



Monitoring & Evaluating of Urban Expansion and Its Impact on Land use Land Cover Change of Sargodha, Pakistan (2000-2025)

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ABSTRACT

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Urban growth is a significant land-use transition that is taking place in many rapidly growing cities, especially where the expansion is taking place on productive agricultural land. The purpose of this research was to explore the Spatio-temporal pattern of urban expansion and changes in land use/land cover (LULC) in Sargodha Tehsil, Pakistan, for the period 2000-2025. This study used the remote sensing and GIS techniques to analyze the satellite imageries of 6 years. These years include 2000, 2005, 2010, 2015, 2020 and 2025. The study area covered an expanse of 1536 km² and comprised four land use/land cover (LULC) classes, including agricultural land, built-up area, barren land, and water bodies. The study used supervised classification Maximum likelihood classifier (MLC) to identify the dominant land use and land cover types and determine the percentage of the region that was covered by each class. The results show that there is a growing trend in the built-up area throughout the years. It increased from 115 km² in 2000 to 180 km² in 2005, 233 km² in 2010, 297 km² in 2015, 361 km² in 2020, and 440 km² in 2025. Thus, it can be stated that there was an increase in the built-up area by 325 km² or 282.6% over the studied period. In contrast, the amount of farmland decreased from 1,014 km² to 815 km² or 199 km². The area of barren land decreased as well from 280 km² to 153 km². At the same time, there was no significant change in the amount of water bodies from 127 km² to 128 km². Findings reveal a significant change from a primarily agricultural region to a region with a considerable presence of developed areas and emphasize the increasing pressure on productive land. The research underlines the significance of planned urbanization, protection of productive agricultural lands, regular geospatial monitoring, and appropriate management of the periphery belt.

Introduction

Urbanization has turned out to be an essential and significant geographical process, which is closely related to demographic, socio-economic, infrastructural, and ecological issues, and changes in the use of the land. Rapid urbanization may lead to a substantial change in the city's relationships with farmland, open spaces, and the environment. Urban expansion is especially important for developing countries because it can take over valuable agricultural lands and intensify the impact on the surroundings. Pakistan has witnessed significant urban growth in recent years. Thesis points out that the rise in population, rural-urban migration, economic development, industrial and commercial activities, and infrastructure development are some of the factors that have contributed to the urbanization process in Pakistan. These factors may surpass the planning capabilities in the country, leading to the conversion of agricultural and open spaces into urbanized land.

Sargodha is an interesting region in terms of the research conducted because it possesses both the features of agriculture and urbanism. On the one hand, the area is traditionally known as the center of agricultural resources, especially citrus fruits. On the other hand, Sargodha is also a growing urban region that continues to develop and expand outward. It is noteworthy that the author of the thesis

highlights several directions of the city's development, namely: the number of inhabitants, housing construction, commercial structures, transport infrastructure, and institutions.

Conversion of agricultural and other non-built up land is especially significant in an area in which agriculture plays an important role in the local landscape. The changes in land use/land cover could impact the availability and continuity of agricultural land and affect the spatial organization of the city-suburb interface. Past studies have proven the value of remote sensing and GIS in recognizing these changes and examining the phenomenon of urban expansion over time (Riaz et al., 2017; Farooq et al., 2024; Fahad et al., 2021).

It allows for obtaining repeated observations of the earth's surface at different times, which makes it possible to use remote sensing for reconstructing past states of the land cover. Landsat imagery, in particular, provides an opportunity to use spectral observations for differentiating major classes of land cover and analyzing their areal distribution over time. GIS software extends the potential of remote sensing by enabling spatial analysis, spatial database creation, calculations of statistical parameters of classes, and comparisons of thematic maps. This combination has become particularly useful for studying urban growth (Subasinghe et al., 2016; Alam et al., 2023).

Earlier research works have been conducted on the topic of urbanization in Sargodha, but each one of them has a different perspective, time frame and area. Riaz et al. (2017) explored the pattern and processes of urbanization and its impact on land-use changes in Sargodha from 1992 to 2015. Riaz et al. (2024) observed the pattern and processes of urban sprawl in Sargodha City from 1987 to 2017. Subsequently, Naqvi et al. (2024) studied urban sprawl and future LULC trends using an MLP–Markov approach and Zhang et al. (2025) used Google Earth Engine and predictive modeling to analyze urbanization processes and land use trends in a district-level socio-ecological system. Each work has its strengths and limitations due to the choice of the area, timeframe, methodology, and tools.

The aforementioned study has been conducted in consideration of the Sargodha Tehsil within the timeline of six observation years, namely 2000, 2005, 2010, 2015, 2020, and 2025. For the analysis, four LULC categories, including agricultural land, built-up, barren land, and water bodies, remained consistent throughout the process. In such a manner, a comparative understanding of the changes in the study area was created in a span of twenty-five years.

The study aimed therefore to analyze changes of spatial structures of the urban land use in different time periods, to assess the changes of the LULC related to urbanization, to evaluate changes of agricultural land, to explore changes of built-up areas, to analyze changes of barren and water bodies, to establish a basis for a further urban-growth analysis by means of the CA–Markov modelling.

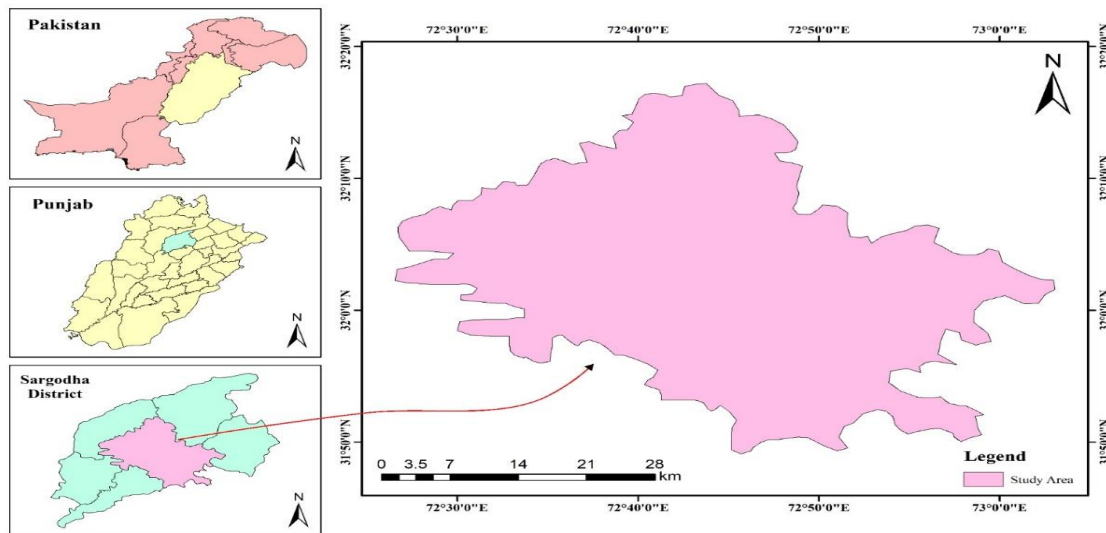


Fig. 1: Map of Study area

Study Area

The research was conducted in Sargodha Tehsil located in Sargodha District of Punjab Province, Pakistan. Sargodha is a city situated in central Punjab, Pakistan, and serves as an important agricultural center, commercial hub, administrative center, and urban area. The province of Sargodha is marked with vast areas of flatlands and rich alluvial soil that have contributed to making it an agricultural center and a hub for trade, industry, and infrastructure development. The study area covered 1,536 km² for the present analysis. The

same area was selected for each of the six observation years, so that classes of the classified LULC could be compared to each other. The study area was assessed through four categories of agricultural land, built-up area, barren land, and water bodies. The urbanization process in Sargodha is determined by its demographic growth pattern, as suggested by the thesis. Indeed, the population of Sargodha Tehsil grew from 1.08 million in 1998 to 1.54 million in 2017 and 1.79 million in 2023. Consequently, the percentage of urbanized areas also rose from 42% (1998) and 43% (2017) to 59% (2023). Meanwhile, the rural population decreased to 41%. Accordingly, the thesis suggests a correlation between the two variables, implying that increased urbanization led to the development of residential areas and housing schemes.

The physical environment is also a significant concern for urbanization. Sargodha is found on the vast alluvial plains of Punjab, with rich and fertile soils that have been the foundation of agriculture. The thesis defines the climate as semi-arid, with hot summers, chilly winters, and an average of around 410 mm of rainfall per annum. The agro-centric nature of the province, compounded by population growth and urbanization, makes Sargodha Tehsil a perfect example of how urbanization affects land-use changes to study. The conversion of agricultural and other non-urbanized land to urbanize is the main reason why Sargodha Tehsil is a suitable case for the study.

Materials and Methodology

The study followed a quantitative, geographic, and time-based design that employed remote sensing and GIS. Its methodological components included predominantly the acquisition of satellite data, image processing, supervised classification, estimation of the area occupied by each land-use and -cover class, temporal comparison, and future-growth modeling. The study's historical component was intended to recreate LULC conditions for six observation years, while its future-growth component was associated with CA-Markov modelling.

Satellite Data and Supporting Information

Multi-temporal Landsat satellite imagery covering 2000, 2005, 2010, 2015, 2020, and 2025 was acquired from the United States Geological Survey (USGS). According to the thesis, the chosen images were suitable for the study area, captured in the same season, and free of clouds. The datasets were kept in the Universal Transverse Mercator (UTM) coordinate system, using the World Geodetic System (WGS) 1984 Zone 43N.

Supporting materials comprised topographical sheets at a scale of 1:50,000 produced by the Survey of Pakistan, population census reports, and existing land-cover maps. These sources served to supply further context for analyzing urban growth and land-use change.

Image Preprocessing

The preprocessing of the data was done to enhance the consistency of the satellite datasets before the classification process began. In the thesis, there is a description of radiometric, atmospheric, and geometric correction procedures followed by layer stacking, image enhancement, spatial referencing, and clipping to the Sargodha Tehsil boundary.

The individual spectral bands were combined using ArcMap 10.8 to form a multispectral image. The images were clipped using the Sargodha Tehsil boundary to ensure that the analysis was done within the specified study area.

LULC Classification

The supervised classification process was done independently for each observation year.

The following four land use/land cover (LULC) classes were used for the analysis:

1. Agricultural land
2. Built-up area
3. Barren land
4. Water

Agricultural land covers irrigated and rain-fed arable land, permanent crops, cultivated land, and orchards. Built-up area consists of urban, rural, commercial, institutional, industrial, road, and other developed lands. Barren land includes exposed soils, vacant land, sparsely vegetated land, and other barren lands. Water covers rivers, streams, canals, ponds, reservoirs, and other surface water features. Training samples representing the four LULC classes were prepared and evaluated for their spectral signatures prior to conducting classification. The image was classified using the Maximum Likelihood Classifier. The procedures included image acquisition, import into ArcMap 10.8, band composition, addition of the tehsil boundary, clipping, signature-file preparation, training-sample development and signature evaluation and finally the MLC classification.

LULC Area Estimation and Temporal Comparison

After the classification step, the extent covered by each LULC class was computed in square kilometers. The percentage of coverage was established by using:

$$P = A_i / A_T \times 100$$

It was calculated using above mentioned Equation,

Where P is the percentage of a LULC class, A_i is the area of the individual class, and A_T is the total study area. The total area considered for each observation year was 1,536 km². The obtained LULC statistics were compared for the six observation years to assess changes in the number of agricultural, built-up, barren, and water-covered regions. The main focus was made on the growth of built-up areas and changes in agricultural and other non-built-up regions.

Results and Discussions

In this study, multi-temporal classification of LULC change reveals that for the period 2000–2025, agricultural land use continued to dominate Sargodha Tehsil in Punjab Province. While agricultural land remained widespread, its cover decreased gradually over time, reaching only 53% by 2025. Meanwhile, built-up areas increased steadily during the same period. Barren land use declined throughout the study period, while water use showed only minor increases and decreases. By using the same four LULC classes in the 1536 km² area under study, it becomes possible to assess these changes in spatial distribution.

Land Use/Land Cover Characteristics and Spatial Distribution in 2000

The supervised classification results of 2000 revealed that agricultural land use was the dominant LULC class, which covered 1014 km² (66%) of the Sargodha Tehsil followed by barren land 280 km² (18%), built-up area 115 km² (8%), and water bodies 127 km² (8%). Agricultural land use dominated in the research area suggesting the majority of the study area is under rural land-use cover classification at the beginning of the study period. These results can provide a baseline for the analysis of urban expansion and corresponding LULC changes in this region between 2000 and 2025.

Table 1: Specified Land Use Classes Area (km²) in Sargodha Tehsil 2000

Specified Classes	Covered Area in km ²	Covered Area in Percentage
Agricultural land	1014	66%
Built up Area	115	8%
Barren land	280	18%
Water Bodies	127	8%
Overall Area	1536	100%

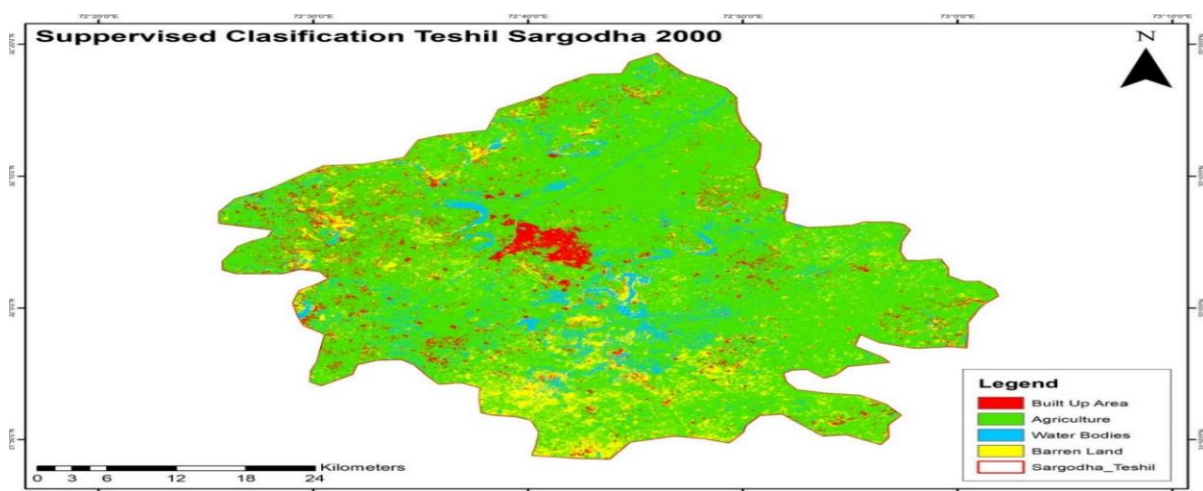


Figure 1: Supervised Classification/Land use of 2000 in Sargodha Tehsil

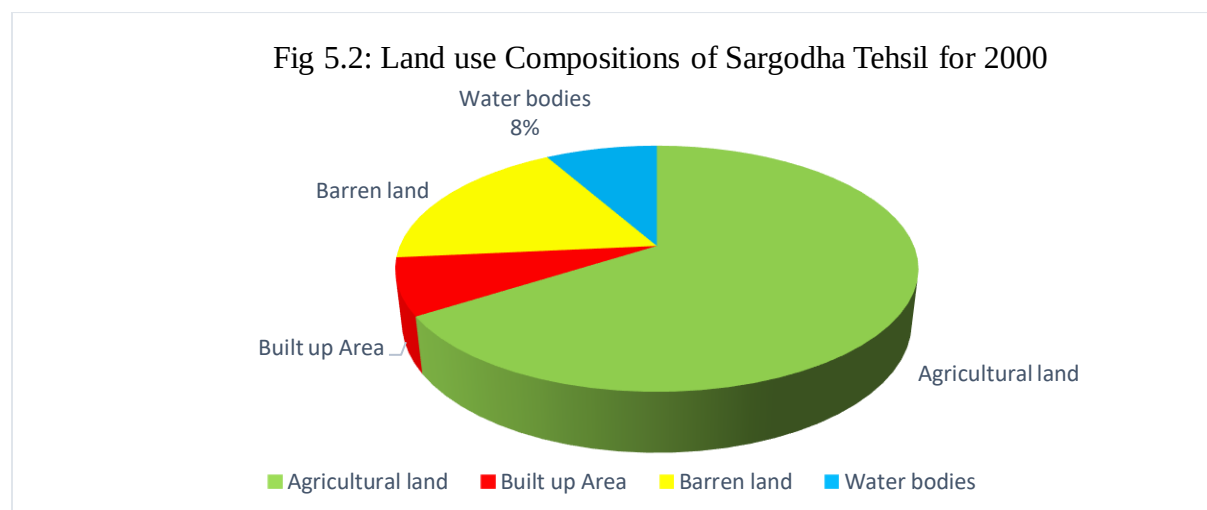


Fig. 2: Pie Chart Shows Land use Compositions of Sargodha Tehsil for 2000

Land Use/Land Cover Characteristics and Spatial Distribution in 2005

The 2005 classification revealed that agricultural land continued to dominate the study area with an approximate percentage of 65%, equivalent to 998 km² compared to 1,014 km² in 2000, indicating a decrease by about 16 km² over the five-year period. Built-up area witnessed a tremendous increase in percentage from 8% to 12% in the same period, equivalent to an increase from 115 km² to 180 km². Barren land also decreased from approximately 280 km² to 240 km² or 15% in 2005, while water bodies decreased from 127 km² to 118 km², representing about 8%. These changes might be attributed to the changes in farming practices, anthropogenic activity, seasonal variations, and the acquisition month of the imageries. The overall assessment demonstrated the increasing pressures of urbanization as well as the gradual decrease in agricultural and barren lands in the study area.

Table 2: Specified Land Use Classes Area (km²) in Sargodha Tehsil 2005

Specified Classes	Covered Area in km ²	Covered Area in Percentage
Agricultural land	998	65%
Built up Area	180	12%
Barren land	240	15%
Water Bodies	118	8%
Overall Area	1536	100%

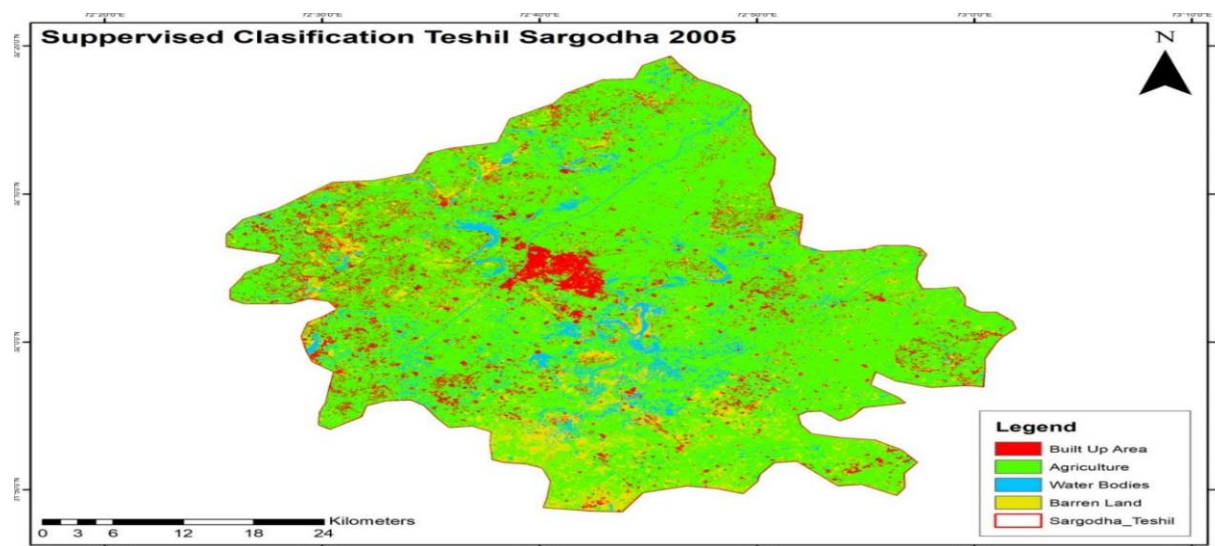


Fig. 3: Supervised Classification/Land use of 2005 in Sargodha Tehsil

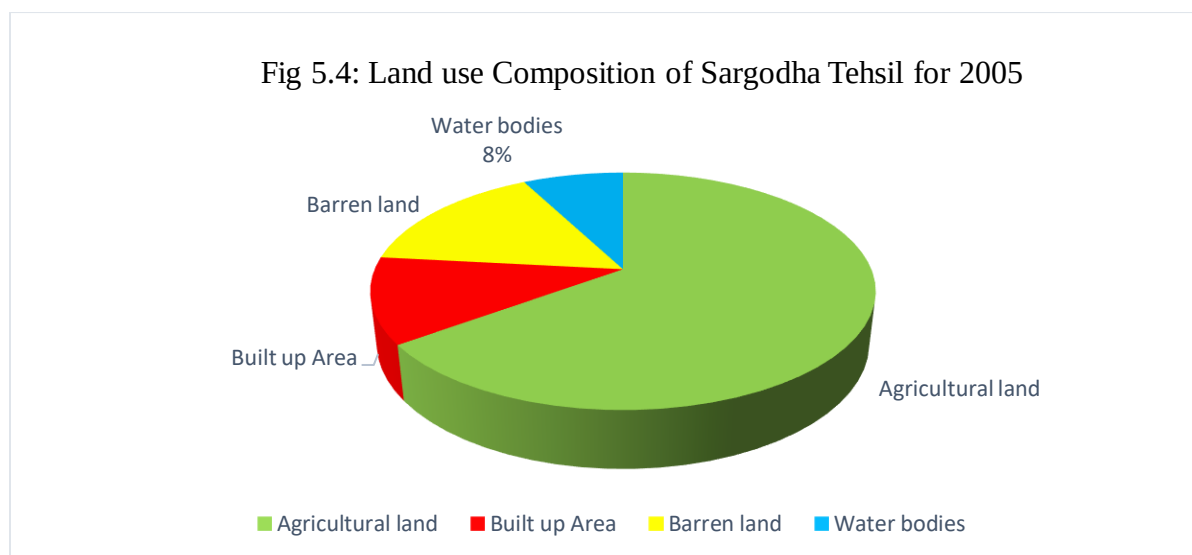


Fig. 4: Pie Chart Shows Land use Compositions of Sargodha Tehsil for 2005

Land Use/Land Cover Characteristics and Spatial Distribution in 2010

The 2010 classification suggested that agricultural land use was still the largest LULC class, which covered approximately 930 km² (61%) of Sargodha Tehsil, but it decreased by about 84 km² than that of 2000. However, the built-up land use gained an opposite trend, which increased from 115 km² in 2000 to 233 km² in 2010, accounting for about 15% of the study area. In addition, barren land decreased gradually from 280 km² in 2000 to 236 km² in 2010, occupying about 15% of the total land use in 2010. Water bodies also increased from 127 km² in 2000, 118 km² in 2005, to 137 km² in 2010, comprising about 9% of the study area. This increment might be due to seasonal changes of water condition, rainfalls, irrigations, or different acquisition dates of the satellite images. Overall, the 2010 results illustrated a progressively transforming scenario, with a decreasing percentage of agricultural land use, but a significantly enhanced built-up landscape.

Table 3: Specified Land Use Classes Area (km²) in Sargodha Tehsil 2010

Specified Classes	Covered Area in km ²	Covered Area in Percentage
Agricultural land	930	61%
Built up Area	233	15%
Barren land	236	15%
Water Bodies	137	9%
Overall Area	1536	100%

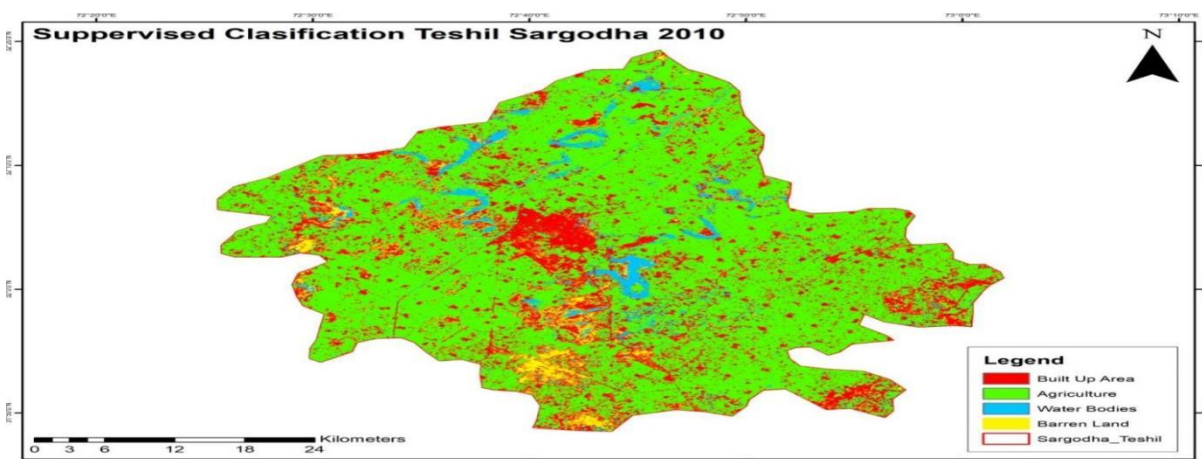


Fig. 5: Supervised Classification/Land use of 2010 in Sargodha Tehsil

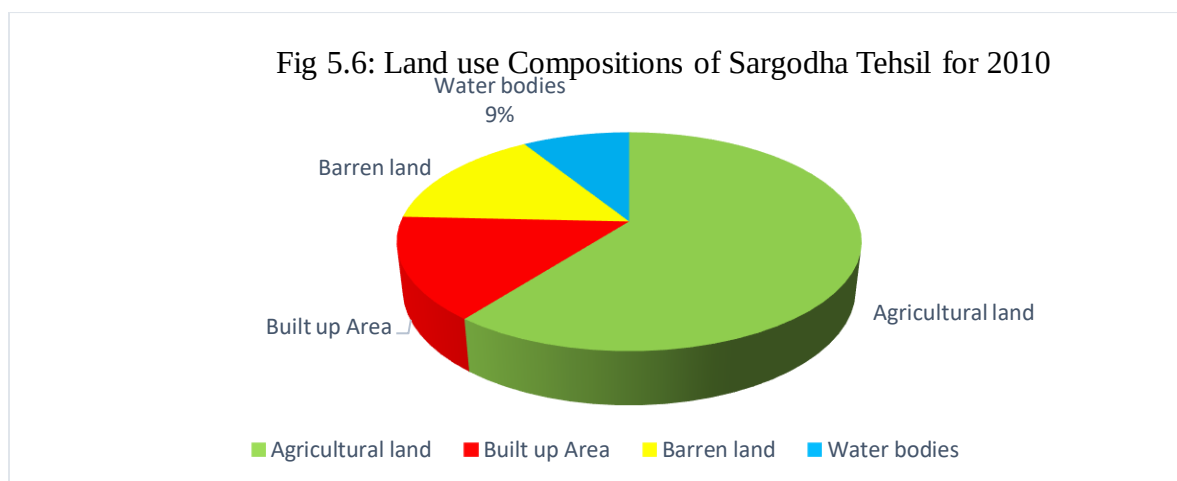


Fig. 6: Pie Chart Shows Land use Compositions of Sargodha Tehsil for 2010

Land Use/Land Cover Characteristics and Spatial Distribution in 2015

The 2015 classification revealed that agricultural land remained the dominant LULC with a cover of 890 km² (58%) but a reduced cover by 124 km² relative to 2000. Built-up land, on the other hand, increased sharply to 297 km² (19%) compared with 115 km². Barren land was recorded at 219 km² (14%) thus maintaining its declining trend since 2000. Water bodies were sparsely distributed at 130 km² (9%) with a slight reduction from the 2010 value but an increase from that of 2000. The variations recorded with water bodies are partly attributed to seasonal differences, rainfall, and irrigation as well as differences in cloud cover at the time of image acquisition. Generally, the results indicate that the study site is gradually shifting towards a more built-up landscape while agricultural lands are shrinking at a high rate. The apparent opposite trends imply that natural land use and cover types are under increasing pressure, and specific use type conversions must be examined closely using transition analysis.

Table 4: Specified Land Use Classes Area (km²) in Sargodha Tehsil 2015

Specified Classes	Covered Area in km ²	Covered Area in Percentage
Agricultural land	890	58%
Built up Area	297	19%
Barren land	219	14%
Water Bodies	130	9%
Overall Area	1536	100%

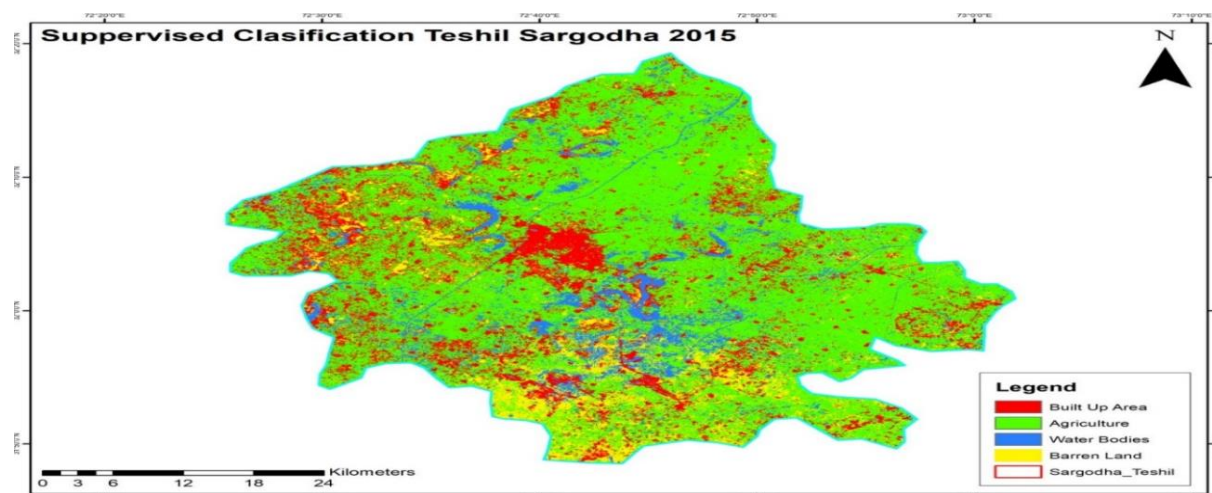


Fig. 7: Supervised Classification/Land use of 2015 in Sargodha Tehsil

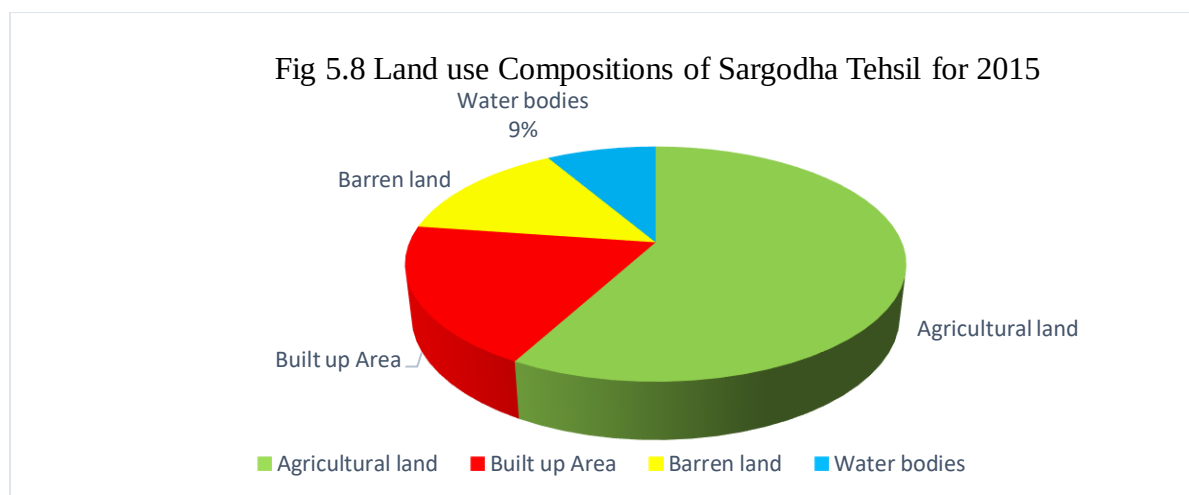


Fig. 8: Pie Chart Shows Land use Compositions of Sargodha Tehsil for 2015

Land Use/Land Cover Characteristics and Spatial Distribution in 2020

The 2020 classification reveals that agricultural land covers around 856 km² (56%) of the study area, which constitutes a decrease of around 158 km² from the 2000 value of 1,014 km². At the same time, built-up land increased substantially to 361 km² (24%) from the 2000 value of 115 km², an increase of 246 km² (213.91%). Barren land decreased steadily to around 191 km² (12%) from the 2000 value of 280 km² (89 km² decrease). The water cover was around 128 km² (8%) in the study area. The change is in line with seasonal variations of water bodies as well as variations caused by the different time of image acquisition. Thus, the results of 2020 reveal a significant increase in the built-up area and a simultaneous decrease in agricultural and barren lands showing high pressure on the urban expansion in Sargodha Tehsil.

Table 5: Specified Land Use Classes Area (km²) in Sargodha Tehsil 2020

Specified Classes	Covered Area in km ²	Covered Area in Percentage
Agricultural land	856	56%
Built up Area	361	24%
Barren land	191	12%
Water Bodies	128	8%
Overall Area	1536	100%

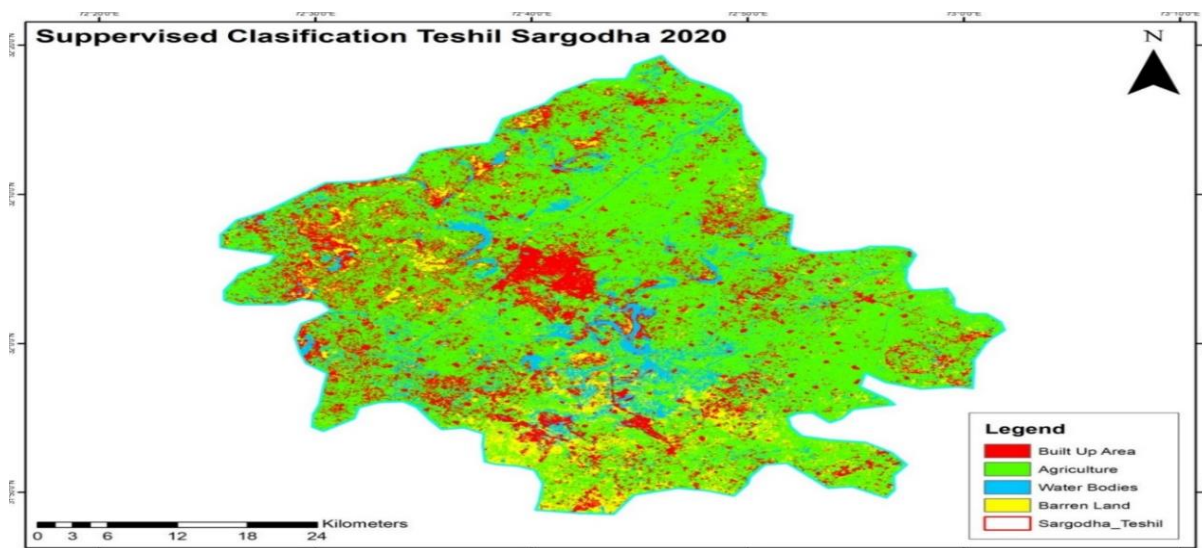


Fig. 9: Supervised Classification/Land use of 2020 in Sargodha Tehsil

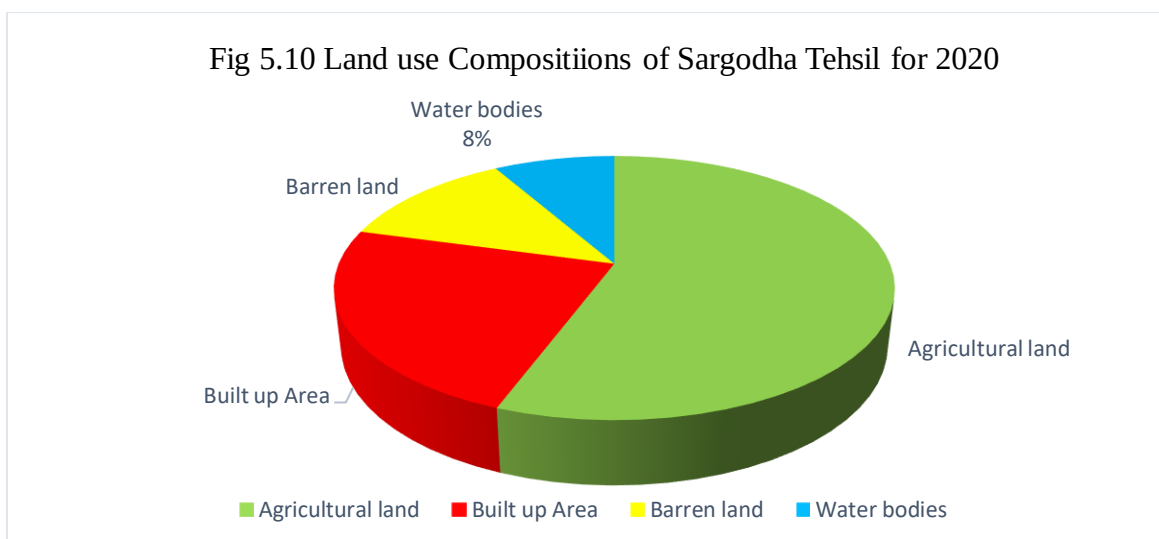


Fig. 10: Pie Chart Shows Land use Compositions of Sargodha Tehsil for 2020

Land Use/Land Cover Characteristics and Spatial Distribution in 2025

According to the 2025 classification, agricultural land remained the largest land use/land cover (LULC) category, comprising of about 815 km² (53%) of the 1,536 km² study area, but it had declined by 199 km² from its 2000 extent. By comparison, built-up land reached 440 km² (29%) which is an increase of 325 km² or 282.61% compared with 2000. Barren land decreased substantially to about 153 km² (10%) which is a reduction of 127 km² from its 2000 extent. Water bodies were comparatively stable and occupied around 8% of the study area throughout the period. The continuous expansion of built-up land use and declining agricultural and barren areas indicate significant changes in the land use structure of Sargodha Tehsil. In fact, these opposite trends imply the growing urban pressure and gradual transformation of surrounding land around the existing settlements.

Table 6: Specified Land Use Classes Area (km²) in Sargodha Tehsil 2025

Specified Classes	Covered Area in km ²	Covered Area in Percentage
Agricultural land	815	53%
Built up Area	440	29%
Barren land	153	10%
Water Bodies	128	8%
Overall Area	1536	100%

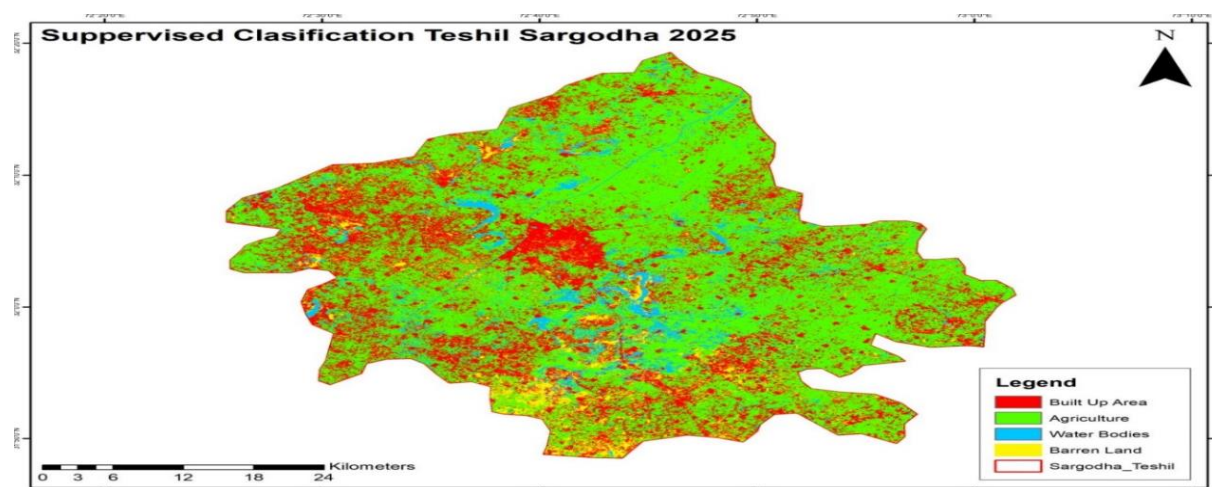


Fig. 11: Supervised Classification/Land use of 2025 in Sargodha Tehsil

Fig 5.12: Land use Compositions of Sargodha Tehsil for 2025

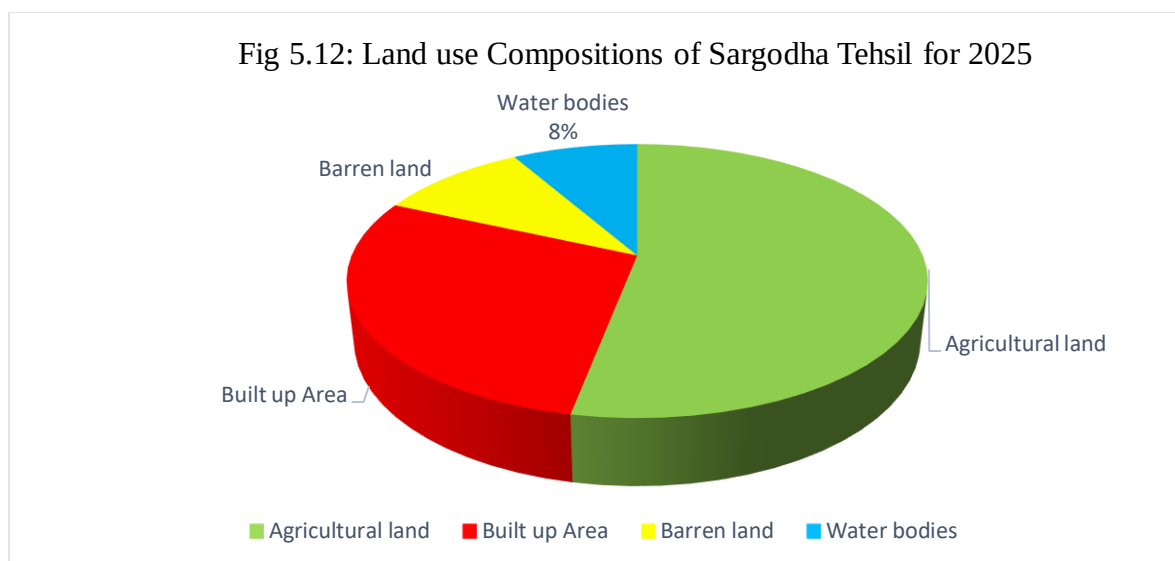


Fig. 12: Pie Chart Shows Land use Compositions of Sargodha Tehsil for 2025

Land Use/Land Cover Characteristics and Spatial Distribution in 2000 to 2025

The results of the multi-temporal classification demonstrated changes in the LULC configuration of the study area during 2000–2025. Within the six considered classes, farmland was the largest one; however, its cover gradually decreased. In contrast, the built-up land increased continuously during the observed period. Barren land also decreased, while the areal extent of water bodies experienced only minor variations. Considering the same four classes, as well as the same 1536 km² area, enabled detecting these differences.

Table 7: Land Use Area (km²) in Sargodha Tehsil (2000-2025)

Specified Classes		Agricultural land	Built up Area	Barren land	Water Bodies	Overall Area
2000	Covered Area in	1014	115	280	127	1536
	Covered Area in Percentage	66%	7%	18%	8%	100%
2005	Covered Area in	998	180	240	118	1536
	Covered Area in Percentage	65%	12%	16%	8%	100%
2010	Covered Area in	930	233	236	137	1536
	Covered Area in Percentage	61%	15%	15%	9%	100%
2015	Covered Area in	890	297	219	130	1536
	Covered Area in Percentage	58%	19%	14%	8%	100%
2020	Covered Area in	856	361	191	128	1536
	Covered Area in Percentage	56%	24%	12%	8%	100%
2025	Covered Area in	815	440	153	128	1536
	Covered Area in Percentage	53%	29%	10%	8%	100%

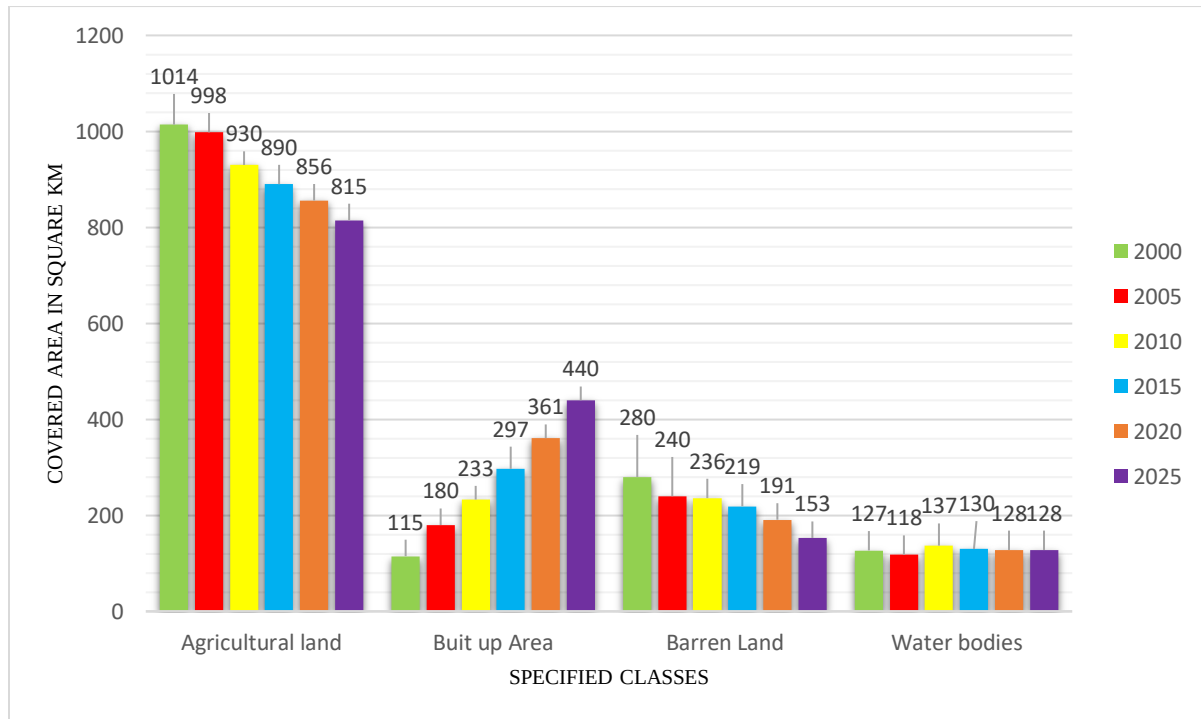


Fig. 13: Land use Bifurcations of Sargodha Tehsil for 2000-2025

The bar graph Fig. 13 shows the changing trends of land use in Sargodha Tehsil for the years 2000–2025. The four major classes of land use viz., agricultural land, built-up area, barren land, and water bodies have been taken into consideration. The graph illustrates that a significant change has occurred in the spatial distribution pattern of land use during the past 25 years, especially the decrease in agricultural land and increase in built-up area.

Changes in Agricultural Land

Agricultural land dominated the study area at the start of the research. Specifically, it amounted to 1014 km² or 66% of the whole region in 2000. It decreased to 998 km² in 2005, 930 km² in 2010, 890 km² in 2015, 856 km² in 2020, and 815 km² in 2025. Therefore, the size of agricultural land decreased by 199 km² from 2000 to 2025. The decrease was not consistent throughout the study period. The most significant early decline occurred between 2005 and 2010, during which agricultural land decreased from 998 km² to 930 km². The negative trend continued up until 2015, 2020, and 2025. The proportion of farmland to total area in the tehsil ended at approximately 53% compared with 66% in 2000.

This trend reflects the growing pressure on agricultural land due to the footprint of built-up areas. This thesis attributes this pressure to settlement expansion, infrastructure development, housing needs, commercialization, and other related developments. On the Other hand, changes in total class area cannot prove that all agricultural losses were directly transformed into built-up land because it would require a complete transition matrix to do so. It is significant when it comes to determining the relationship between urbanization and agricultural-land loss.

Supervised Classification Tehsil Sargodha 2000_2025

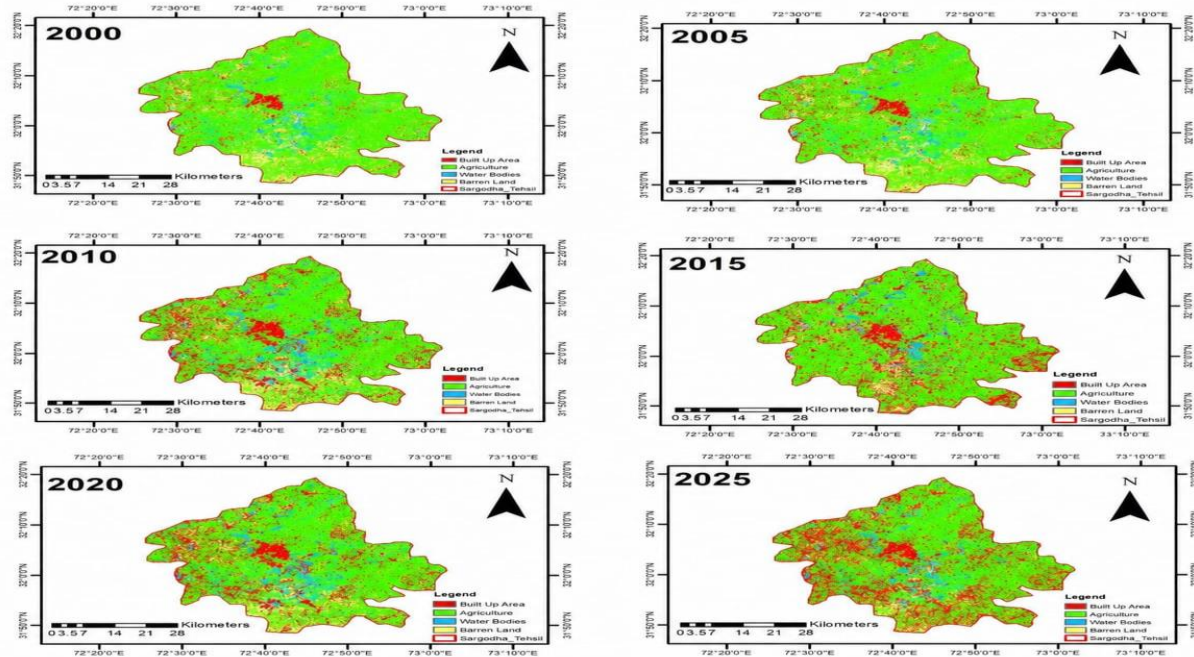


Fig. 14: Supervised Classification of Tehsil Sargodha in 2000-2025

Expansion of Built-up Area

Built-up land changed the most of all the four LULC categories. The classified built-up was 115 km² which is approximately 8% of the study area in 2000. It increased to 180 km² in 2005 and 233 km² in 2010. The built-up area continued to increase to 297 km² in 2015, 361 km² in 2020, and 440 km² in 2025.

Thus, between 2000 and 2025, built-up land rose by 325 km². Compared to its size in 2000, this is an increase of 282.6%. The growth happened steadily throughout the years at each observation point, instead of being concentrated at one period. This consistent rise is the best proof that the city grew continuously since 2000.

The growth rate was most prominent during the first decade. Indeed, the area covered by built-up land increased from 115 to 233 km² between 2000 and 2010. Thus, a rise of 118 km² occurred over ten years. Between 2005 and 2010, built-up land rose by approximately 53 km² in the classified area. Then, it reached 297 km² in 2015, 361 km² in 2020, and 440 km² in 2025.

The thesis attributes this proliferation to population growth, housing needs, residential development, commercial activities, road and transportation infrastructure, institutional expansion, and outward expansion of existing suburbs.

However, these explanations are similar to those provided by previous research conducted on Sargodha. For example, Riaz et al. (2017) noticed an increase in the number of urban land use and a decrease in agricultural and other land uses between 1992 and 2015. In addition, Ashraf et al. (2022) also agree that the expansion of Sargodha city is taking place outwardly, as built-up land increased from 9 km² in 1987 to 31 km² in 2017.

The present study thus builds on the evidence of urban transformation up to 2025, and a consistent six-date sequence for Sargodha Tehsil is provided. Although the values of different studies should not be compared directly if the extents and classifications are different, the direction of change is generally in line with Sargodha experiencing an ongoing outward expansion of the city.

Changes in Barren Land

Barren land also showed a consistent decline. It covered an area of 280 km² in 2000, 240 km² in 2005, 236 km² in 2010, 219 km² in 2015, 191 km² in 2020, and 153 km² in 2025. On the whole, it was reduced by 127 km², which equals about 45.4% of its area in 2000. The decline in barren land could suggest that the previously exposed or uncultivated land became used for agriculture, infrastructure development, construction, and other purposes.

With the development of urban areas new patches of barren ground may emerge, thus being integrated into the developed area. However, the mere presence of these barren areas would not be sufficient to define their destination, as suggested by the thesis. To be precise, it should be supplemented with a spatial transition analysis.

The decrease in percentages of both agricultural and barren lands and the growth of the built-up land suggest the restructuring of the landscape rather than a mere expansion of the urban footprint. This is consistent with the viewpoint that urbanization should be regarded as a multivariate process involving changes throughout different types of anthropogenic lands.

Dynamics of Water Bodies

Water bodies demonstrated the least significant changes over time compared to other LULC categories. Their coverage area reached a maximum of 127 km² in 2000, decreased to 118 km² in 2005, increased to 137 km² in 2010, and then decreased again to 130 km² in 2015. The area of water bodies was 128 km² both in 2020 and 2025. Therefore, the overall area in 2000 and 2025 was only 1 km² different. Perhaps, the changes might be explained by seasonal variations of water level, precipitation, irrigation, or the month of image capture.

Accordingly, the relatively stable long-term outcome should not be taken to indicate that the hydrological stability of this region has been full, without additional investigations on water hydrology. Compared with agricultural, barren, and built up regions, water bodies were therefore the least transformed of the four mapped classes during this study period.

Implications of Urban Planning

The changes in built-up and barren/land-use categories are significant determinants for the land-use planners. The findings imply a pressure for the development around the conurbation. A need for conservation of cultivable land is more important as Sargodha is growing into a large city. The thesis recommended focusing residential, commercial, and industrial growth on well-planned sites and away from productive farmland. The thesis also recommended development control zones or urban-growth boundaries, continued GIS and remote-sensing surveillance, improved peri-urban land-use planning, and better integration of transportation and infrastructure planning.

The results also confirm the necessity of the continuous update of the LULC databases. The dynamic geo-database can be used for monitoring processes of anthropogenic development and for detecting rapidly changing areas as well as evaluating proposals for the development of housing construction and infrastructure. The thesis also suggests the need to protect water bodies and ecologically valuable areas, preserve the green spaces, and take into account the projections of population growth in the development of land use plans.

Future Growth Modelling: Scope & Reporting Limitation

The future growth of urbanization is an essential component of the research, and the thesis selected CA–Markov modelling for analysis of possible changes in LULC. In this case, the historical classification sequence is a basis for calculations, and the most recent situation in 2025 represents the closing date of the study.

Overall, the Sargodha Tehsil witnessed a significant change in its overall LULC use between 2000 and 2025, primarily marked by an increase in built-up structures and a decrease in agricultural and barren lands. The study recommends the importance of proper planning to manage urbanization in a manner that minimizes the possible negative impact on the other land uses, particularly the agricultural and barren lands, while allowing sustainable development to occur.

Conclusion

Overall LULC Transformations, 2000-2025

The full chronological sequence offers a clear view of how the land-use structure has changed:

Table 8: Chronological Sequence How the land-use structure has changed (2000-2025)

LULC class	2000 (km ²)	2025 (km ²)	Net change (km ²)	Direction
Agricultural land	1014	815	-199	Decrease
Built-up area	115	440	+325	Increase
Barren land	280	153	-127	Decrease
Water Bodies	127	127	+1	Nearby Stable

This Research has expressed numerically urban growth pattern level in Sargodha Tehsil for the 26 years using satellite images data which has numerical value from 2000-2025. The major research conclusions are:

Agricultural land area in Sargodha Tehsil Decreases gradually -199 km² in two significant pulses (2000 and 2025). Agricultural land use decreased from approximately 66% to 53%, over the same period. A total number of productive lands and natural landscapes were lost due to urbanization, resulting in the decrease in agricultural land use.

The built-up area within Sargodha Tehsil grows steadily, expanding by 325 km² across two notable surges (2000 and 2025). As a percentage, built-up land use rose from 7-8% of the study area in 2000 to 29% in 2025.

The barren land area in Sargodha Tehsil declines steadily, dropping 127 km² across two notable pulses (2000 and 2025). Barren land use decreased from 18% to 10%, whereas water bodies stayed close to 8%.

The area of water bodies in Tehsil Sargodha has remained relatively stable, increasing by about 1 km², with two significant peaks occurring in 2000 and 2025.

The transformations underline the protracted progression of urbanization in Sargodha Tehsil. However, the intermediate findings are of particular importance as they suggest that the 2025 condition did not emerge from a single episode of accelerated development, but rather successive expansions take place throughout the whole 25 years' course.

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