing Application Centre, Jodhpur (Raj.)*
[2]*Student, MDSU, Ajmer, Rajasthan.*

[*]*Corresponding Author : hemantprakash30@yahoo.in*

Received: 29 January 2024 Revised: 05 March 2024 Accepted: 23 March 2024 Published: 08 April 2024

Abstract *- The rate of urbanization in the Jodhpur district, Rajasthan, India, has been amplified by factors such as population growth, the aspiration for higher income, improved transportation facilities, and rural-to-urban migration. These dynamics have not only accelerated urban development but also added complexity to its patterns. In this paper, the technique for detecting changes in land use and land cover is an invaluable tool for comprehending the interplay between human activities and the environment. Consequently, monitoring these changes becomes crucial to track and understand the alterations taking place. The alteration of Land Use and Land Cover (LULC) has evolved as a pivotal element in contemporary approaches to natural resource management and environmental monitoring. The land use/land cover (LU/LC) change detection study over two periods highlights a substantial increase in built-up, mining, and industrial areas. It is noteworthy that there has been a significant decrease in vegetation, water bodies, and other areas during the study period attributed to rapid urbanization around the Mandore area.*

Keywords *- Urbanization, LU-LC, Environment, Change Detection.*

1. Introduction

The transformation in land use and land cover is widely acknowledged as a crucial element of global environmental change, exerting a pivotal influence on regional socio-economic development [1]. The correct information on land use and land cover (LULC) is indispensable for effective planning and sustainable management of land and natural resources. It serves as a foundational element for assessing resource inventories and ensuring their proper utilization. Consequently, its importance is seen to be on the rise, playing a vital role in the sustainable and effective management of natural resources and the environment [2]. LULC changes are recognized as the most significant anthropogenic disturbances to the local environment, leading to a variety of microclimatic alterations [3-4]. The correct and timely LULC maps derived from remotely sensed images serve as crucial tools for monitoring and quantifying various aspects of both global and local climate change, hydrology, biodiversity conservation, and air pollution [5-8].

Land cover and land-use change information serves practical purposes across a range of applications, including deforestation monitoring, damage assessment, disaster monitoring, urban expansion analysis, planning, and land management. Change detection frameworks utilize multi-temporal datasets to qualitatively analyze the temporal impacts of phenomena and quantitatively measure the changes. This approach not only offers insights into the spatial distribution of features but also provides both qualitative and quantitative information on feature alterations. The inventory and monitoring of land-use/land-cover changes are indispensable components for gaining a deeper understanding of change mechanisms and modeling the impacts of these changes on the environment and associated ecosystems across various scales [9]. The objective of change detection is to identify areas within digital images that exhibit significant changes, such as forest clearing or alterations in land use and cover, between two or more image dates. Remotely sensed data from Earth-orbiting satellites are extensively utilized for change detection due to their repetitive coverage at short intervals and consistent image quality, making them invaluable for various applications [10-12].

The primary aim of the study is to develop a comprehensive GIS database comprising multiple thematic layers, such as roads, railways, settlements, drainage systems, land use/land cover, villages, and transportation networks. Subsequently, the study will conduct an analysis and mapping of land use/land cover using satellite data to assess changes between the years 2011-2012 and 2019-2020.

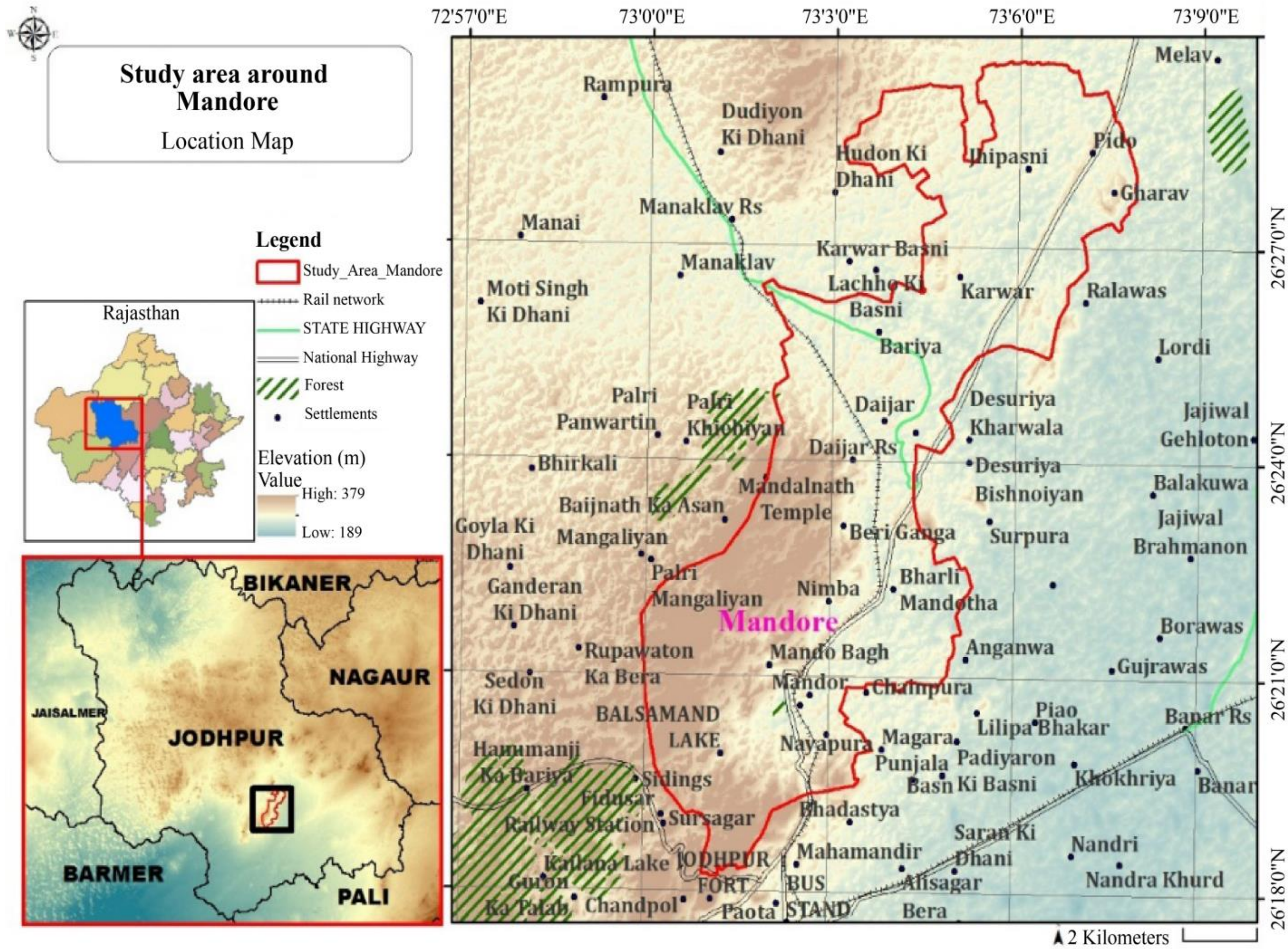

Fig. 1 Location map of the study area

2. Materials and Methodology

In this research endeavor, digital remote sensing data from the Landsat series satellites was employed to delineate different Land Use and Land Cover (LULC) classes in the Jodhpur district, Rajasthan. The imagery captured by Landsat satellites stands as one of the most widely utilized sources of satellite remote sensing data. Its impressive spectral, spatial, and temporal resolutions render it exceptionally valuable for mapping and planning endeavors.

The Landsat-7 and sentinel-2 satellite data covering the study area were obtained from the Earth Explorer site (http://earthexplorer.usgs.gov/). The imagery of Landsat series satellites stands as one of the most widely utilized sources of satellite remote sensing data, and their spectral, spatial, and their impressive temporal resolutions make them invaluable inputs for mapping and planning purposes [13].

The imagery was digitized within a GIS environment using ArcGIS 10.8 software, where it was transformed into polygons representing various land use and land cover categories. This digitization process adhered to the Technical Guidelines provided by NRSC Hyderabad SIS-DP, ensuring consistency and accuracy in the classification of land cover. The study involved calculating the trend and pattern of urban expansion, wherein each polygon representing a specific land use or land cover class was quantified and visualized on respective maps. Subsequently, land transformation analysis was conducted by overlaying the land use/cover maps from two different periods to assess changes over time.

3. Results and Discussion

The Land Use/Land Cover analysis was conducted utilizing a hybrid classification technique, leveraging digitally enhanced and geo-referenced satellite imagery from Landsat-7 and Sentinel-2. Subsequently, comprehensive Land Use/Land Cover maps were prepared based on the findings of this analysis. The accuracy of the Land Use/Land Cover classification was further validated and refined using high-resolution data.

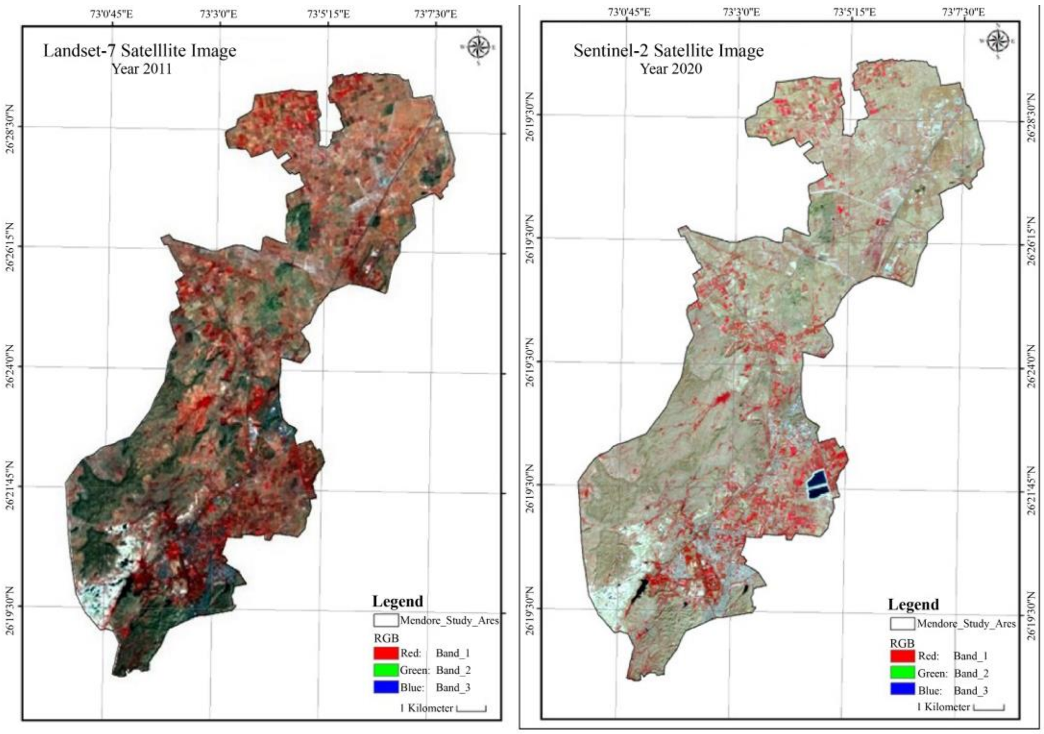

Fig. 2 Satellite images of the study area Landset-7 (2011) and Sentinel-2 (2020)

The total area of Land Use/Land Cover surrounding the Mandore study area is depicted, and the analysis of land use/land cover is conducted utilizing data from Landsat and Sentinel satellites. Data further changes analysis with respect to the year 2011 has been carried out shows the land use/land cover map of the study area for the year 2020 year. Comparisons of two different years (2011 to 2020) of land use/land cover maps are shown in Figure 2.

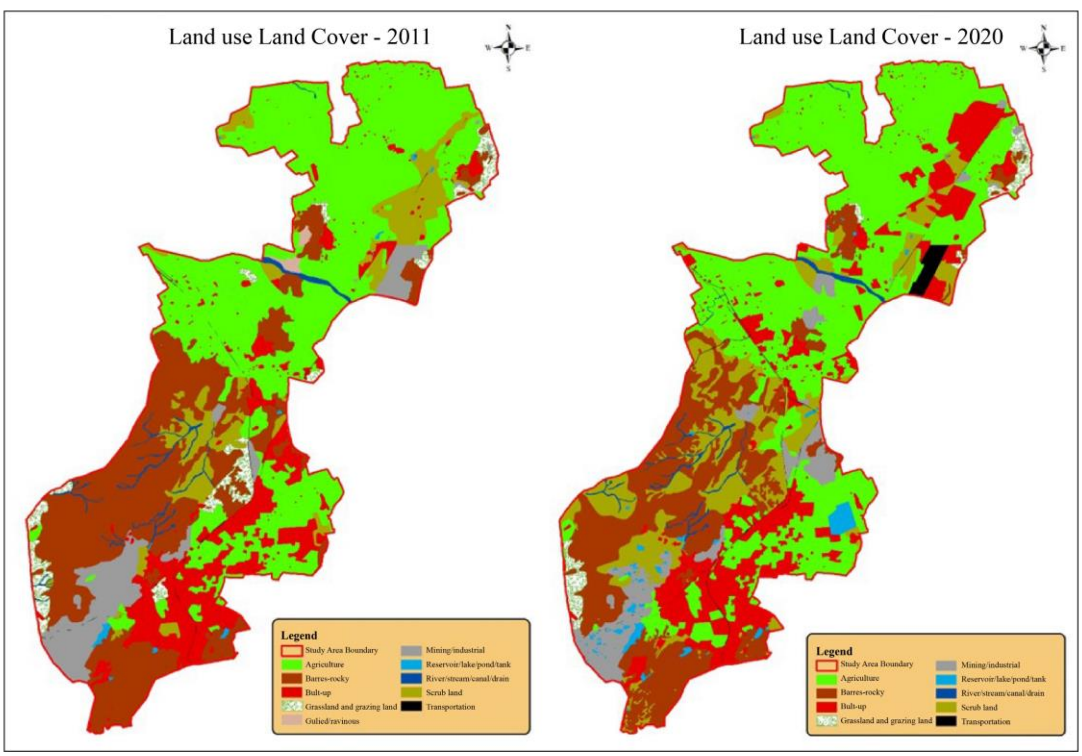

Fig. 3 Land use/land cover maps of 2011 and 2020

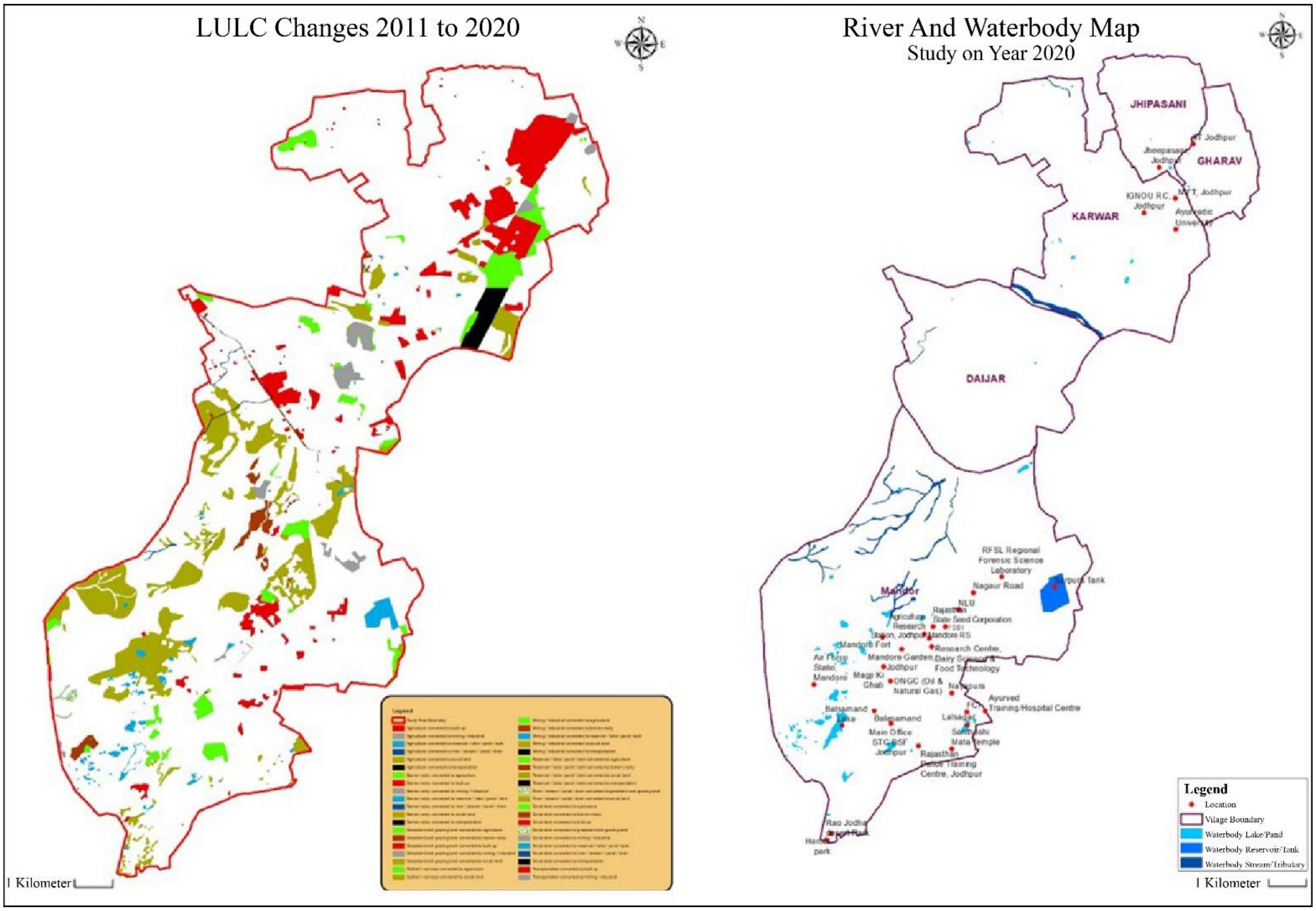

Fig. 4 Land use/land cover Changes 2011 to 2020 and River and Waterbody Maps

Table 1. Statistics of changing LULC for the years 2011 to 2020

Land use Land Cover		2011	2020	Change (Ha.)	Change%
S. No.	**Category**	**Area (Ha.)**	**Area (Ha.)**		
1	Agriculture	4740.88	4602.86	-338.02	-3.54
2	Barren-rocky	3007	2193.26	-813.74	-15.64
3	Built-up	1304.76	1728.79	424.3	13.97
5	Gullied/ravinous	39.34	00	-39.24	-100
6	Grassland and grazing land	378.56	185.62	-192.94	-34.19
7	Mining/industrial	512.46	677.89	165.43	13.89
8	Reservoir/lake/pond/tank	0.83	146.32	145.49	98.87
9	River/stream/canal/drain	125.49	118.95	-6.54	-2.67
10	Scrub land	903.41	1550.14	646.73	26.35
11	Transportation	20.47	29.37	8.9	17.85
Total		11233.2	11233.2		

Based on the results of the analysis and the data presented in Table 1, as well as Figures 3 and 4, it is evident that significant and dramatic changes have occurred between the years 2011 and 2020. The land use and land cover (LULC) changes experienced the most significant variations in settlement and cultivation between 2011 and 2020. Comparison of LULC 2011 to 2020 indicates that the anthropogenic activity like settlement, mining /industrial and road/transportation area is largely broadened like 13.97%, 13.89% and 17.85% in the year 2020. The cultivated land, which is used for agriculture and vegetables, and other mixed varieties are, largely decreased. In the year 2011, it was 4740.88 hectares, and in the year 2020, it is 4602.86 hectares, with a net decrease of 338 hectares in the year 2011, mining/industrial area was found to be 512.46 hectares, but in the year 2020 area is 677.89 with a net increase of 165.43

hectares. Drainage and lake area also decreased by about 6.54 hectares because of anthropogenic activity. In the study area, notably the southwestern and eastern parts of Mandore, there has been a sudden increase in water bodies. Sandstone mining around Mandore often involves the excavation of large pits or quarries to extract the stone. Over time, these pits can accumulate water, especially during periods of rainfall or when groundwater levels rise. As mining activities progress and pits are abandoned or left unused, they can become natural reservoirs or water bodies, contributing to the increase in water presence in the area.

4. Conclusion

The present study will be very useful in monitoring rapid urban growth through changes in land use, as evidenced in this study. However, it has been hindered by the lack of up-to-date information on changes in urban land use. The present study showcases the application of remote sensing and Geographic Information Technology techniques to assess changes in Land Use and Land Cover (LULC) by utilizing satellite imagery from the years 2011 and 2020. The expansion of settlement areas suggests population growth, urbanization, and the spread of human habitation into previously undeveloped areas. This can lead to changes in land cover, increased demand for resources, and impacts on local ecosystems and biodiversity. The increase in mining and industrial areas reflects economic activities such as mineral extraction, manufacturing, and industrial production. While these activities contribute to economic growth and employment, they can also have environmental consequences such as habitat destruction, pollution, and land degradation. The expansion of road and transportation infrastructure indicates efforts to improve connectivity, facilitate trade and commerce, and enhance mobility for residents and businesses. However, the construction of roads, highways, and transportation networks can fragment habitats, disrupt natural ecosystems, and contribute to urban sprawl.

These changes in LULC reflect the dynamic nature of human activities and development in the area over the past decade. While urbanization and industrial growth contribute to economic development, they also raise concerns about environmental sustainability, habitat loss, and land degradation. Here are some implications of these changes:
Human activities such as land use changes, urbanization, agricultural practices, and water management interventions can also contribute to the formation or expansion of water bodies. For example, changes in land use, such as deforestation or urban expansion, can alter runoff patterns and increase water accumulation in certain areas. The Land Use/Land Cover analysis conducted in this study employed a hybrid classification technique, combining Landsat-7 and Sentinel-2 satellite imagery to create comprehensive maps. These maps were then further refined and validated using high-resolution data. The analysis revealed significant changes in land use and land cover between 2011 and 2020, with notable increases in settlement, mining/industrial areas, and road/transportation zones.

Conversely, cultivated land decreased during this period, alongside reductions in drainage and lake areas due to anthropogenic activities. The emergence of water bodies in the southwestern and eastern regions of Mandore, attributed to sandstone mining, is a notable phenomenon. As mining operations continue, abandoned pits accumulate water, gradually transforming into natural reservoirs or water bodies. This transformation underscores the dynamic nature of land use and highlights the intricate interplay between human activities and environmental changes. The emergence of water bodies, particularly in the southwestern and eastern areas of Mandore, is a notable phenomenon attributed to sandstone mining activities. As mining operations advance, abandoned pits left behind from excavation efforts can gradually collect water, eventually transforming into natural reservoirs. This occurrence highlights the dynamic nature of land use and underscores the intricate relationship between human activities and environmental changes. It exemplifies how anthropogenic interventions, such as mining, can inadvertently lead to environmental alterations, including the creation of new water bodies. Such observations emphasize the importance of understanding and managing the impacts of human activities on the natural landscape.

Acknowledgment

The author expresses gratitude to Prof. S. R Jakhar, HOD, Department of Geology, JNV University, Jodhpur (Rajasthan), for her kind support and valuable suggestions. I also benefited from the published information of many unknown workers; their contributions provided me with useful suggestions that helped me a lot and improved the manuscript.

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