Spatial Analysis of Land Use and Land Cover of Gujranwala District Using Remotely Sensed Data

Farheen Tahir, Ali Iqtadar Mirza, Mariam Sarwar, Shakeel Mahmood
Department of Geography, Government College University Lahore, Pakistan
*Correspondence: farheentahir42@gmail.com , mariamsarwar29@gmail.com

Citation | Tahir. F, Airza. A. I, Sarwar. M, Mahmood. S, "Spatial Analysis of Land Use and Land Cover of Gujranwala District Using Remotely Sensed Data", IJIST, Vol. 07 Special Issue. pp 258-265, August 2025
Received| July 28, 2025 **Revised|** August 15, 2025 **Accepted|** August 16, 2025 **Published|** August 17, 2025.

Land use and land cover change is a major problem in most metropolitan areas in the world, where a natural land surface is changed to commercial land. Gujranwala is the 5th most populous city in Pakistan. The present population is 2,290,000. This study is an effort to assess the land use changes in Gujranwala District from the years 1990 to 2020. Land Use Land Cover (LULC) is the spatial change in land use and land cover from 1990 to 2020. The entire research is categorized into four classes (i.e., Vegetation, Uncultivable Land, Built-up Area, and Waterbody). The objectives revolve around the detection and assessment of Land Use and Land Cover in the district. The land cover is directly proportional to the expansion of the population of the district. The reasons for the changes are the development of residential and commercial buildings. Two types of analysis are used in the methodology. The temporal analysis is done using spatial techniques, including Geographic Information System (GIS) and Remote Sensing. Furthermore, statistical analysis was also performed using the statistical data of the built-up area. The findings show that the alterations in land cover were due to an increase in built-up area and population in the city.

Keywords: Geographic Information System, Remote Sensing, Change Detection, Land Use Land Cover

Introduction:

Natural and built objects covering the land surface are called "land cover", while human uses of the land are called "land use". Classifications of Land Use/Land Cover (LULC) are generated to assess the configuration of urban sites and visualize the various segments of the place. Land cover refers to the physical characteristics of the Earth's surface. The change of land from a natural land surface to an urban area is the morphological conversion [1]. The proportions of the land use and land cover are used to represent an environment [2]. Different components come together to justify the land use land cover varieties, which may include practical**, ** social, natural, political, biophysical, and institutional factors. Their interaction behind the changes makes it difficult to comprehend how these changes work. Information on LULC is available as maps and statistics, which are significant for planning, management, and utilization of land for various purposes, including economic development as well as agricultural development [3].

The change of the land is the result of human activities driven by social, economic, political, and cultural reasons [4]. Before the development of computers and other technical innovations, the land use land cover changes (LULC) were identified by simple land surveys and by drawing them on paper and topographic sheets [5]. These records were very hard to maintain and problematic. Whenever we needed land records**,** it was very tough and time-consuming to find the desired records. With the advancement in Geographic Information System (GIS) and Remote Sensing (RS) technology, it is much faster and easier to obtain the spatial data and the information associated with it [6]. Therefore, this study aims to determine the spatial change in land use and land cover of the Gujranwala district from 1990 to 2020 using GIS and remote sensing.

Study Area:

Gujranwala is a city and the capital of a division located in Punjab, Pakistan. It is the 5th most populous city in Pakistan. It is commonly known as the "City of Wrestlers". This city was founded in the 18th century. It is also the 3rd largest industrial city in Pakistan. The latitude of Gujranwala is 32.166351, and the longitude is 74.195900. In eastern Pakistan, Gujranwala is a large town. The total area of Gujranwala is 240 km^2. This city has a hot semi-arid climate (BSh) according to the Koppen-Geiger system, and the climate changes throughout the year. During summer, the temperature rises from 36 to 42 degrees (June to September). The temperature can drop to an average of 7 degrees during the months from November to February. The highest-precipitation months are usually July and August when the monsoon reaches the Punjab. During the other months, the average rainfall is about 25 millimeters (0.98 in) from October to May**,** which have little rainfall. It is one of the most populated regions in Pakistan. This city lies in the 5th most populous area of Pakistan. The population in 2021 was 2,290,000, an increase of 2.74% from 2020. The population in 2020 was 2,229,000. Gujranwala is the heart of Rachna Doab. This city is a strip of land between the Chenab in the north and the Ravi River in the south. Gujranwala is 226 meters (744ft) above sea level. Gujranwala is situated along the Grand Trunk Road. Gujranwala is the 3rd largest center of industrial production in Pakistan. The industries of this city employ up to 500,000 people, and its GDP comprises 5% of the economy of Pakistan. This city is expanding day by day due to an increase in population. Most towns are developed in open areas and metropolitan areas where the urban population is mixed with the rural population.

Methodology:

Data Collection:

In this research, the collection of data is the primary step. Data are collected from facts, figures, statistics, and images, which are further processed and analyzed to produce output. The sources from which the data were obtained include:

Research Articles

Reports
Census Data
Satellite Images

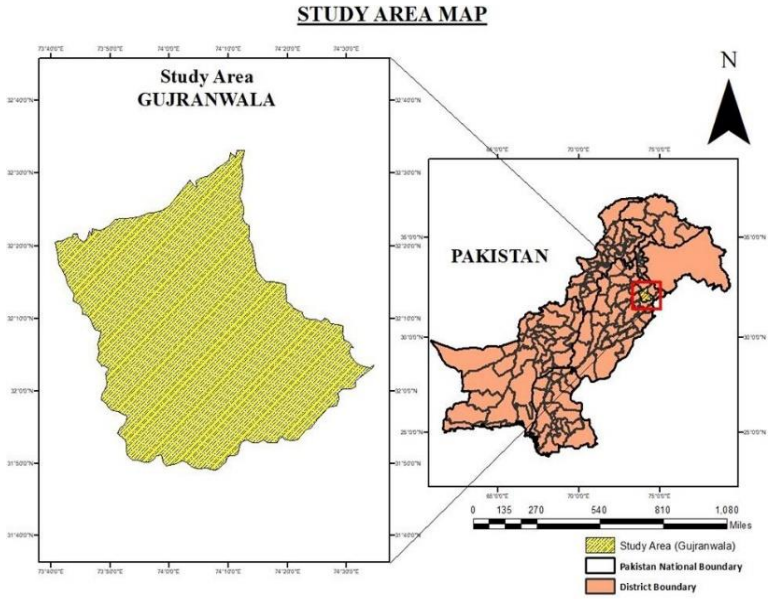

Figure 1. Location of study area

Downloading Satellite Images:

Satellite images were downloaded from the USGS website to detect changes in land use in Gujranwala. Various LANDSAT images were collected.

Table 1. Details of satellite imagery used, including year, sensor type, number of bands, and acquisition month

Sr no.	Year	Images	Bands	Month
1.	1990	LANDSAT 5	7	March
2.	2000	LANDSAT 5	7	March
3.	2010	LANDSAT 5	7	March
4.	2020	LANDSAT 8	9	March

Pre-processing of Satellite Images:

Pre-processing refers to the processing of satellite images by using different techniques of GIS and RS. All the images were enhanced in ArcGIS software to be displayed in a geographic information system. One cannot identify those areas that have changed without performing these steps:

Layer Stacking
Extraction of area

Layer Stacking:

Layer stacking is a process in which multiple images are combined to form a single image. The images downloaded from the USGS geodatabase were available in different bands. These bands had to be combined to create a single-layer image. This process was performed by the software ArcGIS.

Classification of Satellite Images:

Classification refers to the extraction of information from a multiband image. Four classes were added under the names of:

Vegetation
Built-up Area
Waterbody
Uncultivable Land

Area Calculation of Land Cover:

The area was determined in square kilometers. All four images were prepared. Likewise, the area of the images was determined individually.

Accuracy Assessment:

Accuracy assessment is the process of estimating the land cover data accuracy in thematic categories. For conducting an accuracy assessment, we use:

Ground check utilizing Global Positioning System (observing the area).

Analysis of the classified picture compared to a picture that is considered correct, (for example, an aerial photo, Google Earth).

Outputs:

The final outcomes of the work and functions performed on the available data were presented as graphical maps and statistical tables**, ** or layouts. These were further explained in the sections below. For different years of images, different outputs were observed.

Layouts:

After performing all the necessary functions on the satellite images taken from the USGS geodatabase in ArcGIS, layouts of the processed images were generated in ArcGIS. Then, the layout images were exported at the desired resolution, for example, 300 dpi. The map was exported in JPG format. JPGs were inserted in the results.

Statistical Data:

In this research, statistical data were exported from the area calculated from specific images from ArcGIS to MS Excel. This data allows us to calculate the percentage of a specific class. Comparative analysis was done for different periods. Maps were created from the area calculated for each year. These maps were also inserted in the results.

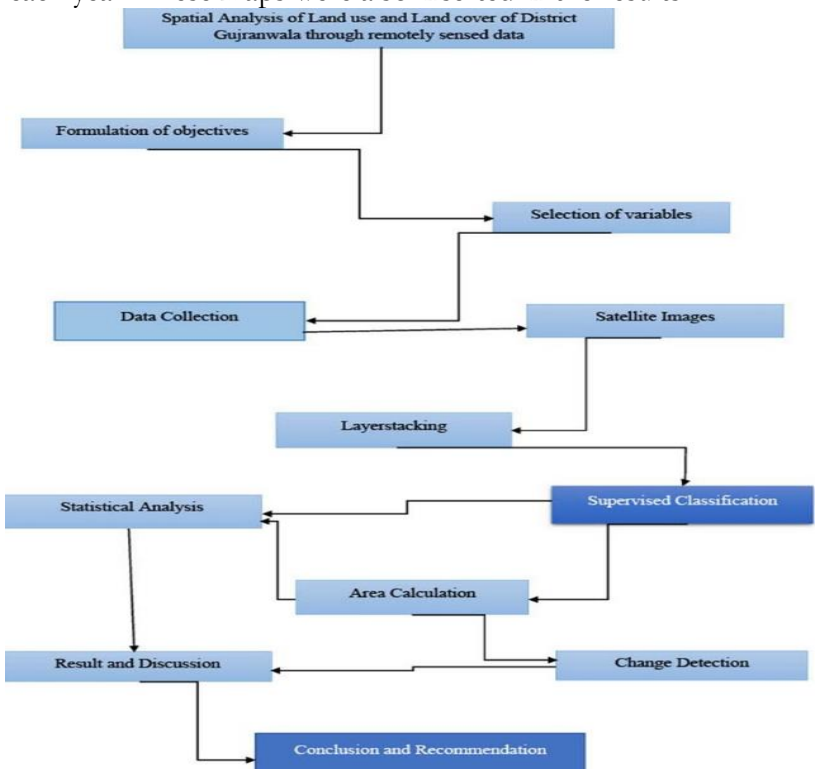

Figure 2. Flowchart showing the methodology for spatial analysis of land use and land cover in District Gujranwala using remotely sensed data

Results and Discussion:

Results:

In this research, the results of different years were discussed. A comparison of different years was shown. The total area of Gujranwala district is 3510.12 km².

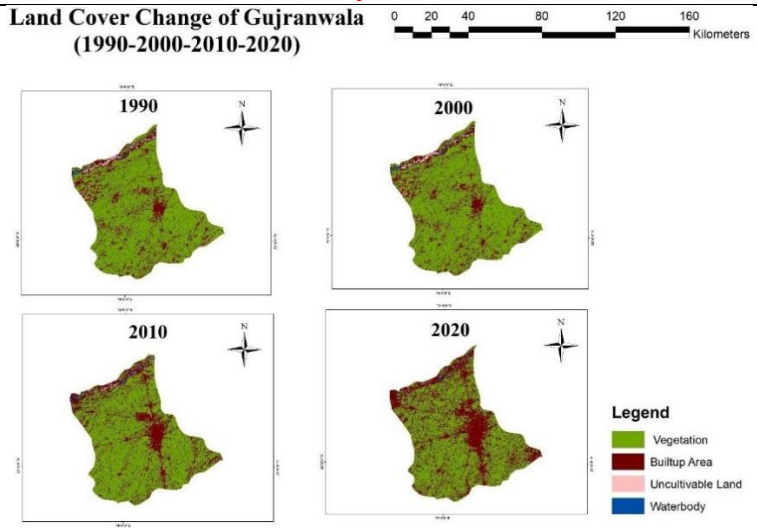

Figure 3. Land cover change in Gujranwala from 1990 to 2020 showing shifts in vegetation, built-up areas, uncultivable land, and water bodies

LULC (1990-2020):

It is evident that the built-up area increased from the year 1990 to 2020. By comparing the images of these years, it is calculated that land cover changed over the 30-year interval from 1990 to 2020. The built-up area increased from this interval, 700 to 1300 km². However, the vegetation, waterbody, and uncultivable land decreased in a significant way**,** as shown in the table below. The main reason for the land cover change is the increase in population in the district.

Table 2. Land cover area statistics of Gujranwala from 1990 to 2020.

Land Cover	Area (1990)	Area (2000)	Area (2010)	Area (2020)
Built-up Area	722.17	849.42	918.71	1307.59
Uncultivable Land	69.36	72.95	22.32	7.25
Vegetation	2688.67	2544.1	2533.7	2175.92
Waterbody	29.92	43.65	35.69	19.36
Total	**3510.12 sq.km**			

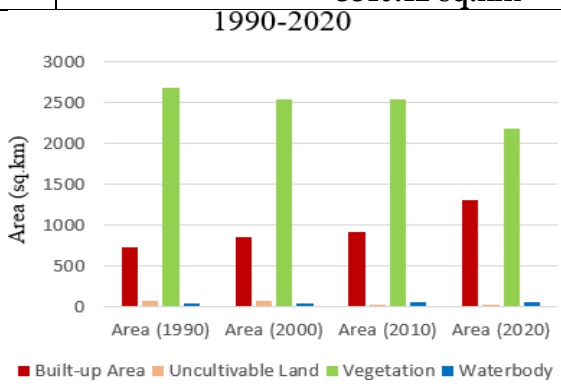

Figure 4. The chart shows changes in built-up area, uncultivable land, vegetation, and waterbody areas from 1990 to 2020

Comparative Analysis of Built-up Area (1990-2020):

It is evident that the built-up area increased from the year 1990 to 2020. The expansion of built-up areas was seen in the image. By comparing the built-up area over 30 years, the area increased from 20% of land cover to 38% of land cover. The built-up area increased with the increase in population in the district.

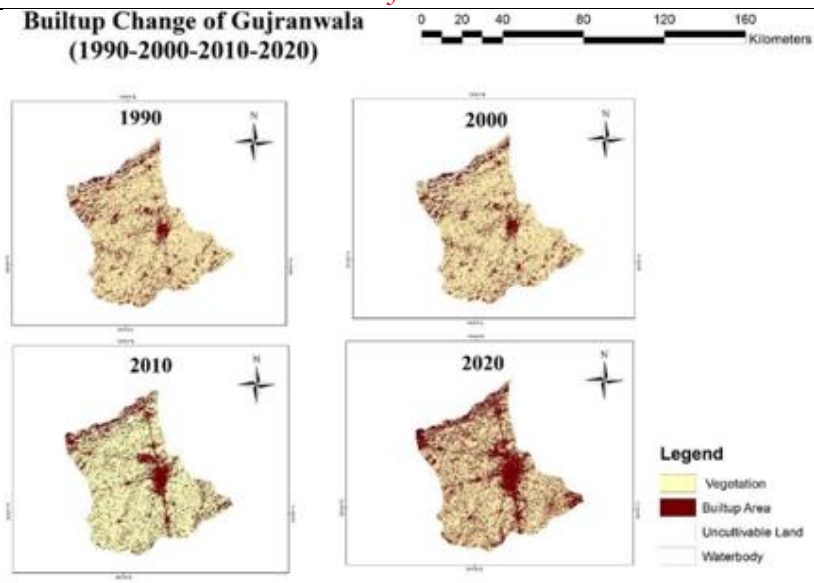

Figure 5. The maps depict the growing built-up and uncultivable land in Gujranwala from 1990 to 2020.

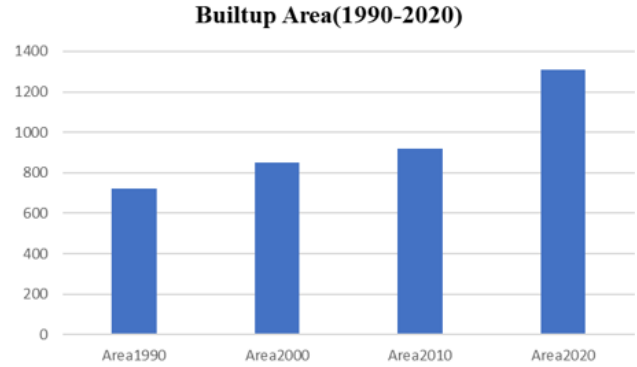

Figure 6. The chart shows a steady increase in built-up area in Gujranwala from 1990 to 2020.

Comparative Analysis of Vegetation (1990-2020):

It is evident that the vegetation decreased from the year 1990 to 2020. By comparing the images of these years, it is calculated that vegetation decreased from 76% of the land cover to 61% of the land cover. Mostly, vegetation has been converted into built-up areas over the past 30 years.

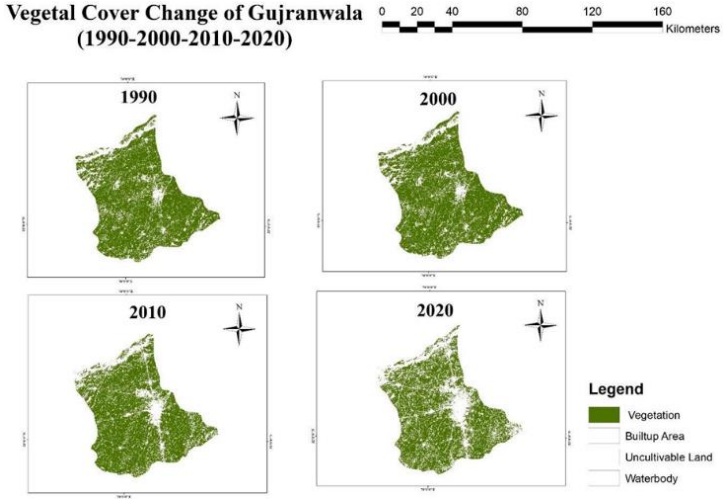

Figure 7. Vegetal Cover Change of Gujranwala (1990-2000) (2010-2020)

Accuracy Assessment of Classified Images (1990-2020):

This indicates the overall accuracy, user's accuracy, producer's accuracy, and Kappa coefficient for all four images. User's accuracy and producer's accuracy are calculated for each image separately. An error matrix was drawn to assess the accuracy of all four images. The overall accuracy of 1990, 2000, 2010, and 2020 images is 95%, 92%, 95%, and 88%, respectively. However, all the images show acceptable overall accuracy. The Kappa coefficient for each image is displayed in Table 3. The Kappa coefficient of 1990, 2000, 2010, and 2020 shows 91%, 88%, 92%, and 81%, respectively.

Table 3. Accuracy assessment of land cover classification for Gujranwala (1990–2020) based on producer's and user's accuracy, overall accuracy, and Kappa coefficient

	Built-up Area		Uncultivable Land		Vegetation		Waterbody		Overall Accuracy %age	Kappa Coefficient %age
	P (%)	U (%)	P (%)	U (%)	P (%)	U (%)	P (%)	U (%)		
1990	100	92	100	100	81.8	100	100	100	95	91
2000	100	88.2	88.9	100	100	92.3	100	100	92	88
2010	100	87.5	93.3	100	92.8	100	100	75	95	92
2020	95	92	25	50	92	92	85.7	75	88	81
P stands for the producer's accuracy, and **U** stands for the user's accuracy.										

Discussion:

The analysis shows that changes occurred in the land cover from 1990 to 2020. The change was seen in all four categories of the land cover. The change in the built-up land shows that the other land has been converted to built-up land from 1990 to 2020. A positive trend is seen in built-up land. The vegetation cover was present in a vast area as seen in 1990, but a slight decrease was seen in vegetation cover from 1990 to 2020, and uncultivable land is converted either to vegetation cover or is used as built-up land.

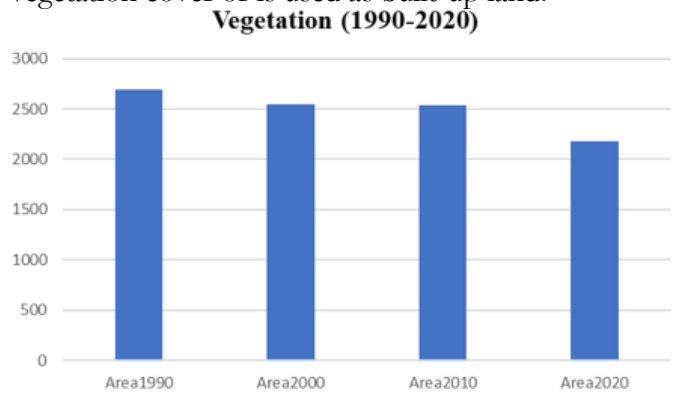

Figure 8. Vegetation (1990-2020)

By comparing the images and area calculations from 1990 to 2020, it is noticed that the built-up area increased from 700 to 850 km², which shows a positive increase of 24.19%, but the vegetation cover, uncultivable land, and waterbody have decreased**, ** respectively**, ** by -4.13%, -0.1%, and -0.39%.

Conclusion:

The results extracted from this research are systematic, consistent, and reliable. The temporal analysis of 30 years of land cover from 1990 to 2020 was done by a supervised classification method of the images, i.e., 1990, 2000, 2010, and 2020. The main focus of this research is the built-up land. Built-up land over the years was calculated, and the result shows that an increase in population causes an increase in built-up land. Four different classes were generated by this method**, ** namely, uncultivable land, vegetation, built-up area, and waterbody. The area of all four classes was calculated and comparatively analyzed. The result

obtained from four different years' images showed that the built-up area increased from 700 km² to 1300 km² in just 30 years (from 1990 to 2020).

References:

[1] I. Abbas, K. Muazu, and J. Ukoje, "Mapping land use-land cover and change detection in Kafur local government, Katsina, Nigeria (1995-2008) using remote sensing and GIS," *J. Artic. - Res. J. Environ. Earth Sci.*, vol. 2, no. 1, pp. 6–12, 2010, [Online]. Available: https://catalog.ihsn.org/citations/61113

[2] Z. B. Jianjun Zhang, Meichen Fu, Jin Tao, Ying Huang, Ferri P. Hassani, "Response of ecological storage and conservation to land use transformation: A case study of a mining town in China," *Ecol. Modell.*, vol. 221, no. 10, pp. 1427–1439, 2010, doi: https://doi.org/10.1016/j.ecolmodel.2010.02.011.

[3] M. Aboelnour, B. A. Engel, M. Aboelnour, and B. A. Engel, "Application of Remote Sensing Techniques and Geographic Information Systems to Analyze Land Surface Temperature in Response to Land Use/Land Cover Change in Greater Cairo Region, Egypt," *J. Geogr. Inf. Syst.*, vol. 10, no. 1, pp. 57–88, Jan. 2018, doi: 10.4236/JGIS.2018.101003.

[4] P. C. Yikalo H. Araya, "Analysis and Modeling of Urban Land Cover Change in Setúbal and Sesimbra, Portugal," *Remote Sens*, vol. 2, no. 6, pp. 1549–1563, 2010, doi: ttps://doi.org/10.3390/rs2061549.

[5] E. F. Lambin *et al.*, "The causes of land-use and land-cover change: moving beyond the myths," *Glob. Environ. Chang.*, vol. 11, no. 4, pp. 261–269, Dec. 2001, doi: 10.1016/S0959-3780(01)00007-3.

[6] J. Tang, L. Wang, and Z. Yao, "Spatio-temporal urban landscape change analysis using the Markov chain model and a modified genetic algorithm," *Int. J. Remote Sens.*, vol. 28, no. 15, pp. 3255–3271, 2007, doi: 10.1080/01431160600962749.