Land Use Change in Selected Districts of Rajasthan using GIS

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Abstract. Among the emerging technologies, the Geographical Information System (GIS) is a powerful tool used in detecting, assessing, mapping, and monitoring information related to the earth's surface. GIS has been effectively used in multidisciplinary projects, and it proves to be an effective tool in handling spatial data and performing integrated analysis of data on innumerable resources of any region across the globe; it also helps to achieve optimal solutions for such problems. With climate change happening throughout the world, concern for monitoring the physical, chemical, and biological degradation of natural resources using GIS has also increased. Amongst many applications of GIS, civil engineers use GIS to address plenty of issues like town planning and site investigation, terrain mapping, urban infrastructure development, transportation network analysis, landslide analysis, etc. The present study tries to assess the changes in land use, especially in the context of selected seven districts of Rajasthan, which are mainly focused on agricultural activities. The specific objectives of this study were to identify the percentage of land use under four different categories and change in the land use within a time span of ten years in these selected districts by using satellite data and GIS software.

Keywords: Land use, GIS, Rajasthan, ArcGIS

1 Introduction

Land use change is a regular and global phenomenon. The land use changes combine the effects of both natural and man-made activities. They also have a strong influence on the environmental parameters impacting the quality of air, water, and soil. Recently, academicians around the globe have been working on several projects leading to land use changes and determining the process that has led to land use change at both regional and global levels. Amongst several models to understand land use changes, Geographical Information System (GIS) plays an important role in studying land use changes. For this purpose, a group of seven districts that are actively involved in agriculture from the state of Rajasthan is selected. Literature was available on the soil fertility reports of these districts. In the present study, an attempt is made to study the land use change in selected districts of Rajasthan. The district area has been categorized under four groups: Vacant Area, Built-up Area, Vegetation Area, and Water Bodies Area. Further, the change in land use is compared and presented herein for time spans, 2013 and 2022.

2 Study area selection

For the case study, different districts in Rajasthan are selected based on their contribution to agricultural activity. The southeast and eastern part of the Aravalli range is productive for agriculture with clay loam soil type.

The soil fertility status of these districts was examined and reported by researchers in the recent past [1-5]. In addition, data from the Soil Health Card (SHC) scheme Cycle 2 [8] was also considered to select the study areas. The first phase of SHC, i.e., SHC Cycle I, was from 2015 to 2017, whereas the duration of SHC Cycle II was from 2017 to 2019.

Basically, SHC displays soil health indicators and associated descriptive terms. It also indicates fertilizer recommendations and soil amendments required for the farm. Seven such districts of Rajasthan were actively involved in farming, namely, Sri Ganganagar, Churu (Shekhawati), Jhunjhunu (Shekhawati), Sikar (Shekhawati), Sawai Madhopur, Bundi, and Bhilwara are considered in the present study.

According to SHC Cycle 2, the soils in all seven districts had sufficient levels of Copper, which is >0.2 ppm. Similarly, the levels of Sulphur (> 10.0 ppm) and Manganese (> 2.0 ppm) were also sufficient in all these seven selected districts. Except for Churu district (10- 25 kg/ha), all other six districts had high levels (> 280 kg/ha) of Phosphorus. The organic carbon available in all the seven selected districts was as low as < 0.50%. The pH range of all seven districts was slightly alkaline, with pH values ranging between >7.5 to 8.5. All seven districts were in the non-salinity region (0 to 1.68 dS/m). The status of Zinc, Iron, and Potassium available in soil in the selected districts are presented in Tables 1 to 3.

Table 1. Available soil Zinc in selected districts of Rajasthan

District	Deficient (<0.6ppm)	Sufficient (>0.6ppm)
Sri Ganganagar	✓	
Jhunjhunu	✓	
Churu	✓	
Sikar		✓
Sawai Madhopur		✓
Bundi		✓
Bhilwara		✓

Table 2. Available Iron in selected districts of Rajasthan

District	Deficient (<4.5 ppm)	Sufficient (>4.5 ppm)
Sri Ganganagar		✓
Jhunjhunu	✓	
Churu	✓	
Sikar	✓	
Sawai Madhopur		✓
Bundi		✓
Bhilwara	✓	

Table 3. Available Potassium in selected districts of Rajasthan

District	Medium (120- 280 kg/ha)	High (>280 kg/ha)
Sri Ganganagar		✓
Jhunjhunu	✓	
Churu	✓	
Sikar		✓
Sawai Madhopur	✓	
Bundi	✓	
Bhilwara		✓

3 Methodology Adopted

The methodology adopted for conducting the study on the selected districts has been briefed in the following sections.

3.1 Basic information

For the analysis of seven districts of Rajasthan, we need data on these districts. The sentinel-2 satellite data used herein was downloaded from the Copernicus Open Access Hub supported by the European Space Agency (ESA).

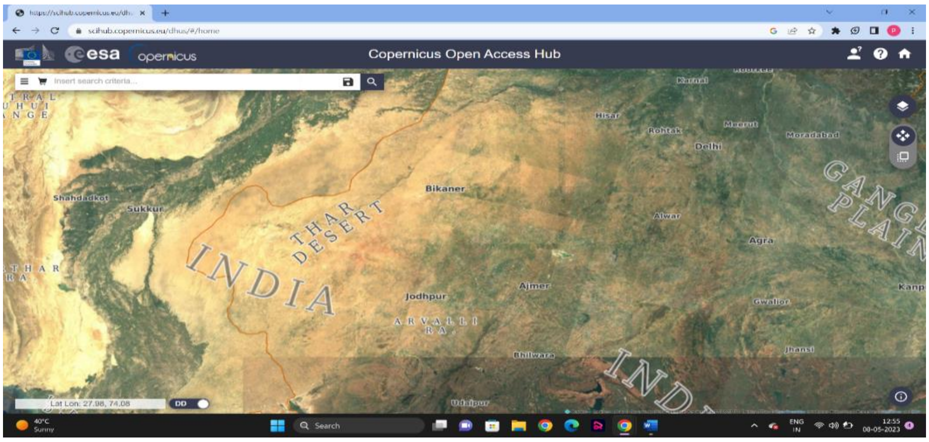


Fig. 1. Copernicus Open Access Hub

To select the area of our consideration from the map, as shown in Fig. 1, we have filled in the following mandatory fields: Sensing period, Ingestion Period, satellite, product type, and cloud cover. In the present study, we have used a sensing and ingestion period of 2022/01/01 to 2022/12/31, Sentinel-2 satellite with product type S2MSI2A and cloud cover of 0 to 0.5%. After filling up the above details on the site, we will get the data of the selected region in the form of tiles (as shown in Fig. 2), and we have to select the tile that covers the area of the considered district.

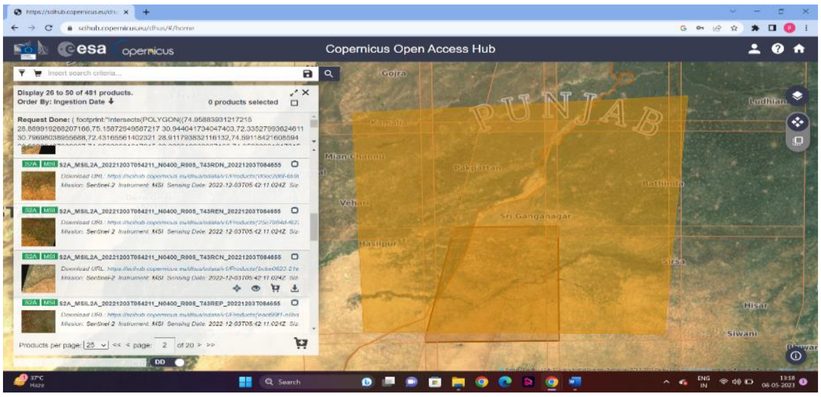


Fig. 2. Selected area divided into tiles

After downloading the tiles, we should open the data in ArcGIS [7] as we need to prepare a false-color (FCC) band combination for our study. We have used multispectral data for analysis consisting of information corresponding to bands 3, 4, and 8 of sentinel satellites, as shown in Figs. 3, 4, and 5, respectively.

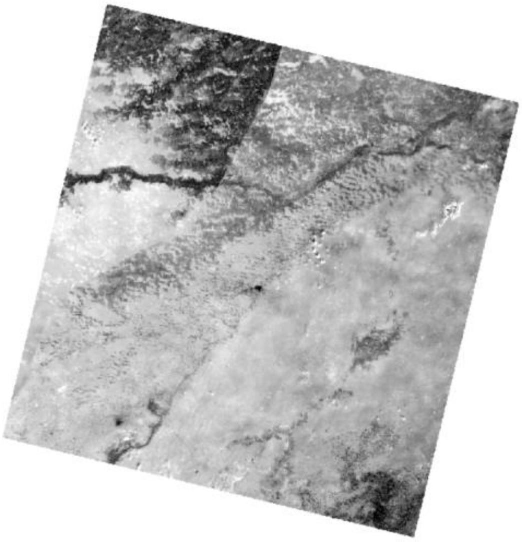


Fig. 3. Band-3

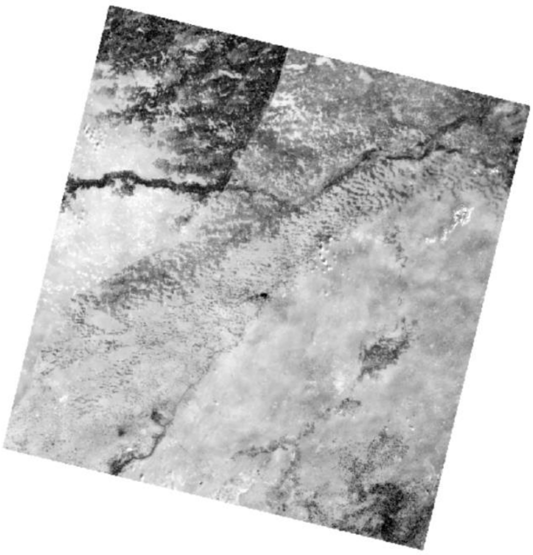


Fig. 4. Band-4

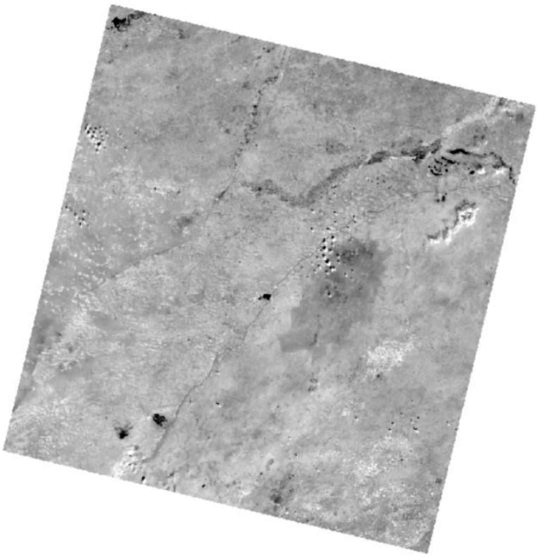


Fig. 5. Band-8

Adding all three bands in ArcGIS, we can prepare the False Colour Combination using the Composite Bands tool in ArcGIS (see Fig. 6). The same process is repeated for all the data (tiles) downloaded to cover the area of the district under consideration.

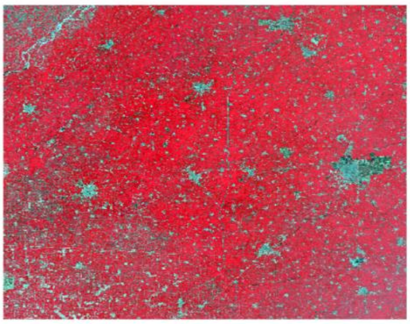


Fig. 6. Composite tile

Compositing all the tiles for a district, now we need to mosaic all the tiles to make a single tile (as shown in Fig. 7), which will cover the entire area of the district considered for which we are analyzing. For mosaic in ArcGIS, we use the mosaic tool.

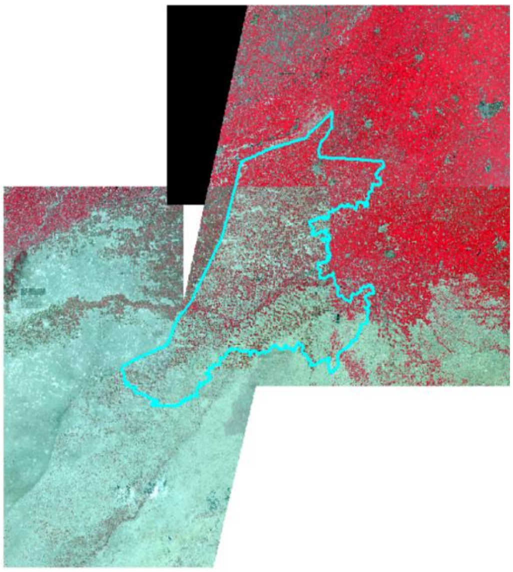


Fig. 7. Mosaic of Sri Ganganagar

It can be seen from Fig. 7 that we have areas beyond the district boundaries. Now, to extract the data corresponding to a particular district, we obtain the district shapefile from the district map of India. Figure 8 shows the shapefile of the Sri Ganganagar district obtained from India's District Map.

Fig. 8. Shapefile of Sri Ganganagar extracted from Indian boundary shapefile

Now, the extra area beyond the district boundary, as shown in Fig. 7, can be removed using the Clip tool in the ArcGIS Software. Thus, the data corresponding to the considered district (see Fig. 9) can be extracted for further use.

Fig. 9. Clip of Sri Ganganagar

For further processing, Maximum Likelihood Classification has been used on the obtained data. In this supervised classification, the data belonging to three different bands (i.e., 3, 4, and 8) are analyzed and categorized into different land use categories. The band combination of 3, 4, and 8, also known as the colour infrared band combination, mainly emphasizes healthy and unhealthy vegetation. Each data pixel is then analyzed to determine the class into which it most likely belongs.

To avoid any potential error or inaccuracies during the classification process, a base Google Earth satellite map that portrays the features of that particular area is also considered. The presented study did not include any accuracy assessment nor consider any socio-economic impact on the selected study areas.

In the present study, we have considered four different land use categories: Vacant Area, Built-up Area, Vegetation Area, and Water Bodies Area.

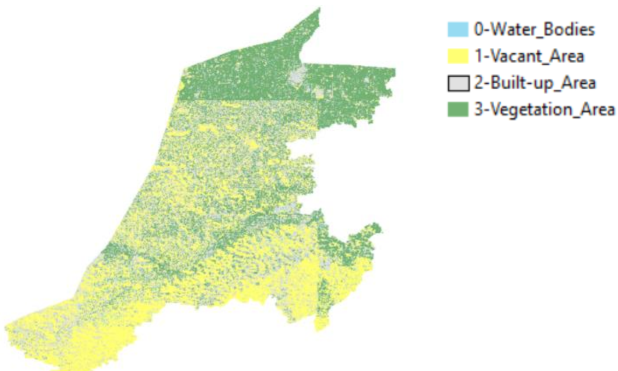
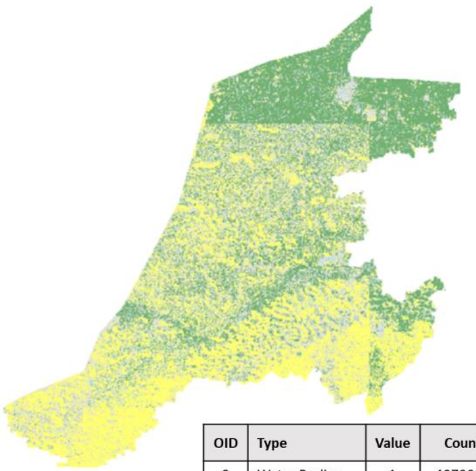


Fig. 10. Maximum likelihood classification of Sri Ganganagar

4 Comparison

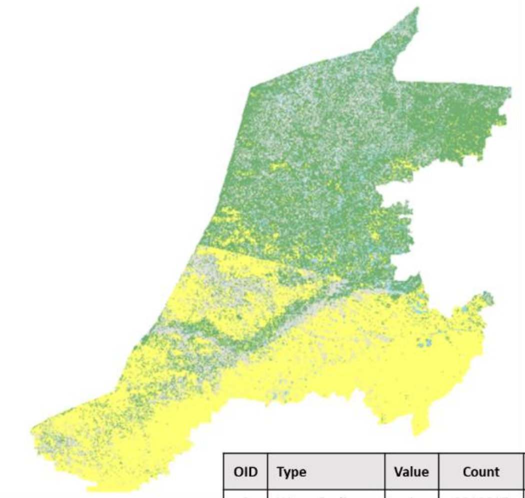
Two districts, Bundi and Sri Ganganagar have been considered, corresponding to two different time spans (i.e., 2013 and 2022), to understand the change in land use. The change in land use in these districts over a time period of ten years has been identified and compared in four different categories: Vacant Land (VL), Built-up Area (BUA), Vegetation Area (VGA), and Water Bodies (WB). For calculating the area, the inbuilt calculate area feature of ArcGIS has been used.

The areas thus calculated for Sri Ganganagar district for the years 2022 and 2013 are presented in Figs. 11 and 12, respectively. Similarly, the data for the Bundi district is also obtained and presented herein.



OID	Type	Value	Count	Area
0	Water Bodies	1	4079934	407993000
1	Vacant Area	169	41122643	4112260000
2	Built Up Area	217	29920000	2992000000
3	Vegetation Area	354	33936598	3393660000

Fig. 11. Sri Ganganagar district 2022 data



OID	Type	Value	Count	Area
0	Water Bodies	1	2012817	1811540000
1	Vacant Area	197	359405	323465000
2	Built Up Area	274	4496222	4046600000
3	Vegetation Area	275	5249611	4724650000

Fig. 12. Sri Ganganagar district 2013 data

A comparison of changes in land use of both the selected districts is presented in Figs. 13 and 14.

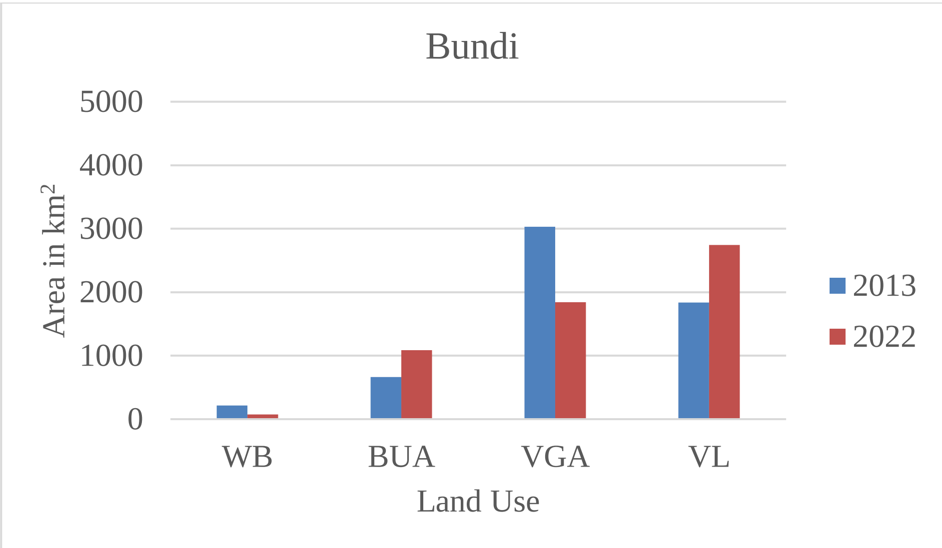


Fig. 13. Land use change in Bundi

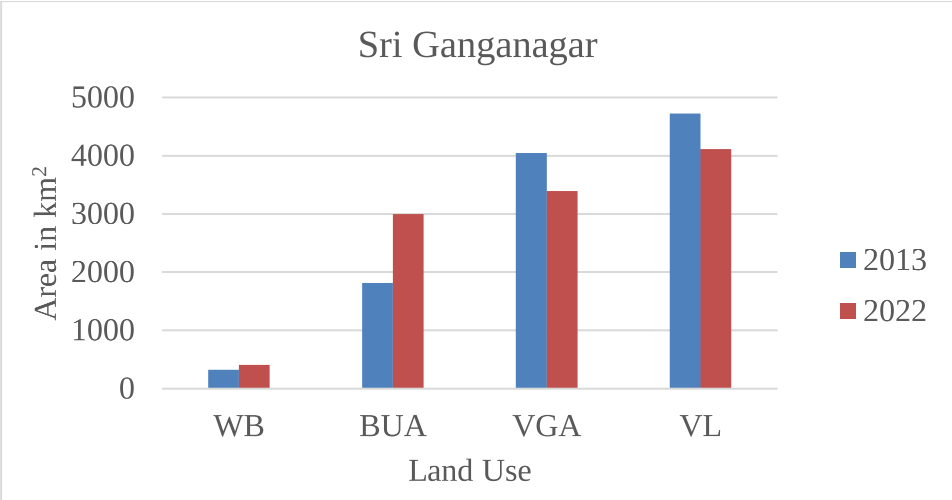


Fig. 14. Land use change in Sri Ganganagar

5 Discussion and Conclusion

It can be observed from these figures that the built-up area has increased in both the study regions. The increase in the built-up area can be attributed to the effect of urbanization in these districts. The vegetation area in both these districts has decreased. The vacant land has increased significantly in Bundi, whereas it has decreased in Sri Ganganagar. The water bodies area has decreased significantly in Bundi, whereas in Sri Ganganagar, it is surprising to note that the water bodies have increased marginally. This increase in the water bodies area in Sri Ganganagar can be attributed to the water logging issues in some parts, which are also reported in the literature. Further mapping of subsurface water logging in Sri Ganganagar might give a clear picture of the water bodies area. This can be attributed to the water logging issues addressed in Sri Ganganagar.

From the comparison of the land use of both districts, the following conclusions can be made:

i. The total area of water bodies in Sri Ganganagar has improved by 25%, whereas in Bundi, the water body areas have reduced by 75%.

ii. The built-up area in both districts has improved drastically. The overall increase in the built-up area is around 65% for both districts.

iii. The total vegetation area in both districts has declined by 40% and 17% in Bundi and Sri Ganganagar, respectively.

iv. The total vacant area in Bundi has increased by 45%, whereas in Sri Ganganagar, it has declined by 13%.

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REFERENCES

1. Gurjar, O.P., Ramawatar Meena and Achin kumar and Surya Kant. (2017), Soil Fertility Status of Mandal Block in Bhilwara District of Rajasthan, International Journal of Current Microbiology and Applied Sciences, Vol. 6, No. 9, pp. 1154-1158.
2. Mahesh Kumar, Amal Kar, Pramila Raina, Surendra Kumar Singh, Pratap Chandra Moharna and Jagdish Singh Chauhan (2019), Spatial Variability of Available Soil Nutrients in the Shekhawati Region of Thar Desert, India. Journal of the Indian Society of Soil Science, Vol. 67, No. 1, pp. 21-33.
3. Mukesh Kumar, SR Yadav and IJ Gulati (2017), Evaluation of soil fertility status in Sriganganagar district of Rajasthan. International Journal of Chemical Studies; Vol. 5, No. 4, pp. 776-780.
4. Kirti Mohan Sharma, Ranu Soni (2020), Physicochemical Analysis of Soil of Bundi Tehsil, of district Bundi and their Statistical Interpretation. International Journal of Emerging Technologies and Innovative Research, Vol.7, Issue 8. pp. 2126-2129.
5. Kothyari, H.S., Meena, K.C., Meena, B.L. and Meena, R. (2018), Soil Fertility Status in Sawai Madhopur District of Rajasthan, International Journal of Pure & Applied Bioscience. Vol. 6, No. 4, pp. 587-591.
6. Mohamed A.E. Abdelrahman, A. Natarajan, C.A. Srinivasamurthy, Rajendra Hegde (2016), Estimating soil fertility status in physically degraded land using GIS and remote sensing techniques in Chamarajanagar district, Karnataka, India, The Egyptian Journal of Remote Sensing and Space Science, Volume 19, Issue 1, pp. 95-108.
7. ArcGIS Desktop: Release 10 (2011), Environmental Systems Research Institute, Redlands.
8. Soil Health Card Scheme, Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India (https://soilhealth.dac.gov.in/home)