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ASSESSING LAND USE AND LAND COVER CHANGE IN HARYANA, INDIA: A STUDY OF TRENDS FROM 2017 TO 2023 USING GEOSPATIAL APPROACH

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Abstract

This paper uses geospatial techniques to assess land use and land cover change (LULC) trends in Haryana. The study period was from 2017 to 2023, and data from ESRI LULC product which uses Sentinel-2 satellites were used for the analysis. The study found that urbanization and agricultural expansion were the main drivers of LULC change in the region. Urban areas increased by 503.08 Sq. Kms during the study period, while agricultural land decreased by 421.35 Sq. Kms. The study also identified areas of significant change, such as the cities of Gurugram and Faridabad, where urbanization was particularly rapid. The results of this study have important implications for land use planning and management in Haryana, as well as for understanding the impacts of LULC change on ecosystem services and biodiversity. The use of geospatial techniques in this study provides a robust and objective approach to LULC analysis, which can be used to inform decision-making and policy development in the region.

Keywords : Land use and land cover change (LULC), ESRI, Land use planning, Urbanization, Geospatial techniques, Sentinel-2.

1 INTRODUCTION

The land is the main natural resource on which economic, social, infrastructural, and other human activities depend. Changes in land use-land cover have occurred at all times in the past and are likely to continue in the future (Melka, 2021). Land use and land cover change (LULC) is a critical issue that affects the sustainability and resilience of ecosystems, especially in rapidly developing regions such as Haryana, India. Understanding the dynamics and drivers of LULC change is essential for effective land use planning, natural resource management, and sustainable development. Land use and land cover change (LULC) implies anthropogenic and natural modification of the land surface.(Kidane et al., 2019).

Understanding land use and land cover (LULC) dynamics, as well as the associated impacts on the multiple ecosystem service value (ESV), is extremely important in decision-making processes and effective implementation of an ecosystem-based management approach.(Makwinja et al., 2021).In recent years, geospatial technologies have become increasingly popular for analyzing LULC change due to their ability to provide accurate and objective data on land use and land cover patterns and changes over time.

Satellite Remote Sensing and GIS are the most common methods for quantification, mapping and detection of patterns of LULCC because of their accurate geo-referencing procedures, digital format suitable for computer processing and repetitive data acquisition(Hassan et al., 2016).Land use and land cover (LULC) refers to the types of activities that occur on the earth's surface and the physical characteristics of the surface itself. Land use refers to the human activities that take place on the land, such as urbanization, agriculture, forestry, mining, and transportation. Land cover, on the other hand, refers to the physical characteristics of the land, such as forests, grasslands, wetlands, and water bodies.

Remote sensing technologies and geographic information systems (GIS) have made it possible to collect and analyze large amounts of data on LULC at different spatial and temporal scales, providing valuable insights into land use dynamics and their impacts on the environment. In the region, the land use and land cover (LULC) are constantly changing, resulting in a fragmented ecosystem. The main drivers of these changes include complex socio-economic and environmental factors combined. Among these causes, demographic pressure and population dynamics, the importance of cash crops, unrealistic rainfall trends, markets and the local economy could be the most important causes(Kouassi et al., 2021).

Land use and land cover change (LUCC) has been recognized as a major driving force of global environmental perturbations. Through human history, land surface cover has been altered through land clearing of natural forests, subsistence agriculture, intensification of farmland production, modification of rangeland and urbanization. The consequence of this change in the natural land cover is the modification of the world’s landscape in pervasive ways(Manandhar & Odeh, 2014).

Haryana is a state in northern India with a growing population and economy, making it an important region for studying LULC change. The state has experienced significant urbanization and agricultural expansion in recent years, leading to changes in land use and land cover patterns. However, there is a lack of comprehensive studies that examine the spatial and temporal dynamics of LULC change in the region. The urbanization process has led to chaotic growth in city, deteriorated the living conditions and has worsened the environmental scenario having detrimental impacts on human health. Therefore, it is required to determine the rate and trend of land cover/use conversion for devising a rational land use policy(Hassan et al., 2016)

This paper aims to address this gap by assessing the trends and patterns of LULC change in Haryana from 2017 to 2023 using geospatial techniques. Specifically, the paper will analyze data from ESRI Living atlas LULC prepared by using Sentinel 2 on scale of 10 m to identify areas of significant change and to understand the drivers of LULC change in the region.

Overall, this study contributes to the growing body of literature on LULC change and highlights the importance of geospatial technologies for analyzing and monitoring LULC change in rapidly developing regions. The findings of this study will have important implications for land use planning and management in Haryana, as well as for understanding the impacts of LULC change on ecosystem services and biodiversity.

1. Data and Methods

1.1 Study Area

Haryana State, with 19 districts, is located in between 27°39’N and 30° 55’N latitudes and 74°27’ E and 77°36’E longitudes.(Patel et al., 2006) The State has a geographical area of about 4.37M ha and forms 1.35% of the total area of India. Haryana is a state in northern India, bordered by Punjab to the north, Himachal Pradesh to the northeast, Rajasthan to the west and south, and Delhi to the south and southeast. With an area of 44,212 square kilometers and a population of over 28 million, Haryana is the 18th largest state in India by area and 16th largest by population.

The state is predominantly rural, with agriculture being the main source of livelihood for a majority of the population. The state is one of the major agricultural producers in India, with crops such as wheat, rice, sugarcane, and cotton being the mainstay of the agricultural economy. Haryana is also home to several major industries, including automobiles, textiles, and pharmaceuticals, and has seen rapid urbanization and infrastructure development in recent years.

The state is divided into 22 districts, each with its unique socio-economic and environmental characteristics. The landscape of Haryana is predominantly flat, with the Aravalli Mountain range running along the southwestern border of the state. The climate is semi-arid, with hot summers and relatively cold winters. Annual rainfall varies from 1100mm in the north-eastern hilly tract of the Ambala district to less than 300mm in the south-western parts of Bhiwani, Hisar and Sirsa districts(Patel et al., 2006).

Given its unique geographical and socio-economic characteristics, Haryana is an ideal study area for assessing land use and land cover change dynamics. The state has undergone significant changes in recent years, driven by urbanization, agricultural expansion, and industrialization, and understanding these changes is crucial for sustainable land use management and natural resource conservation.

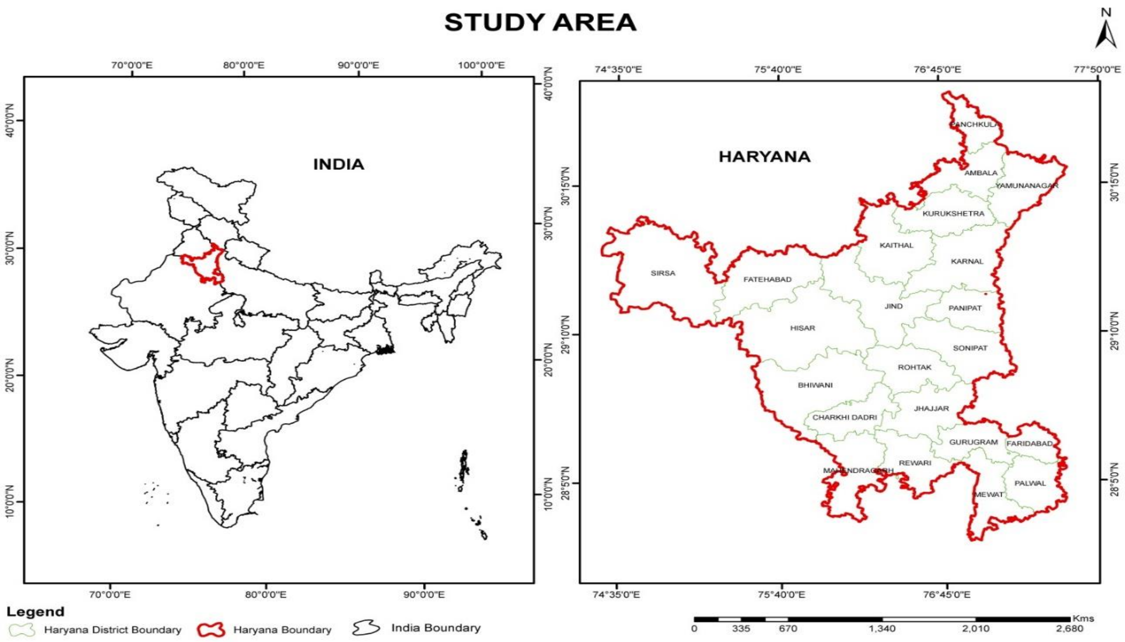

Figure 1 Study Area

1.2 Data and Processing

The LULC data of year 2017 and 2023 is acquired from ESRI Living Atlas. The data is processed and analyzed by ESRI, a leading provider of Geographic Information Systems (GIS) software and services. The LULC data is a classification of the land cover and land use types within a given area, derived from the Sentinel-2 satellite imagery. The classification is based on a combination of spectral, textural, and contextual information derived from the satellite data, which is processed using machine learning algorithms and other analytical techniques.

The Sentinel satellite data used to create the LULC dataset has a spatial resolution of 10 meters, which allows for detailed mapping and analysis of the land cover and land use types within a given area. The LULC data includes a range of land cover and land use classes, including trees, croplands, water bodies, urban areas, and other types of natural and human-modified landscapes.

1.2.1 Classification Process

This map was produced by a deep learning model trained using over five billion hand-labeled Sentinel-2 pixels, sampled from over 20,000 sites distributed across all major biomes of the world.(*Esri | Sentinel-2 Land Cover Explorer*, n.d.)

The deep learning model uses 6-bands of Sentinel-2 L2A surface reflectance data: visible blue, green, red, near infrared, and two shortwave infrared bands. To create the final map, the model is run on multiple dates of imagery throughout the year, and the outputs are composited into a final representative map for each year.

The input Sentinel-2 L2A data was accessed via Microsoft's Planetary Computer and scaled using Microsoft Azure Batch.(*Sentinel-2 10m Land Use/Land Cover Time Series - Overview*, n.d.)

LULC acquired from ESRI for year 2017 and 2023 is processed and study area is being clipped. Classes are assigned into Water, Trees, Flooded Vegetation, Crops, Built area, Bare ground, and Rangeland. The area statistic is calculated from classified LULC.

1.2.2 LULC Change Dynamics analysis

LULC change dynamics analysis helps to understand the drivers and impacts of changes in land use and land cover. It is an essential tool for assessing the changes in the environment and the impact of human activities on the landscape. Area change statistics refer to the quantitative analysis of changes in land use and land cover over time. It involves comparing the area of different land use and land cover classes between two or more time periods and identifying the extent and direction of change.

Common area changes statistics include the net change in area (i.e., the difference between the area of a class in the initial time period and the area of the same class in the final time period), the percent change in area (i.e., the net change in area expressed as a percentage of the initial area), and the rate of change (i.e., the percent change in area divided by the time period over which the change occurred). These statistics can be presented in tables, graphs, or maps to facilitate interpretation and communication of the results.

The data is initially in a raster format, which represents the LULC classes as pixels on a grid. The first step is to convert the raster data into a vector format, which represents the LULC classes as polygons. The next step is to use the intersect tool in ArcGIS 10.4 software to overlay the vector data from the two different years. This process generates a new set of polygons that represent the areas where the LULC has changed between the two time periods.

The Tabulate Intersection tool is a

geoprocessing tool available in ArcGIS that performs a spatial analysis operation on two input feature classes or feature layers. It creates a table that shows the area, length, or count of the features from the two input layers that intersect with each other. The tool is commonly used to generate summary tables that provide information about how features in one layer interact with features in another layer.

The tool can be accessed through the Arc Toolbox in ArcGIS and requires the input feature classes to have a common attribute or field that is used to relate them. The output of the tool is a table that can be exported to various file formats such as Excel, CSV, and DBF for further analysis and visualization.

The Tabulate Intersection tool is then used to calculate the area of the changed polygons. Finally, the area change statistics are exported to Microsoft Excel, where tables and charts are created to compare the changes in LULC between the two time periods.

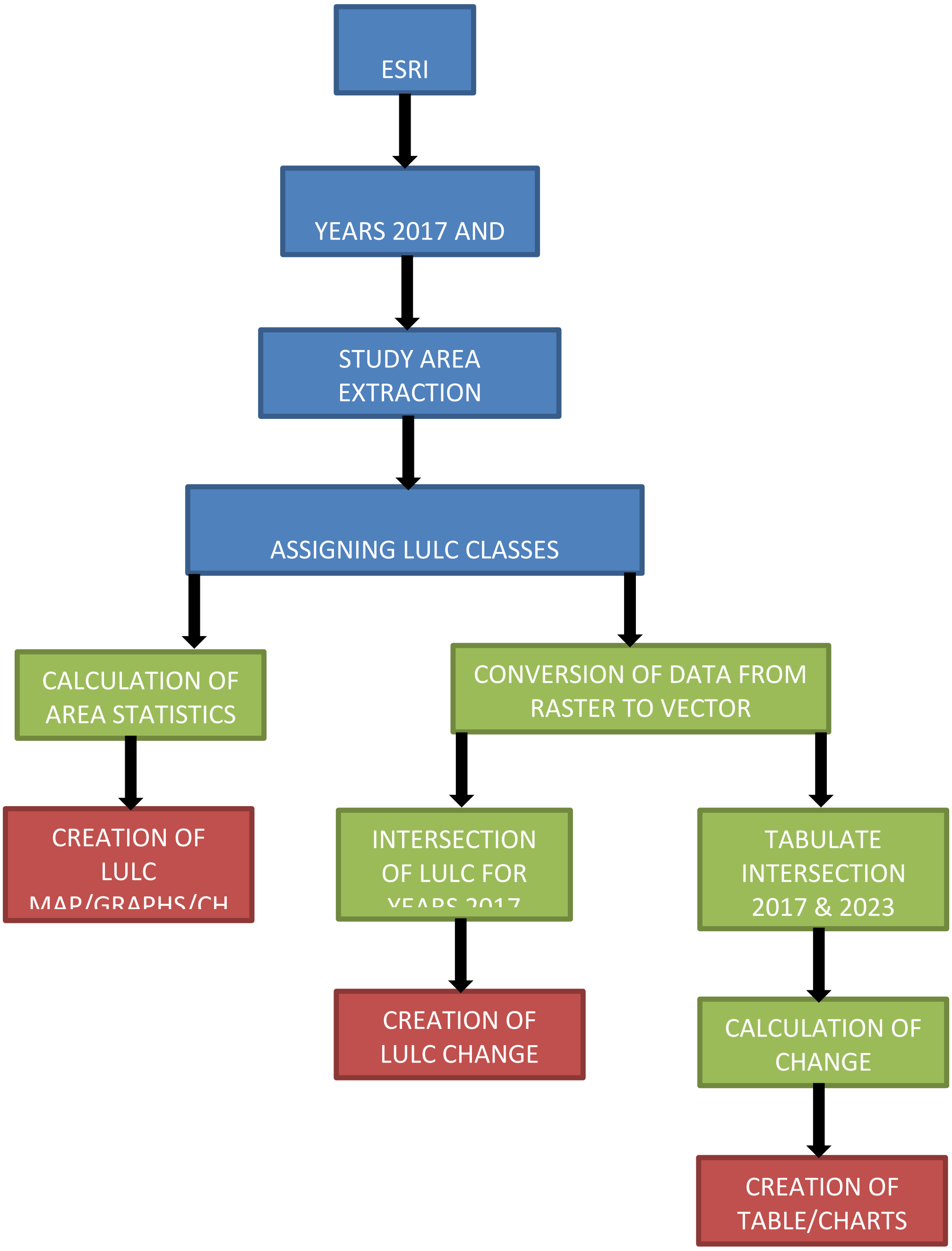

Figure 2 Methodology

2.Results and Discussions

2.1 Land use Land cover analysis of year 2017-18

The table.1 represents the land cover distribution in the study area for the year 2017-2018. The land cover classes included in the table are water, trees, flooded vegetation, crops, built area, bare ground, and rangeland. The area of each class is also provided in the table. The largest land cover class in the study area is crops, with an area of 38,526.29 Sq. Km, which indicates the importance of agricultural activities in the region. The second largest class is trees, which covers an area of 743.22 Sq. Km, followed by built area with an area of 3,738.02 Sq. Km. Water and flooded vegetation classes have relatively small areas, indicating limited availability of water resources in the region. Rangeland and bare ground classes cover relatively small areas as well, indicating low levels of natural vegetation cover in the study area.

Table 1 Area Statistics of LULC Classes 2017-18

LULC Classes (2017-18)	Area in Sq. Km
Water	**167.4649**
Trees	**743.2159**
Flooded vegetation	**1.5691**
Crops	**38526.2868**
Built Area	**3738.0212**
Bare ground	**37.3709**
Rangeland	**1009.3649**

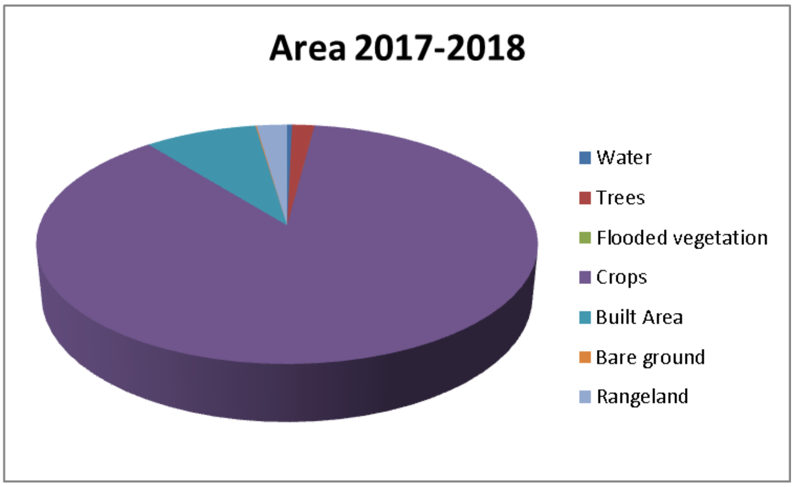

Figure 3 Area Distribution of LULC Classes 2017-18

2.2 Land use Land cover analysis of year 2022-23

The table 2 represents the land cover distribution in the study area for the year 2022-2023. The land cover classes included in the table are water, trees, flooded vegetation, crops, built area, bare ground, and rangeland. The area of each class is also provided in the table. The largest land cover class in the study area is crops, with an area of 38,104.93 Sq. Km, which is slightly less than the area in the previous year. The second largest class is trees, which covers an area of 734.56 Sq. Km, indicating that the forest cover has remained relatively stable over the study period. The built area class has increased to 4,241.11 Sq. Km, indicating that urbanization and infrastructure development have expanded in the region. Water and flooded vegetation classes have also increased slightly, indicating a slight improvement in the water resources in the study area. Rangeland and bare ground classes have remained relatively stable over the study period, indicating that there has been limited change in the natural vegetation cover in the study area.

Table 2 Area Statistics of LULC Classes 2022-23

LULC Classes (2022-23)	Area in Sq. Km
Water	182.5095
Trees	734.5626
Flooded vegetation	4.1058
Crops	38104.9284
Built Area	4241.1098
Bare ground	32.4656
Rangeland	923.6123

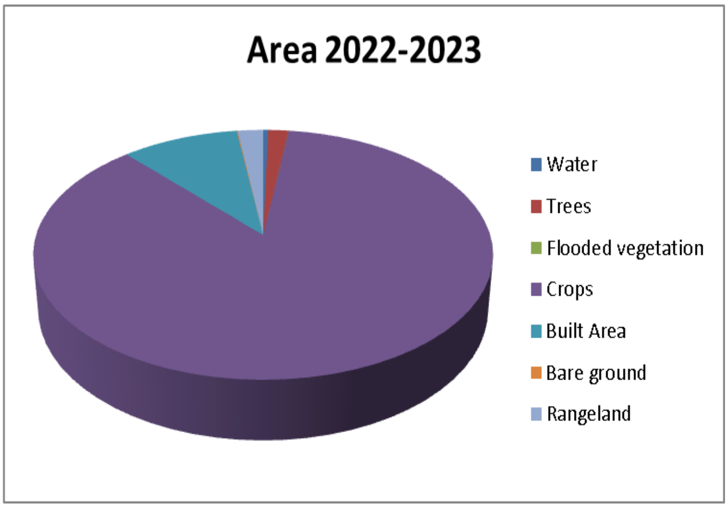

Figure 4 Area Distribution of LULC Classes 2022-23

Table 3 Area Change Statistics of year 2017-18 and 2022-23

Class	Area 2017-18	Area 2022-23	Area Change	Area % 2017-18	Area % 2022-23	Area % change
Water	167.46	182.51	15.04	0.38	0.41	0.03
Trees	743.22	734.56	-8.65	1.68	1.66	-0.02
Flooded vegetation	1.57	4.11	2.54	0.00	0.01	0.01
Crops	38526.29	38104.93	-421.36	87.12	86.16	-0.95
Built Area	3738.02	4241.11	503.09	8.45	9.59	1.14
Bare ground	37.37	32.47	-4.91	0.08	0.07	-0.01
Rangeland	1009.36	923.61	-85.75	2.28	2.09	-0.19

The table 3 represents the changes in land cover area between the years 2017-2018 and 2022-2023 in the study area. The land cover classes included in the table are water, trees, flooded vegetation, crops, built area, bare ground, and rangeland. The area change values are also provided in the table. The water class has increased by 15.04 Sq. Km, indicating a slight improvement in water resources. The trees class has decreased by 8.65 Sq. Km, which may be due to deforestation or natural causes such as disease or wildfire. Flooded vegetation has increased by 2.54 Sq. Km, indicating improved wetland conditions in the study area. The crops class has decreased by 421.36 Sq. Km, indicating a potential decrease in agricultural activities in the region. The built area class has increased by 503.09 Sq. Km, indicating urbanization and infrastructure development have expanded rapidly in the study area. The bare ground class has decreased by 4.91 Sq. Km, which may be due to natural vegetation regeneration. The rangeland class has decreased by 85.75 Sq. Km, indicating a decrease in natural grazing lands in the study area.

The table 3 provides information on the percentage change in land cover between the years 2017-2018 and 2022-2023 in the study area. The land cover classes included in the table are water, trees, flooded vegetation, crops, built area, bare ground, and rangeland. The water class increased by 0.03% between the two years, indicating a slight increase in the water resources in the study area. However, the trees class decreased by 0.02%, indicating a decline in the forest cover in the study area. The flooded vegetation class increased by 0.01%, indicating a slight increase in the wetland areas. The crops class decreased significantly by 0.95%, indicating a decrease in agricultural activities or a shift in crop pattern. The built area class increased by 1.14%, indicating the growing urbanization and infrastructure development in the study area. The bare ground class decreased slightly by 0.01%, while the rangeland class decreased by 0.19%.

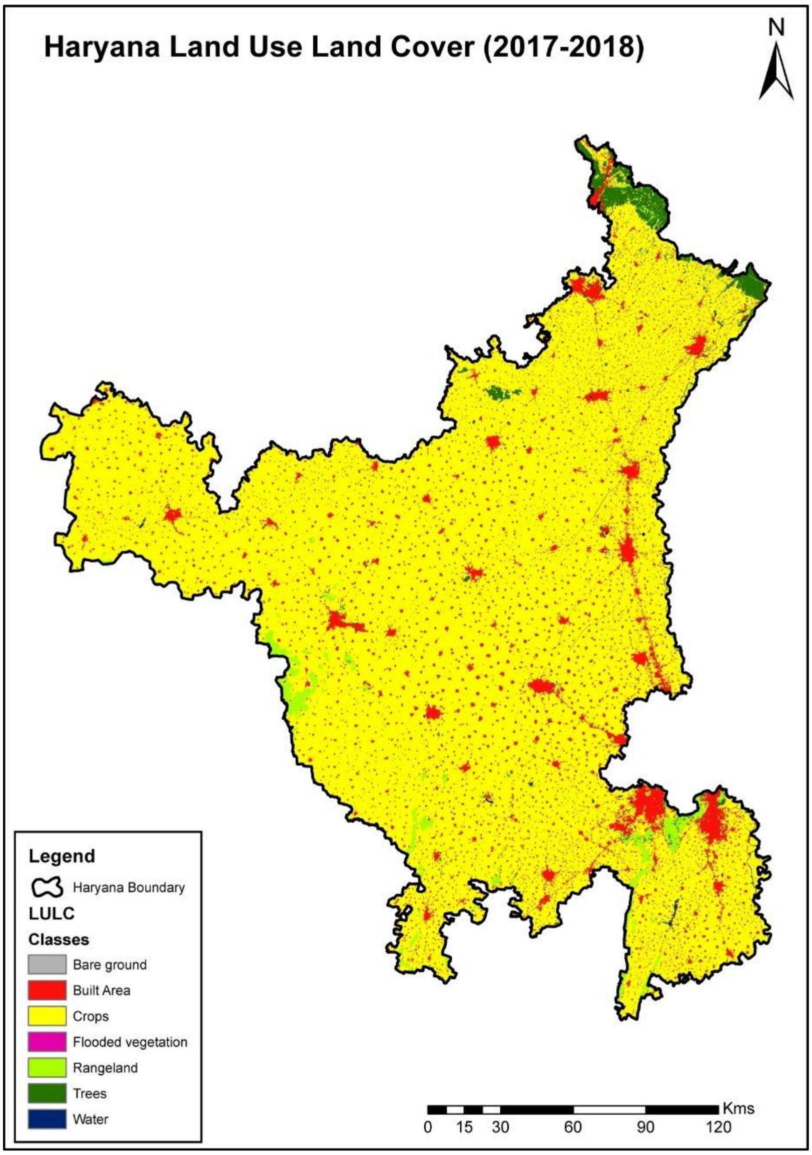

Figure 5 LULC Map of Year 2017-18

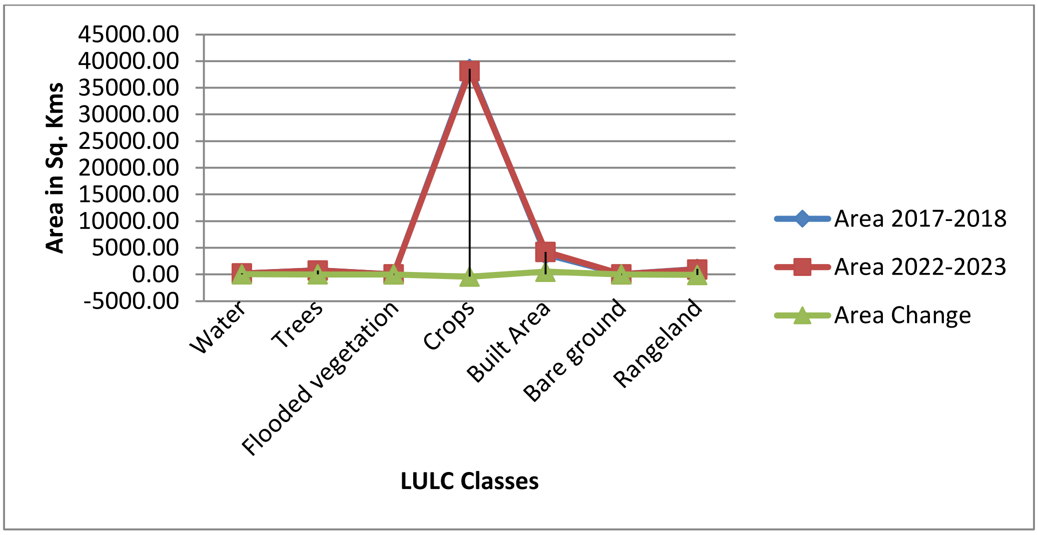

Figure 6- LULC Change Dynamics of Study Period

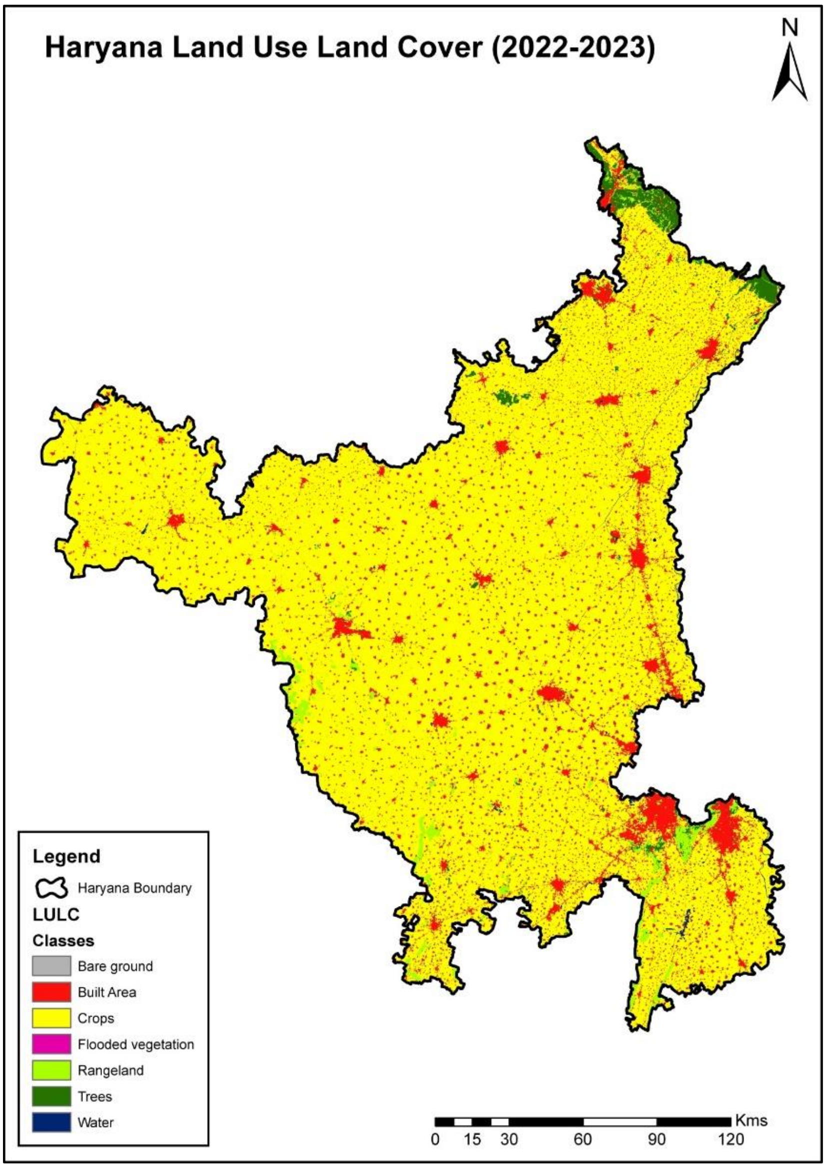

Figure 7 LULC Map of Year 2022-23

Table 4 Class conversion Statistics of year 2017-18 and 2022-23

LULC Class 2017-18	LULC Class 2022-23	Percentage %	Area in Sq. Kms
Bare ground	Bare ground	31.43	11.75
Bare ground	Built Area	7.08	2.65
Bare ground	Crops	24.42	9.13
Bare ground	Rangeland	11.66	4.36
Bare ground	Trees	0.14	0.05
Bare ground	Water	25.26	9.44
Built Area	Bare ground	0.03	1.30
Built Area	Built Area	94.78	3542.82
Built Area	Crops	4.53	169.34

Built Area	Flooded vegetation	0.00	0.04
Built Area	Rangeland	0.37	13.77
Built Area	Trees	0.13	4.69
Built Area	Water	0.16	6.07
Crops	Bare ground	0.02	8.20
Crops	Built Area	1.66	640.64
Crops	Crops	97.72	37648.31
Crops	Flooded vegetation	0.01	2.37
Crops	Rangeland	0.38	145.24
Crops	Trees	0.09	33.76
Crops	Water	0.12	47.78
Flooded vegetation	Bare ground	0.57	0.01
Flooded vegetation	Built Area	1.26	0.02
Flooded vegetation	Crops	22.01	0.35
Flooded vegetation	Flooded vegetation	19.23	0.30
Flooded vegetation	Rangeland	12.72	0.20
Flooded vegetation	Trees	3.42	0.05
Flooded vegetation	Water	40.79	0.64
Rangeland	Bare ground	0.52	5.24
Rangeland	Built Area	3.94	39.80
Rangeland	Crops	19.47	196.57
Rangeland	Flooded vegetation	0.03	0.34
Rangeland	Rangeland	69.35	699.99
Rangeland	Trees	6.30	63.57
Rangeland	Water	0.38	3.85
Trees	Bare ground	0.02	0.13
Trees	Built Area	1.03	7.62
Trees	Crops	6.14	45.62
Trees	Flooded vegetation	0.00	0.00
Trees	Rangeland	7.73	57.43
Trees	Trees	84.98	631.62
Trees	Water	0.11	0.79
Water	Bare ground	3.49	5.85
Water	Built Area	4.52	7.57
Water	Crops	21.27	35.61
Water	Flooded vegetation	0.63	1.05

Water	Rangeland	1.57	2.62
Water	Trees	0.49	0.82
Water	Water	68.04	113.94

The above table 4 and below given pie charts 8 & 9 shows the area of different land use and land cover classes in 2017-18 and 2022-23, along with their percentage change.

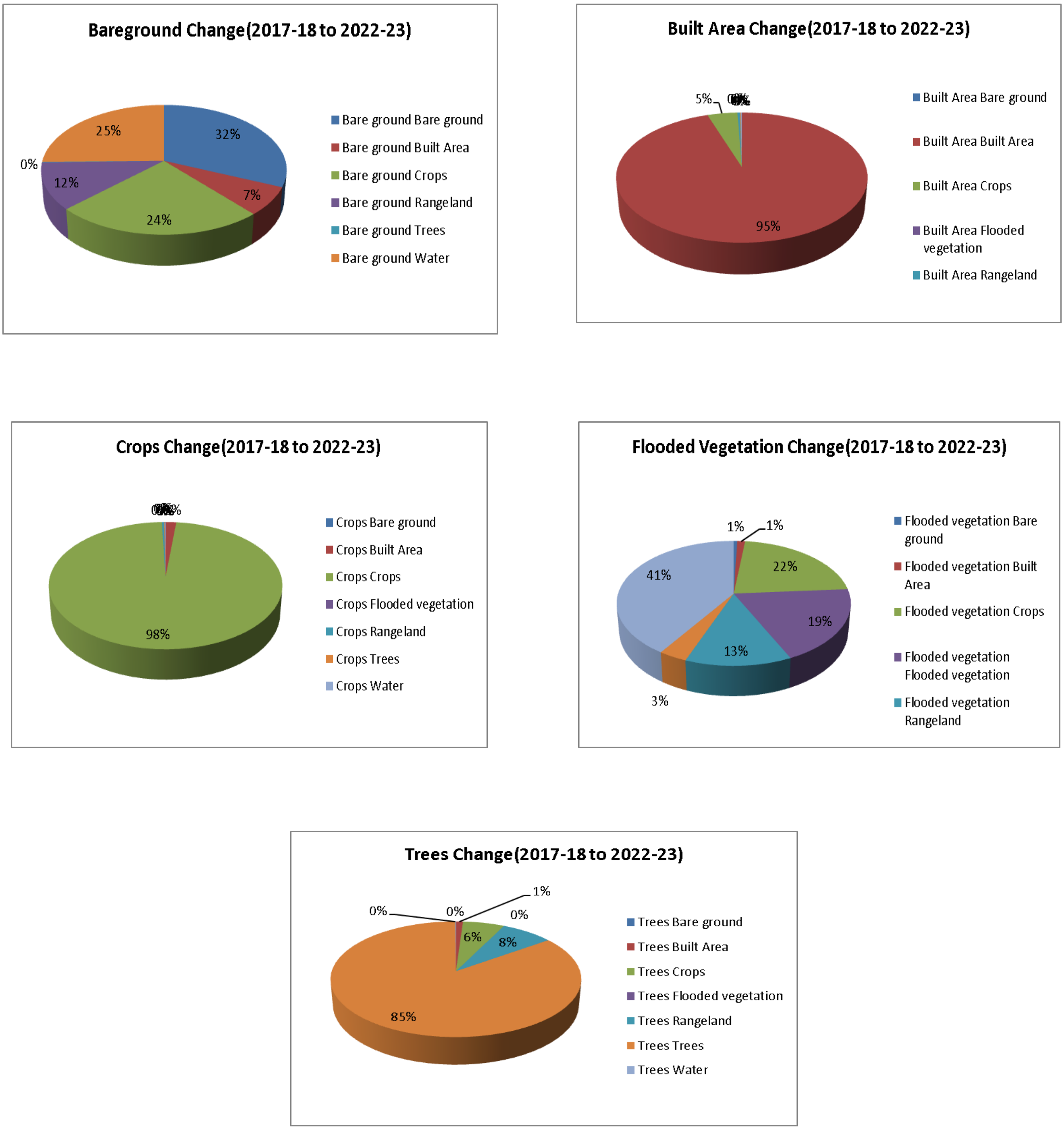

Figure 8 Pie Charts of Area Change into other Classes

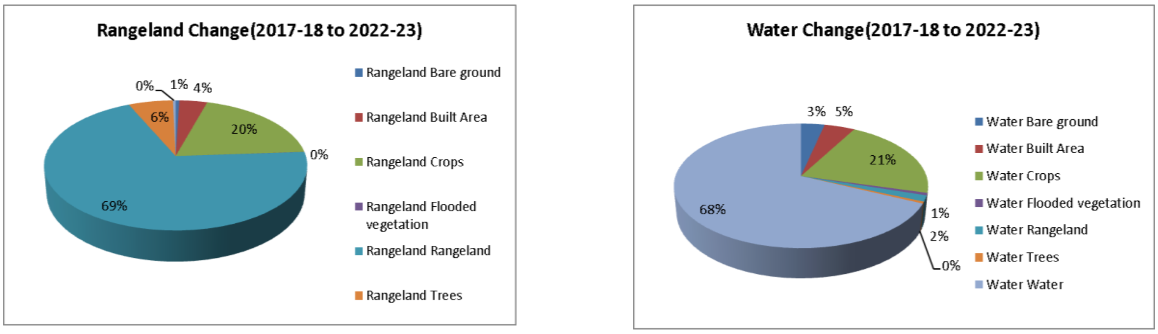

Figure 9 Pie Charts of Area Change into other Classes

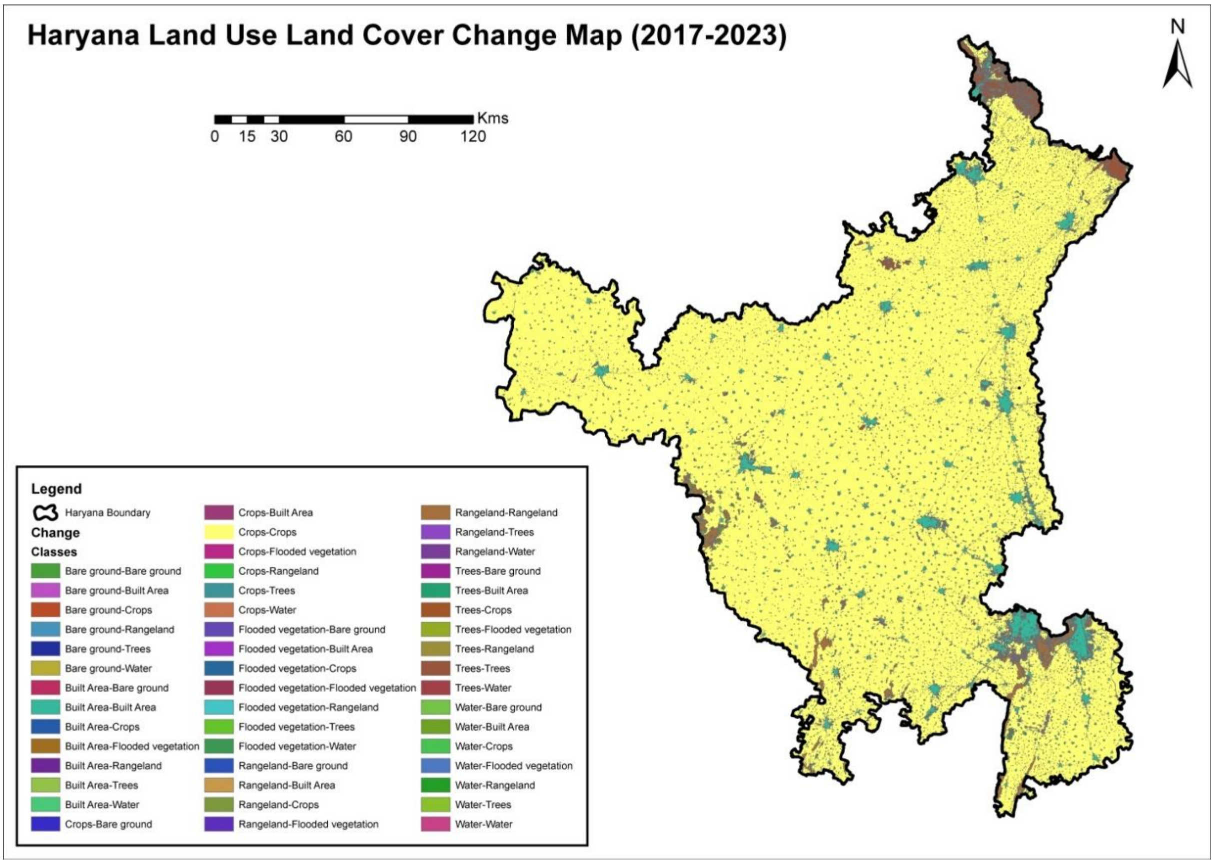

Figure 10 LULC Change Map 2017-2023

CONCLUSION

The LULC analysis reveals significant changes in the study area between 2017 and 2023. The major land use changes observed were the decrease in crop area and increase in built-up area, indicating the urbanization trend in the region. The conversion of agricultural land to built-up area is a cause for concern as it leads to the loss of fertile land and affects food security. The increase in water bodies is a positive sign, indicating an improvement in water resources management. The analysis also highlights the importance of remote sensing and GIS techniques for studying land use changes and monitoring the impacts of human activities on the environment. The findings of this study could be useful for policymakers to develop sustainable land use policies and plan the allocation of resources for better management of the region's natural resources.

REFERENCES

Esri | Sentinel-2 Land Cover Explorer. (n.d.). Retrieved May 10, 2023, from https://livingatlas.arcgis.com/landcoverexplorer/#mapCenter=-117.2%2C34.06%2C11&mode=step&timeExtent=2017%2C2022&year=2022

Hassan, Z., Shabbir, R., Ahmad, S. S., Malik, A. H., Aziz, N., Butt, A., & Erum, S. (2016). Dynamics of land use and land cover change (LULCC) using geospatial techniques: a case study of Islamabad Pakistan. *SpringerPlus*, *5*(1). https://doi.org/10.1186/s40064-016-2414-z

Kidane, M., Bezie, A., Kesete, N., & Tolessa, T. (2019). The impact of land use and land cover (LULC) dynamics on soil erosion and sediment yield in Ethiopia. *Heliyon*, *5*(12), e02981. https://doi.org/10.1016/j.heliyon.2019.e02981

Kouassi, J. L., Gyau, A., Diby, L., Bene, Y., & Kouamé, C. (2021). Assessing land use and land cover change and farmers' perceptions of deforestation and land degradation in south-west Côte d'Ivoire,West Africa. *Land*, *10*(4). https://doi.org/10.3390/land10040429

Makwinja, R., Kaunda, E., Mengistou, S., & Alamirew, T. (2021). Impact of land use/land cover dynamics on ecosystem service value—a case from Lake Malombe, Southern Malawi. *Environmental Monitoring and Assessment*, *193*(8). https://doi.org/10.1007/s10661-021-09241-5

Manandhar, R., & Odeh, I. O. A. (2014). Interrelationships of land use/cover change and topography with soil acidity and salinity as indicators of land degradation. *Land*, *3*(1), 282–299. https://doi.org/10.3390/land3010282

Melka, G. A. (2021). *Evaluation of Spatio-Temporal Land Use and Land Cover Dynamics Using Geospatial Technologies : The Case of Majang Evaluation of Spatio-Temporal Land Use and Land Cover Dynamics Using*. *8*(1).

Patel, N. R., Bhattacharjee, B., Mohammed, A. J., Tanupriya, B., & Saha, S. K. (2006). Remote sensing of regional yield assessment of wheat in Haryana, India. *International Journal of Remote Sensing*, *27*(19), 4071–4090. https://doi.org/10.1080/01431160500377188

Sentinel-2 10m Land Use/Land Cover Time Series - Overview. (n.d.). Retrieved May 10, 2023, from https://www.arcgis.com/home/item.html?id=cfcb7609de5f478eb7666240902d4d3d