Turkish Journal of Geographic Information Systems (2026) 8, 1

Turkish Journal of Geographic Information Systems

https://dergipark.org.tr/tr/pub/tucbis

e-ISSN 2687-5179

Research Article

Spatio-Temporal Analysis of Land Use and Land Cover Change: The case of Yozgat Province

Nezih Furkan Erbaş*[1], Nizamettin Erbaş[2], Abdullah Varlık[3]

[1]*General Directorate of Land Registry and Cadastre, Land Registry and Cadastre Yozgat Regional Directorate, Yozgat, Türkiye*
[2]*Yozgat Bozok University, Yozgat Vocational School, Yozgat, Türkiye; nizamettin.erbas@bozok.edu.tr*
[3]*Necmettin Erbakan University, Faculty of Engineering, Department of Geomatics Engineering, Konya, Türkiye; avarlik@erbakan.edu.tr*
**Corresponding author: furkanerbas999@gmail.com*

Article Info

Received : 14 / 04 / 2026
Revised : 21 / 06 / 2026
Accepted : 22 / 06 / 2026
Published : 01 / 07 / 2026

Abstract

Land use/land cover (LULC) change is one of the most important indicators of environmental transformation and regional landscape dynamics. Monitoring these changes is essential for understanding the impacts of urbanization, agricultural activities, and land conversion processes on semi-arid environments. This study aims to investigate the spatio-temporal LULC dynamics of Yozgat Province, Türkiye, between 2000 and 2024 using multi-temporal Landsat satellite imagery and Geographic Information Systems (GIS)-based spatial analysis techniques. Multi-temporal Landsat-5 TM, Landsat-7 ETM+, and Landsat-8/9 OLI images with 30 m spatial resolution were obtained from the USGS Earth Explorer platform. Image preprocessing, clipping, classification and temporal change detection analyses were performed in ArcGIS/ArcMap 10.8. Four major land use classes were identified: agriculture, settlement, bare land and vegetation/water. Multi-temporal classification results were compared to quantify long-term land transformation patterns. The classification accuracy was evaluated using confusion matrix analysis, Overall accuracy and Kappa metrics. The results revealed significant changes in the spatial structure of Yozgat Province over the 24-year period. Settlement areas exhibited the most substantial increase, rising by 114.38%, indicating strong urban growth and infrastructure expansion. In contrast, bare land decreased by 54.13%, suggesting progressive conversion into agricultural and built-up surfaces. Agricultural land remained relatively stable with a moderate increase of 9.08%, while vegetation/water areas increased by 67.72%. The most pronounced transformation periods were identified between 2006–2012 and 2012–2018, during which major land conversion processes occurred. The findings demonstrate that urban expansion and the reduction of bare land are the dominant drivers of landscape transformation in Yozgat Province. This study provides valuable scientific evidence for sustainable land use planning, regional environmental management, and future GIS-based monitoring studies in semi-arid regions of Central Anatolia. The results demonstrate that remote sensing and GIS techniques provide reliable tools for long-term monitoring of LULC dynamics in semi-arid environments.

Keywords: LU/LC; GIS; Yozgat Province; Landsat; Change Detection; Semi-Arid Region.

Cite this article

Erbaş, N.F., Erbaş, N. & Varlık, A. (2026). Spatio-Temporal Analysis of Land Use and Land Cover Change: The case of Yozgat Province. *Turkish Journal of Geographic Information Systems*, 8, 1, 01-20. https://doi.org/10.56130/tucbis.1929814

1. Introduction

In recent years, the development and rapid growth of urban settlements have emerged as one of the most significant human-induced processes transforming land surfaces and impacting the natural environment (Seto et al., 2011; Ding & Shi, 2013; Dutta et al.,2020; Oli et al., 2025). In around the world, 55 % of people currently reside in cities rather than rural areas, and in the next year, that number is predicted to increase to 68% due to economic development and population growth. (DESA, 2019; Dutta et al.,2020; Oli et al., 2025; Ologunde et al., 2025). Since soil is a natural resource that directly affects life on Earth, its efficient use, conservation, and preservation are of paramount importance. However; urbanization, rapid population growth and economic development are significantly increasing the need for land resources and affecting land use and land cover (LULC) changes (Hatab et al., 2019; Ologunde et al.,2025). Land use and land cover (LULC) change has been widely recognized as one of the most significant indicators of environmental transformation and landscape dynamics at regional and global scales (Lambin et al., 2003; Foley et al., 2005). Rapid population growth, urban expansion, water bodies, agricultural intensification, and infrastructure development have accelerated land surface modifications over recent decades. Due to cropland degradation and land surface modifications, several issues have arisen, including employment, the erroneous movement of people from rural to urban regions, a decline in plant diversity, and desertification. All these also inhibit sustainable agricultural outputs (Erbaş & Çınarer, 2024). In addition to anthropogenic drivers, climate variability and environmental degradation have also contributed to changes in LU patterns. These transformations influence ecosystem services, biodiversity, soil quality, water availability, and agricultural productivity, thereby affecting regional sustainability and socio-economic development (Foley et al., 2005; Turner et al., 2007; Verburg et al., 2015).

Monitoring LU change is essential for understanding landscape evolution and supporting sustainable land management strategies. The identification of spatial and temporal trends in land transformation provides critical information for environmental planning and policy-making processes (Verburg et al., 2015). In this context, Remote Sensing (RS) technologies and Geographic Information Systems (GIS) have become indispensable tools for analyzing large-scale environmental changes (Lu et al., 2004; Weng, 2012). Satellite imagery offers repetitive and consistent observations of the Earth's surface, enabling researchers to detect land cover transitions and assess long-term environmental dynamics. Among the available satellite datasets, Landsat imagery has been extensively used in LULC studies due to its long historical archive, moderate spatial resolution, and open-access data policy (Roy et al., 2014). Multi-temporal Landsat data provide valuable information for evaluating land transformation processes, identifying urban growth patterns, monitoring agricultural changes, and assessing vegetation dynamics (Singh, 1989; Coppin et al., 2002; Hansen et al., 2013). The integration of RS data with GIS-based spatial analysis techniques facilitates the production of thematic LU maps, quantitative change detection analysis, and spatial modeling of landscape transformations (Lu et al., 2004). Central Anatolia represents a region where LU patterns are strongly influenced by semi-arid climatic conditions, agricultural practices, and socio-economic dynamics. Variability in precipitation regimes, increasing environmental pressures, and rural-to-urban migration have led to noticeable changes in LU distribution across the region (Turkes et al., 2009; Turkes and Akgündüz, 2011; Ergene et al., 2024). Yozgat Province, located in Central Anatolia, is located on the Bozok Plateau of the Central Kızılırmak part of Central Anatolia. The northern part of its territories extends to the southern parts of the Central Black Sea Region. It is between 340 05'-36010' eastern meridians and 38040'-40018' north parallels (Erbaş, 2021). Yozgat Province, located in Central Anatolia, is predominantly characterized by agricultural LU, steppe vegetation, and dispersed urban settlements. In decades, demographic shifts, regional development activities, and environmental challenges have contributed to spatial transformations in LU structure. Understanding these changes is essential for sustainable resource management and regional planning (TURKSAT, 2023; Ministry of Environment, Urbanization and Climate Change, 2024; Meydan Yıldız et al., 2022). Therefore, the main objective of this study is to analyze the spatio-temporal changes in land use and land cover in Yozgat Province using multi-temporal Landsat satellite images covering the period between 2000 and 2024. The study aims to classify major land use categories, quantify area changes, and evaluate spatial transformation trends over time. The findings are expected to contribute to environmental monitoring studies and provide scientific support for sustainable land use planning in semi-arid regions.

Recent research conducted in Türkiye highlights the importance of spatial modeling approaches and geospatial analysis techniques in environmental monitoring and land management applications. Studies focusing on landscape transformation and spatial planning have emphasized that GIS-based decision-support systems play a significant role in identifying suitable land use strategies and evaluating environmental impacts (Sivrikaya et al., 2010; Çelik & Yakar, 2023). These studies underline the effectiveness of combining satellite imagery with spatial analysis methods to investigate land transformation processes. Furthermore, regional-scale investigations in Türkiye have revealed that agricultural land dynamics, vegetation change, and urban expansion are among the dominant drivers of land use transformation. RS-based LULC change detection studies conducted in metropolitan and rural regions have demonstrated that spatial and temporal analyses provide essential information for sustainable environmental planning (Cagliyan & Dagli, 2022; Turk & Balcik, 2023; Bozkurt et al., 2023). These findings indicate that continuous monitoring of land use change is crucial for understanding landscape evolution and supporting policy development.

Many studies have examined changes in land cover/land use by using RS and GIS techniques.

Guler et al. (2007), in this study was to analyze LU/LC changes between 1980 and 1999 in Samsun, Turkey, using satellite images. Three Landsat images from 1980, 1987 and 1999 were used to determine changes. A post classification technique was used based on a hybrid classification approach (unsupervised and supervised). Images were classified into six LU/LC types; urban, agriculture, dense forest, open forest-hazelnut, barren land and water area. It is found that significant changes in land cover occurred over the study period. The results showed an increase in urban, open forest/hazelnut, barren land and water area and a decrease in agriculture and dense forest in between 1980 and 1999. In this period, urban land increased from 0.77% to 2.47% of the total area, primarily due to conversions from agricultural land and forest to a lesser degree. While the area of dense forest decreased from 41.09% to 29.64% of the total area, the area of open forest and hazelnut increased from 6.73% to 11.88%.

Gulersoy (2013), a long-term land use/land cover (LULC) change analysis conducted in the central district of Çorum revealed substantial transformations in the regional landscape between 1987 and 2011. The study reported considerable increases in settlement, agricultural land, forest areas, and water surfaces, whereas pasture areas experienced a marked decline over the study period. The expansion of settlement areas was primarily attributed to rapid urban growth, while the increase in agricultural land was associated with rising food demand and the intensification of agricultural activities. In addition, the growth of water surfaces was linked to the construction of dams and reservoirs, whereas afforestation initiatives and demographic changes in rural settlements contributed to the expansion of forest areas. The authors further emphasized that these land use changes resulted in several environmental challenges, including the conversion of land beyond its capability, degradation of soil and water resources, and unsustainable waste disposal practices. Based on these findings, the study highlighted the importance of implementing land use planning strategies that are compatible with the natural environmental characteristics of the region to support sustainable landscape management.

Karakus et al. (2015), a study conducted in Sivas city and its surrounding areas investigated land use and land cover changes using multi-temporal Landsat satellite imagery acquired in 1987 and 2002. In addition to detecting spatial land use changes, the research focused on evaluating land use potential by considering environmental factors such as topography, geology, soil characteristics, climate conditions, and hydrological features. Suitability analysis was carried out to determine optimal land use categories, including settlement areas, agricultural land, forest, and pasture-range zones. The results indicated that urban development occurred predominantly towards the northeast, south, and southwest directions of the city. Furthermore, it was found that new residential areas were generally established on lands that were suitable for agricultural use. The study emphasized the importance of integrating land use change detection with land suitability analysis to support sustainable regional planning and future land management strategies.

Naboureh et al. (2021), a comprehensive review study focusing on the China–Central Asia–West Asia Economic Corridor, which constitutes a major component of the Belt and Road Initiative and hosts a very large population, evaluated recent developments in LULC mapping research across the region. The study systematically analyzed a wide range of scientific publications by considering various factors, including dominant drivers of land transformation, data acquisition techniques, classification methods, and accuracy assessment procedures. The findings revealed that rapid urban expansion, industrial growth, demographic increase, and climate variability are among the primary forces influencing land use change in the corridor. Furthermore, these transformations were associated with several environmental consequences such as land degradation, desertification, biodiversity loss, and increasing levels of air and water pollution. The review also highlighted important methodological challenges, including the limited availability of well-structured national land use datasets and insufficient training and validation data for long-term monitoring studies. In addition, several technical issues related to classification performance and data integration were identified as areas requiring further scientific attention.

Turan et al. (2021), A long-term land use and land cover (LULC) change analysis conducted in the Çarşamba Delta Plain, one of the major agricultural plains in the Central Black Sea Region of Türkiye, examined spatial transformations over an approximately 30-year period using multi-temporal Landsat satellite imagery. The study identified six major land cover classes and achieved classification accuracy values exceeding 85%, indicating reliable mapping performance. The findings revealed that cultivated agricultural lands constituted the most dominant land cover type in the region, while pasture areas showed the lowest spatial distribution. Temporal analysis demonstrated that significant land transformations occurred particularly in pasture and forest areas between 1994 and 2011. In the most recent decade, however, an increase in artificial surfaces and hazelnut plantation areas was observed, accompanied by a notable decline in pasture lands. These land use changes were associated with population growth and increasing human pressure on agricultural landscapes. The study emphasized that RS-based monitoring provides valuable spatial information for decision-making processes related to sustainable land management and regional planning.

Celik and Yakar (2023), A case study conducted in Mersin Province analyzed spatial land use transformations under increasing urbanization pressure using multi-temporal LULC datasets representing the years 2000, 2006, 2012, 2018 and 2022. The study classified land use into five main categories, including built-up areas, agricultural land, vegetation, barren land, and water bodies. The generated thematic maps were compared through pairwise change detection analysis, and areal variations were evaluated using graphical methods. The results revealed a significant increase in built-up areas over the study period, indicating the influence of urban expansion on landscape dynamics. In contrast, notable decreases were observed in agricultural land, barren areas, and water bodies, while vegetation areas showed moderate growth. The study emphasized that continuous monitoring of LULC changes is essential for understanding spatial development trends and supporting sustainable urban management strategies in regions experiencing rapid socio-economic transformation.

Ologunde et al. (2025), A recent study conducted in the Ado-Odo Ota region of Ogun State, Nigeria, investigated spatio-temporal land transformation between 2015 and 2023 using multi-temporal Landsat imagery and GIS-based analysis. The research classified land cover into several categories, including water bodies, dense vegetation, sparse vegetation, built-up areas, and bare land. The results revealed a considerable expansion of urban areas and sparse vegetation, while forested areas experienced a significant decline during the study period. The conversion of forest and vegetated land into agricultural and built-up areas was identified as a major indicator of increasing human pressure and urban development. In addition, reductions in water surfaces and bare land were also observed. The study highlighted that rapid urban growth can alter landscape structure and emphasized the need for sustainable land use strategies to maintain ecological balance while supporting socio-economic development.

Oli et al. (2025), A long-term study conducted in Atlanta, Georgia, analyzed spatio-temporal changes in LULC patterns and land surface temperature (LST) between 2001 and 2021 using multi-temporal Landsat imagery. Supervised classification based on a random forest algorithm was applied to generate land use maps, while spatial regression techniques were used to evaluate the relationship between LULC classes and temperature variations. The results indicated a noticeable increase in built-up areas over the study period, accompanied by reductions in forests, agricultural lands, open spaces, and water surfaces. These land transformations were associated with a significant rise in average land surface temperatures, particularly in densely urbanized zones where strong spatial clustering of high temperature values was observed. The study also demonstrated that vegetated and open areas contributed to cooling effects, whereas the expansion of impervious urban surfaces intensified the urban heat island phenomenon. Overall, the findings highlighted the importance of sustainable urban planning strategies aimed at preserving green infrastructure to mitigate the environmental impacts of rapid urbanization.

Kadak (2025), in this study conducted in the Yenişehir district of Bursa Province analyzed LULC dynamics between 2020 and 2024 using high-resolution Dynamic World data derived from Sentinel-2 satellite imagery. The research integrated cloud-based image processing techniques within the Google Earth Engine platform and spatial analysis tools in ArcGIS Pro to generate annual land use maps, inter-class transition maps, and NDVI-based vegetation change assessments. The results revealed a noticeable decline in cropland areas, particularly after 2022, accompanied by decreasing NDVI values in the same regions. These changes were mainly observed in peri-urban agricultural landscapes and were associated with both human-induced pressures and climate-related impacts. The study emphasized the importance of ecological-based strategic planning approaches and demonstrated the effectiveness of satellite-derived datasets for monitoring short-term land transformation processes in agricultural environments.

Pirzada et al. (2025), a long-term study conducted in Hyderabad District, Pakistan, investigated spatial land transformations over a 51-year period using multi-temporal Landsat satellite imagery integrated with Geographic Information Systems (GIS) techniques. The research employed a supervised classification approach based on the Maximum Likelihood algorithm to generate thematic land use maps for different time periods. The results revealed a substantial expansion of built-up areas, largely driven by rapid urbanization and rural-to-urban migration processes. This growth occurred at the expense of agricultural lands, orchards, and barren areas, indicating significant landscape modification. The study emphasized that uncontrolled urban development can reduce fertile agricultural land resources and intensify environmental challenges such as land degradation and climate change impacts. These findings highlight the importance of continuous remote sensing-based monitoring to support sustainable land management and spatial planning policies in rapidly developing regions.

Ferynandari et al. (2026), a recent study conducted in the Rejoso Watershed in East Java, Indonesia, analyzed spatio-temporal LULC changes between 2005 and 2024 using multi-temporal Landsat satellite imagery. The research applied a hybrid classification approach combining unsupervised clustering and visual interpretation, and classification accuracy was validated through ground reference data and confusion matrix analysis. The results revealed a considerable decline in vegetation cover during the early study period, followed by partial recovery after 2020. Agricultural lands showed a significant expansion until 2020 and then decreased in extent, indicating a shift in land management practices. Built-up areas exhibited a continuous increase, reflecting ongoing urban development pressures, while open lands fluctuated and water bodies remained relatively stable. The study emphasized that spatial reconfiguration of land use patterns within watershed systems has important implications for environmental management, upstream rehabilitation strategies, and sustainable spatial planning.

Saha and Saaj (2026), a geospatial analysis conducted in Dhaka District, Bangladesh, investigated the spatio-temporal dynamics of land use and land cover (LULC) and their relationship with land surface temperature (LST), vegetation condition, and water availability using multi-temporal Landsat satellite imagery. Remote sensing-based indices such as NDVI and NDWI were calculated to evaluate vegetation cover and surface water changes over time. The findings revealed a substantial increase in built-up areas between 2010 and 2025, accompanied by a significant decline in vegetation cover. This land transformation contributed to a noticeable rise in land surface temperature, indicating the intensification of urban heat island effects associated with impervious surface expansion. Although slight vegetation recovery was observed in later years, water index values generally declined, reflecting increasing environmental stress in rapidly urbanizing landscapes. The study emphasized the importance of maintaining green infrastructure and water bodies to mitigate temperature increases and support sustainable urban development.

Due to its semi-arid environmental conditions, dominant agricultural land use pattern, and observable land transformation processes, Yozgat Province provides a suitable case study area for investigating long-term land use and land cover changes by using RS and GIS. Understanding spatial land dynamics in such rural transitional landscapes is essential for supporting sustainable land management strategies and regional planning policies. Based on the literature reviewed, it is clear that land use and land cover (LULC) change detection studies play a crucial role in understanding spatial landscape dynamics and supporting sustainable land management practices (Turkes et al., 2009; TURKSTAT, 2023; Ministry of Environment, Urbanization and Climate Change, 2024; Verburg et al., 2015; Lambin et al., 2003; Lu et al., 2004). However, long-term LULC change analyses focusing on the semi-arid regions of Central Anatolia are limited in the current literature. Therefore, this study aims to investigate the spatial and temporal patterns of land use and land cover change in Yozgat province of Türkiye using multi-temporal Landsat satellite images covering the period 2000-2024. This study will classify the main land use categories and perform change detection analysis to quantify land transformation trends over time from thematic land use maps. In addition, spatial distribution patterns and area statistics of land use classes will be evaluated using GIS-based analytical techniques. The findings are expected to contribute to regional environmental monitoring studies and provide scientific support for sustainable land use planning and natural resource management in semi-arid environments.

2. Materials and Methods

2.1. Study Area

Yozgat Province is located in the Central Anatolia Region of Türkiye and is characterized by semi-arid climatic conditions and climate features (Turkes et al., 2009). The province lies approximately between 39°00′–40°20′ N latitudes and 34°00′–36°00′ E longitudes. In terms of areal extent, Yozgat is among the relatively large provinces of Türkiye, with a projected area of about 13,597 km² and an actual surface area of approximately 14,123 km² (Ministry of Environment, Urbanization and Climate Change, 2024) (Figure 1).

The longitudinal extent of the province is approximately 2°05′, corresponding to a local time difference of about 8 minutes and 20 seconds between the easternmost and westernmost points. The latitudinal difference is around 1°38′; however, this relatively small variation does not create a significant impact on the regional climatic characteristics The straight-line distance between the eastern and western boundaries is approximately 216 km, while the north–south extent is about 144 km (Ministry of Environment, Urbanization and Climate Change, 2024). Steppe vegetation, pasture areas, and limited forest patches also represent important land cover types. Agricultural activities constitute the dominant land use pattern due to the rural socio-economic structure of the province (TURKSTAT, 2023; Ministry of Environment, Urbanization and Climate Change, 2024). It is farmed in 44.5% (598.059 ha) of the surface area of the province. Despite rural migrations, more than one-third (33.9%) of the total population still lives in rural areas. 29.3% of the active population was employed in the agricultural sector (Erbaş, 2023; Erbaş & Cinarer, 2024).

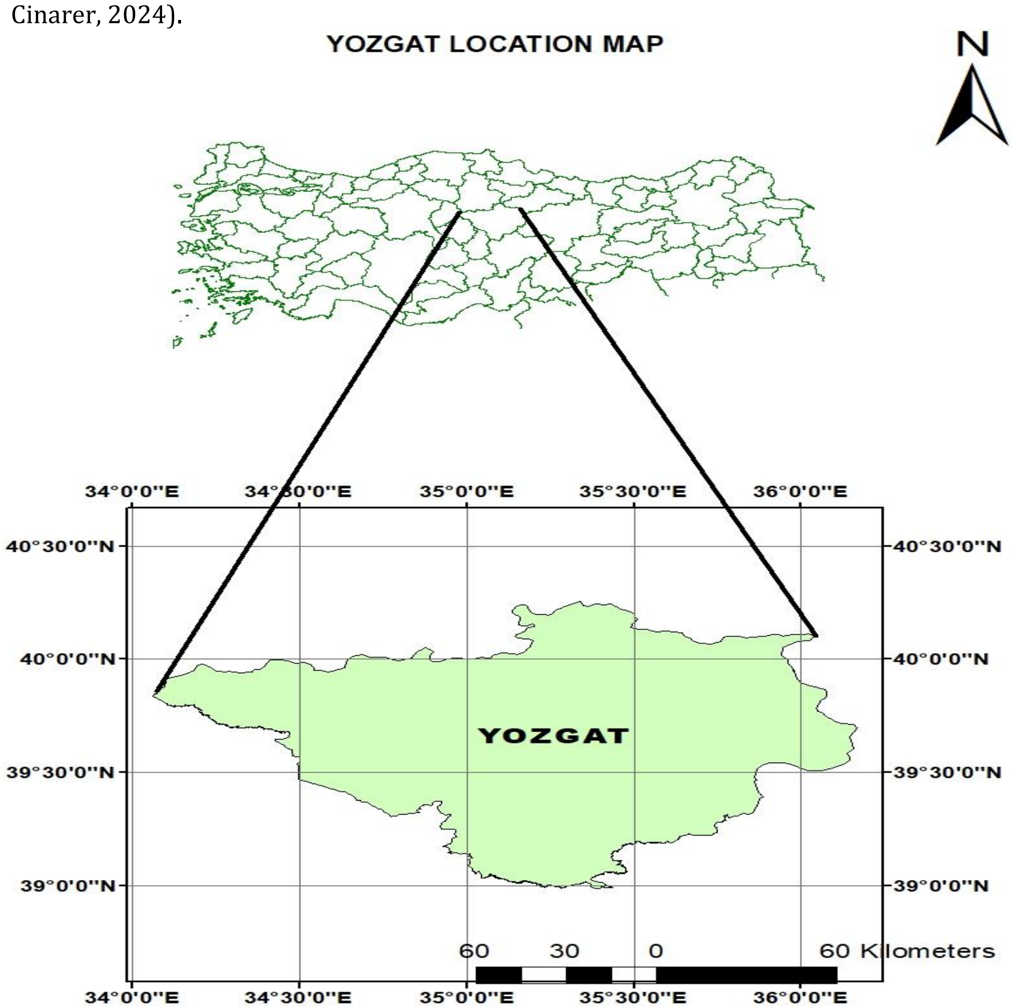


Figure 1. Location map of Yozgat Province within Türkiye.

2.2. Satellite Data and Pre-processing

Multi-temporal Landsat satellite images were used to analyze land use and land cover (LULC) changes in Yozgat Province between 2000 and 2024. The satellite data were obtained from the United States Geological Survey (USGS) Earth Explorer platform (Earthexplorer, 2024). Landsat-5 TM, Landsat-7 ETM+, and Landsat-8/9 OLI sensor datasets with 30-m spatial resolution were utilized in the study. Landsat imagery was preferred due to its moderate spatial resolution, long-term archive availability, and suitability for regional-scale environmental studies. To ensure temporal consistency and improve the comparability of multi-temporal land use/land cover classifications, satellite images were preferentially selected from the summer season (June–August), with particular emphasis on July acquisitions whenever cloud-free scenes were available. The summer period was chosen because vegetation activity reaches its maximum development stage, agricultural parcels become more spectrally distinguishable, and seasonal snow cover or excessive soil moisture effects are minimized. All image processing and spatial analyses were carried out using ArcGIS/ArcMap 10.8 software. Pre-processing steps included layer stacking, radiometric and geometric corrections, and clipping of satellite images based on the administrative boundary of Yozgat Province. Multi-temporal land use maps were generated using supervised classification techniques. Training samples were selected for major land cover classes, including agricultural land, built-up areas, vegetation, bare land, and water bodies. The downloaded Landsat images were first subjected to band composite processing in ArcGIS/ArcMap 10.8 in order to generate multi-band false color composite images suitable for visual interpretation and classification. For Landsat-5 and Landsat-7 imagery, the 4-3-2 band combination was used, whereas 5-4-3 was preferred for Landsat-8/9 images to enhance vegetation and land surface discrimination. Subsequently, all composite images were clipped to the administrative boundary of Yozgat Province using the provincial "shapefile" in order to ensure spatial consistency and reduce the influence of surrounding areas outside the study region. Following the clipping process, an Iso Cluster approach was applied to classify the images into four major LULC classes: agriculture, settlement, bare land, and vegetation/water. The initial spectral clusters generated by the Iso Cluster algorithm were then refined using Maximum Likelihood Classification, which improved the thematic consistency of the final land cover maps. Finally, temporal change detection analysis was performed by comparing the classified images from 2000, 2006, 2012, 2018 and 2024. The areal changes of each class were quantified using pixel-based comparison, percentage change calculations, and inter-period difference analysis.

Table 1. Characteristics of Landsat datasets used in the study.

Year	Sensor	Path/Row	Acquisition Date	Cloud Cover
2000	Landsat 5 TM	176/032	14 July 2000	Low
2006	Landsat 5 TM	176/032	31 July 2006	Low
2012	Landsat 7 ETM+	176/032	23 July 2012	Low
2018	Landsat 8 OLI	176/032	17 August 2018	Low
2024	Landsat 9 OLI-2	176/032	09 August 2024	Low

Table 1 presents the characteristics of the Landsat datasets used in this study for LULC analysis in Yozgat Province. All satellite images were acquired during the summer season to minimize seasonal variability and ensure temporal consistency between different years. The selected images belong to the same path/row (176/032) and were chosen under low cloud cover conditions to improve classification accuracy and change detection reliability.

2.3. Classification Procedure and Accuracy Assessment

Landsat satellite images acquired for the years 2000, 2006, 2012, 2018, and 2024 were used to analyze land use/land cover (LULC) changes in Yozgat Province. Image preprocessing procedures, including layer stacking, clipping, and image enhancement, were performed in the ArcGIS environment prior to classification. Supervised classification was applied using the Maximum Likelihood Classification (MLC) algorithm. Based on spectral characteristics and visual interpretation, four major land use/land cover classes were identified: Wetland, Vegetation, Agricultural Land, and Bare Land. Spectral separability between training classes was visually evaluated using false color composites and histogram distributions prior to classification. Due to the moderate spatial resolution (30 m) of Landsat imagery and the limited spatial extent of surface water bodies in Yozgat Province, vegetation and water classes were evaluated together to minimize spectral confusion and improve classification consistency. The land use/land cover (LULC) statistics were initially generated as pixel counts, which represent the direct output of the raster-based classification process. Since all Landsat images used in this study have a spatial resolution of 30 m, the reported pixel counts can be readily converted into area values (km^2 or hectares) using the corresponding pixel area (900 m^2 per pixel). Pixel counts were retained in this study to preserve the original classification output and to facilitate direct comparison among different study years, while equivalent area values can be derived using the standard conversion factor when required. This approach was preferred to minimize spectral confusion and improve overall classification consistency. Training samples were manually selected from homogeneous areas representing each class. Approximately 40–60 training samples were collected for each land cover class depending on spatial heterogeneity. To evaluate the reliability of the classification results, an accuracy assessment was conducted using randomly generated validation points and confusion matrix analysis. Validation points were visually interpreted using high-resolution World Imagery basemaps in ArcGIS. Overall Accuracy (OA) and Kappa Coefficient values were calculated for each classified image. Producer's and user's accuracy values were also evaluated during confusion matrix analysis and confirmed acceptable classification reliability for all classes. The obtained results demonstrated acceptable classification performance for all years. Overall Accuracy values ranged between 75% and 89%, while Kappa Coefficient values ranged from 0.65 to 0.75, indicating substantial agreement between classified maps and reference data.

2.4. Change Detection Analysis

Temporal change detection analysis was conducted to quantify spatial transformations between the selected years. LULC maps generated for each year were compared to identify transitions between land use classes. Area statistics were calculated to determine the magnitude and direction of land use changes. Additionally, transition matrices were produced to evaluate class conversions and landscape transformation patterns. Spatial distribution patterns and area change trends were analyzed using GIS-based statistical tools. The results were presented through, graphical representations and tabular summaries to facilitate interpretation of land use dynamics. The methodological approach provides a comprehensive framework for understanding long-term land transformation processes in semi-arid regions.

3. Results and Discussion

The LULC classification results of Yozgat Province for the years 2000, 2006, 2012, 2018 and 2024 revealed considerable spatial and temporal changes among the major land cover classes. The findings indicate remarkable variations in settlement, bare land, agricultural land, and vegetation/water areas throughout the study period.

Table 2. Temporal distribution of LULC classes in Yozgat Province (pixel count).

Year	Agriculture	Settlement	Bare Land	Vegetation/Water
2000	2,726,445	1,792,432	3,424,240	1,216,915
2006	2,076,848	2,110,938	3,579,210	1,690,151
2012	2,719,496	2,624,764	1,167,140	1,050,783
2018	3,113,748	3,488,607	1,766,544	2,107,284
2024	2,974,026	3,842,717	1,570,582	2,041,009

As shown in Table 2, settlement areas exhibited a continuous increase throughout the study period, rising from 1,792,432 pixels in 2000 to 3,842,717 pixels in 2024. Agricultural land showed moderate fluctuations but remained one of the dominant land use classes in the province. Bare land, which covered a large area at the beginning of the study period, decreased substantially by 2024. In contrast, vegetation/water areas displayed an overall increasing trend despite some temporal fluctuations.

3.1. LULC distribution in 2000

In 2000, bare land constituted the dominant land cover class in Yozgat Province with 3,424,240 pixels. Agricultural land ranked second with 2,726,445 pixels, indicating the strong rural and production-oriented character of the province. Settlement areas occupied 1,792,432 pixels, while vegetation/water areas represented the smallest class with 1,216,915 pixels. These findings suggest that bare surfaces and agricultural landscapes were the principal land cover components at the beginning of the study period.

3.2. LULC distribution in 2006

In 2006, bare land remained the largest class with 3,579,210 pixels, while agricultural land decreased to 2,076,848 pixels. Settlement areas increased to 2,110,938 pixels, indicating an early stage of urban expansion in the province. Vegetation/water areas also rose to 1,690,151 pixels. The 2000–2006 period therefore reflects an increase in settlement and vegetation/water classes, accompanied by a decline in agricultural land.

3.3. LULC distribution in 2012

By 2012, agricultural land increased substantially to 2,719,496 pixels, while settlement areas continued to expand and reached 2,624,764 pixels. Bare land sharply declined to 1,167,140 pixels, representing the most remarkable reduction among all classes. Vegetation/water areas decreased to 1,050,783 pixels. These results indicate that a considerable portion of previously bare surfaces was transformed into agricultural and built-up land during this period.

3.4. LULC distribution in 2018

In 2018, settlement areas reached 3,488,607 pixels, representing the highest value recorded up to that date and indicating a strong urban growth trend. Agricultural land also increased to 3,113,748 pixels. Vegetation/water areas nearly doubled compared to 2012 and reached 2,107,284 pixels, whereas bare land rose moderately to 1,766,544 pixels. The results demonstrate that the 2012–2018 period was characterized by rapid land transformation and intensified spatial development.

3.5. LULC distribution in 2024

In 2024, settlement areas reached 3,842,717 pixels, representing the highest value of the entire study period. Agricultural land slightly decreased to 2,974,026 pixels but remained one of the dominant land use classes. Bare land declined to 1,570,582 pixels, while vegetation/water areas remained relatively high at 2,041,009 pixels. These findings suggest that urban growth continued steadily, whereas agricultural and natural land covers experienced moderate adjustments.

3.6. LULC Change Intensity Analysis

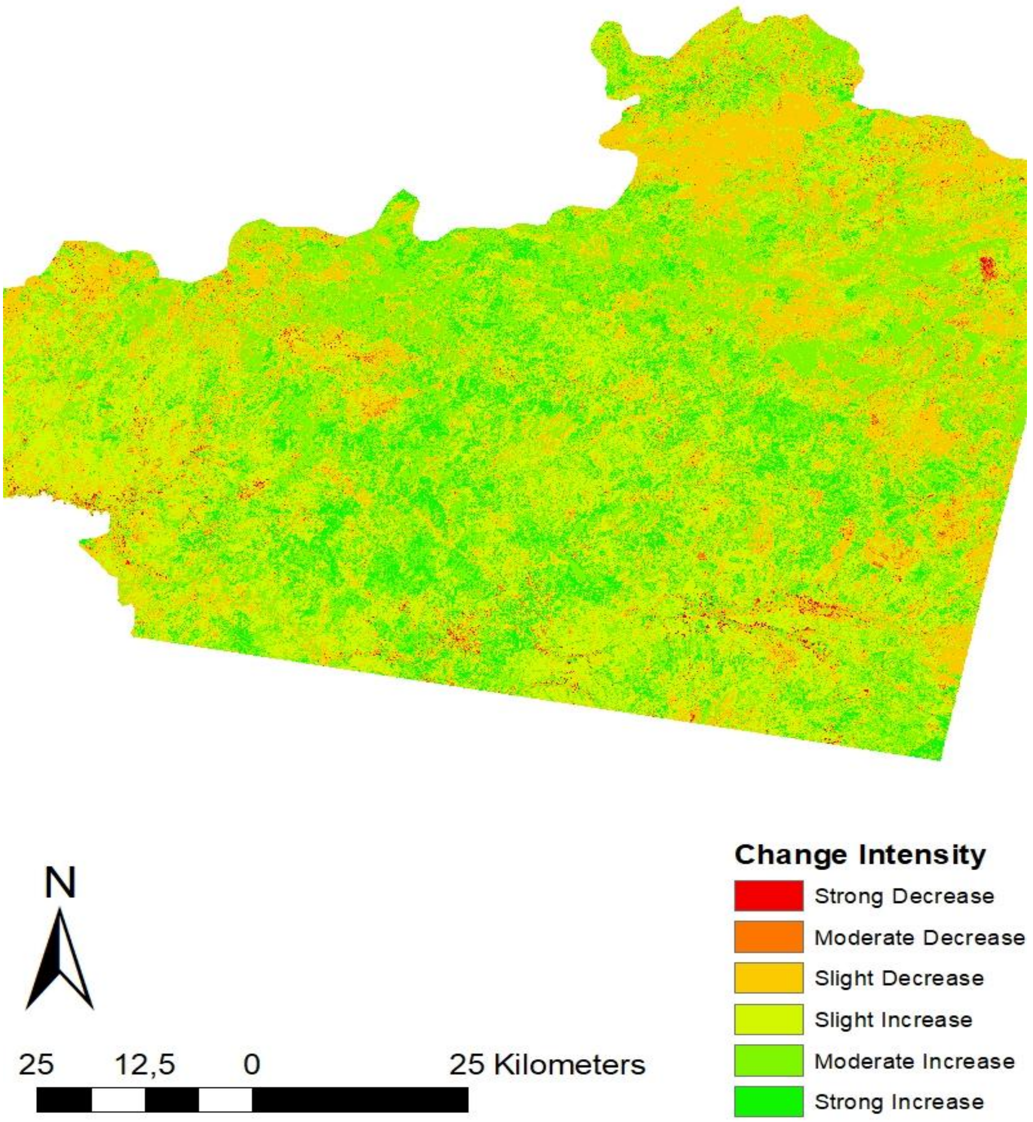


Figure 2. LULC change intensity map of Yozgat Province between 2000 and 2024.

Figure 2 illustrates the spatial distribution and intensity of land use/land cover (LULC) changes in Yozgat Province between 2000 and 2024. The map was clipped using the administrative boundary of Yozgat Province to display only the study area, thereby improving the clarity and interpretability of spatial change patterns. Green tones indicate areas characterized by increasing change intensity, whereas yellow to red tones represent areas with decreasing change intensity. The spatial pattern reveals that most parts of the province experienced slight to moderate changes, while localized zones of high change intensity are concentrated around settlement expansion areas and intensively cultivated agricultural lands. Conversely, areas with decreasing change intensity are mainly associated with land conversion processes involving bare land and agricultural surfaces. Overall, the map demonstrates that land cover transformations in

Yozgat Province were spatially heterogeneous and largely driven by urban expansion, agricultural development, and long-term landscape transformation during the study period.

3.7. Accuracy Assessment

As shown in Table 3, accuracy assessment was performed using generated validation points and confusion matrix analysis in ArcGIS.

Table 3. Overall Accuracy and Kappa Coefficient values of classified LULC maps.

Year	Overall Accuracy	Kappa Coefficient
2000	0,77	0,66
2006	0,89	0,74
2012	0,75	0,65
2018	0,76	0,67
2024	0,83	0,75

Overall Accuracy (OA) and Kappa Coefficient values were calculated for each classified image. The obtained OA values ranged from 75% to 89%, while Kappa coefficients ranged between 0.65 and 0.75. These results indicate that the classification performance is acceptable and reliable for land use/land cover change analysis. The highest classification accuracy was obtained for the year 2006 with an OA value of 89 %, whereas the lowest accuracy was observed in 2012. Overall, all classified images produced acceptable accuracy levels for LULC change analysis.

Following the class-specific area evaluations for each reference year, the long-term temporal trajectories of the major LULC classes were further examined to reveal the overall direction and magnitude of landscape transformation in Yozgat Province. Figure 3 illustrates the temporal variation in pixel counts for agriculture, settlement, bare land, and vegetation/water classes between 2000 and 2024. As illustrated in Figure 3, settlement areas showed a persistent increasing trend from 2000 to 2024, whereas bare land declined considerably over the same period.

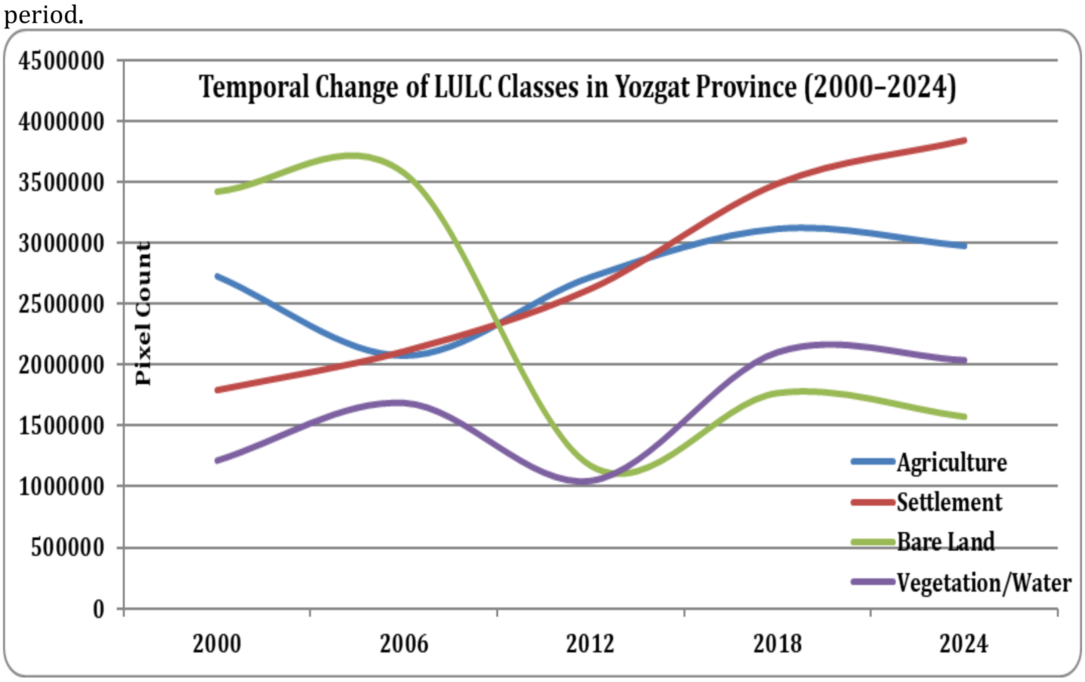


Figure 3. Temporal change trends of LULC classes in Yozgat Province (2000–2024).

Figure 3, the temporal change graph illustrates the long-term trajectories of the major land use/land cover classes in Yozgat Province between 2000 and 2024. The most remarkable trend is the continuous increase in settlement areas, which reflects persistent urban growth and infrastructure development throughout the study period. In contrast, bare land displayed a substantial declining trend, particularly after 2006, indicating progressive land conversion into agricultural and built-up surfaces.

Agricultural land remained relatively stable with moderate fluctuations, confirming the sustained importance of agricultural activities in the province. Vegetation and water-related areas showed an overall increasing tendency, especially after 2012, suggesting improvements in surface cover density, irrigation expansion, or seasonal water availability.

Overall, the temporal graph confirms that the dominant long-term landscape transformation processes in Yozgat Province are characterized by continuous urban expansion, a marked reduction in bare land and the relative persistence of agricultural land.

Table 4. Inter-period changes in LULC classes in Yozgat Province.

Period	Agriculture	Bare Land	Settlement	Vegetation/Water
2000-2006	-649,597	+154,970	+318,506	+473,236
2006-2012	+642,648	-2,412,07	+513,826	-639,368
2012-2018	+394,252	+599,404	+863,843	+1,056,501
2018-2024	-139,722	-195,962	+354,110	-66,275

Table 4 summarizes the magnitude and direction of inter-period LULC changes in Yozgat Province. The 2000–2006 period was mainly characterized by a decrease in agricultural land and increases in settlement, bare land, and vegetation/water classes. The most remarkable inter-period change was observed in the Bare Land class during the 2006–2012 period. This sharp decrease may be associated with the conversion of open and sparsely vegetated areas into agricultural land and settlement areas. In semi-arid regions such as Yozgat Province, bare lands are highly dynamic and may rapidly change depending on agricultural expansion, land reclamation practices, seasonal vegetation development, and changes in surface moisture conditions. The increase observed in agricultural and settlement classes during the same period supports the interpretation that a considerable part of bare land was transformed into cultivated and built-up surfaces. In addition, differences in vegetation phenology and surface reflectance during the image acquisition period may have contributed to the reclassification of some bare or sparsely covered areas as agricultural or vegetation/water classes.

Therefore, the decrease in bare land between 2006 and 2012 should be interpreted not only as a statistical change, but also as an indicator of land transformation driven by agricultural use, urban expansion, and environmental conditions. The most dramatic transformation occurred between 2006 and 2012, when bare land decreased sharply by 2,412,070 pixels, while both agriculture and settlement expanded. Between 2012 and 2018, settlement and vegetation/water classes recorded the strongest increases. During the final period, 2018–2024, settlement continued to increase, while agriculture, bare land, and vegetation/water showed slight decreases.

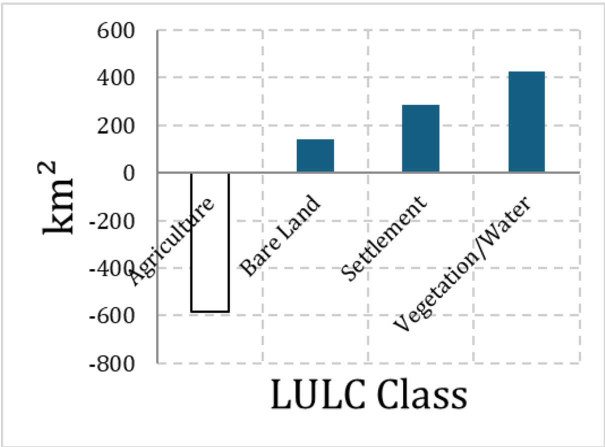
Table 5. Percentage change of LULC classes between 2000 and 2024.

LULC Class	2000	2024	Change (%)
Agriculture	2,726,445	2,974,026	+9.08
Settlement	1,792,432	3,842,717	+114.38
Bare Land	3,424,240	1,570,582	-54.13
Vegetation/Water	1,216,915	2,041,009	+67.72

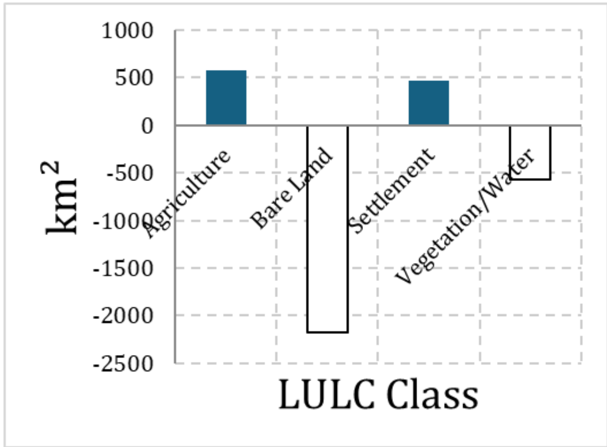
According to Table 5, settlement areas showed the highest proportional increase, rising by 114.38% between 2000 and 2024. The 114.38% increase observed in settlement areas represents one of the most significant LULC changes identified during the study period. This remarkable expansion is likely associated with long-term urban growth, population concentration, infrastructure development, and the increasing demand for residential, commercial, and public service areas in Yozgat Province. In addition, improvements in transportation networks and regional development policies may have accelerated the expansion of built-up areas, particularly around the provincial center and surrounding districts. The conversion of agricultural and bare lands into settlement areas observed in this study is consistent with the general urbanization trends reported for many provinces in Central Anatolia and other semi-arid regions of Türkiye. Vegetation/water classes also increased considerably by 67.72%. In contrast, bare land decreased by 54.13%, revealing a substantial reduction in unused or exposed surfaces. Agricultural land exhibited a relatively limited increase of 9.08%, suggesting that the province preserved its agricultural function despite ongoing urban expansion.

Overall, the LULC results reveal that the most important land transformation process in Yozgat Province between 2000 and 2024 was the continuous expansion of settlement areas together with the significant decline of bare land. Agricultural land remained relatively stable, while vegetation/water classes displayed moderate long-term growth. These findings indicate that urbanization and land conversion processes have played a major role in shaping the spatial landscape dynamics of the province.

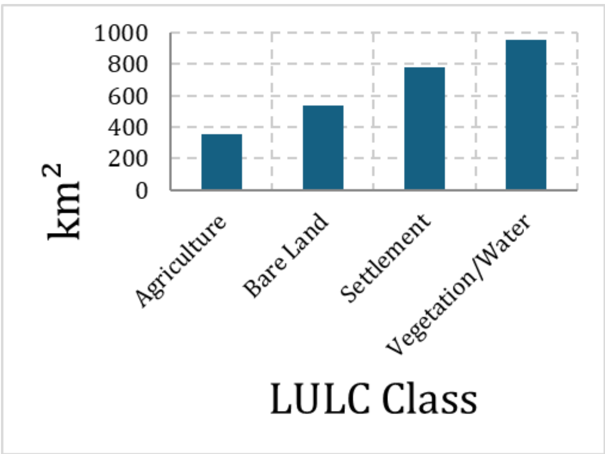
As illustrated in Figure 4, settlement areas exhibited a persistent increasing trend throughout all sub-periods, while bare land showed the most significant decline, particularly during 2006–2012.



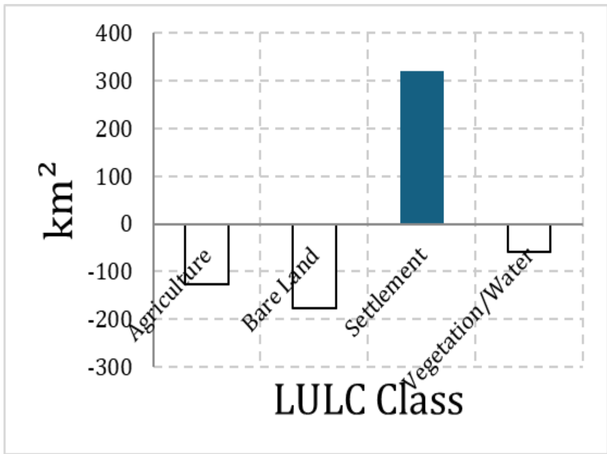
a) 2000-2006



b) 2006-2012



c) 2012-2018



d) 2018-2024

Figure 4. Inter-period areal change graphs of LULC classes in Yozgat Province. **(a)** 2000–2006, **(b)** 2006–2012, **(c)** 2012–2018, and **(d)** 2018–2024.

The inter-period areal change graphs clearly demonstrate the dynamic nature of land use/land cover transitions in Yozgat Province between 2000 and 2024. During the 2000–2006 period, the most significant increase occurred in bare land, while agricultural land showed a notable decline, indicating possible land degradation or temporary abandonment of cultivated fields. In the 2006–2012 interval, the dominant trend shifted toward a substantial increase in agricultural land, accompanied by a strong decrease in bare land, suggesting land reclamation and intensified agricultural activities.

Between 2012 and 2018, settlement areas exhibited the highest increase among all classes, reflecting accelerated urban growth and infrastructure development. At the same time, vegetation/water classes also expanded slightly, whereas agricultural land experienced a moderate decline. In the final period (2018–2024), the most remarkable transformation was the continued expansion of settlement areas, while agricultural land and bare land both declined, indicating that urban sprawl increasingly encroached upon previously cultivated and open lands.

Overall, Figure 4 confirms that the dominant inter-period landscape transformation process in Yozgat Province is the expansion of settlement areas accompanied by a marked decline in bare land, particularly after 2012. The inter-period comparison demonstrates that settlement growth remained the most persistent trend throughout the study period, whereas bare land showed the strongest fluctuations between consecutive years.

3.8. Discussion

The results obtained from the LULC analysis indicate significant land use and land cover changes in Yozgat Province between 2000 and 2024. Agricultural lands remained the dominant land cover class throughout the study period, reflecting the agricultural character of the province.

However, noticeable changes were observed among settlement, vegetation, bare land, and water-related classes over time. The expansion of settlement areas can be associated with population concentration, urban growth, infrastructure development, and changing socio-economic dynamics in the province. In particular, increasing construction activities and transportation investments contributed to the spatial enlargement of urban areas. Similar urbanization-driven land transformations have also been reported in previous LULC studies conducted in semi-arid regions. Changes observed in vegetation areas may be related to agricultural pressure, land degradation and semi-arid climatic conditions.

The climatic characteristics of Central Anatolia, including limited precipitation and seasonal drought conditions, have likely influenced vegetation density and spatial distribution. Furthermore, intensive agricultural practices may have caused the conversion of natural vegetation areas into cultivated lands. Bare land variations observed during the study period are considered to be associated with seasonal land management practices, soil exposure, and climatic variability. In semi-arid environments such as Yozgat, fluctuations in precipitation and land productivity may directly affect the extent of exposed soil surfaces.

The temporal changes detected in water-related areas were relatively limited compared to other classes. The integration of vegetation and water classes represents a methodological limitation of the study and is mainly related to the moderate spatial resolution of Landsat imagery and the limited spatial extent of surface water bodies within the study area. The decision to combine vegetation and water into a single land cover class represents a methodological consideration adopted to improve the overall classification consistency. Due to the 30 m spatial resolution of Landsat imagery and the relatively limited extent of surface water bodies within Yozgat Province, separating these two classes resulted in increased spectral confusion, particularly along transitional zones and small water features. Therefore, merging vegetation and water into a single class reduced classification uncertainty and improved thematic consistency across all study years.

Although this approach limits the possibility of distinguishing ecological and hydrological changes independently, it does not substantially affect the interpretation of the overall long-term LULC dynamics, since the primary objective of this study was to evaluate broad land use and land cover transformations rather than detailed ecosystem-specific processes. Future studies employing higher spatial resolution satellite imagery, such as Sentinel-2 or commercial datasets, may provide a more detailed separation of vegetation and water classes and enable more comprehensive ecological and hydrological assessments. Nevertheless, climatic variability and seasonal hydrological conditions may have influenced the spatial extent of surface water features during different years. The accuracy assessment results demonstrate that the classification outputs are reliable and scientifically acceptable. Overall accuracy and Kappa coefficient values obtained for all years indicate substantial agreement between classified data and reference samples. These findings confirm the suitability of the applied classification methodology for long-term LULC monitoring in Yozgat Province. In comparison with previous studies conducted in Türkiye and other semi-arid regions, the findings of this study are generally consistent with the reported trends of agricultural expansion, urban growth, and vegetation decline. The present study contributes to the literature by providing a long-term multi-temporal analysis of LULC dynamics in Yozgat Province using GIS and remote sensing techniques. One of the most remarkable findings of this study is the substantial decrease in bare land during the 2006–2012 period. This decline is likely associated with the conversion of previously unused or sparsely vegetated areas into agricultural and settlement lands. The simultaneous increase observed in agricultural and built-up classes during the same period supports this interpretation. In addition, land reclamation practices, afforestation activities, and improvements in land management may also have contributed to reducing the extent of exposed bare surfaces.

Similarly, the continuous increase in settlement areas throughout the study period reflects the long-term effects of urban expansion, infrastructure development, and population concentration in and around Yozgat city. These processes have gradually transformed surrounding agricultural and bare lands into residential, commercial, and transportation-related land uses. Overall, the observed LULC dynamics indicate that both socio-economic development and environmental factors jointly influenced landscape transformation in Yozgat Province during the 2000–2024 period. These findings highlight the importance of sustainable land-use planning to balance future urban expansion with the conservation of agricultural land and natural ecosystems in semi-arid regions.

4. Conclusions

This study investigated the spatio-temporal land use/land cover (LULC) dynamics of Yozgat Province between 2000 and 2024 using multi-temporal Landsat imagery and GIS-based classification techniques. The findings revealed significant land cover changes throughout the study period, particularly in settlement, vegetation, bare land, and agricultural areas. Agricultural lands remained the dominant land cover class, reflecting the agricultural structure and socio-economic characteristics of the province. The results demonstrated that settlement areas showed a remarkable increase over the 24-year period, which may be associated with urban expansion, infrastructure development, and population concentration. In contrast, fluctuations observed in vegetation and bare land classes indicate the effects of agricultural pressure, land management practices, and semi-arid climatic conditions. The accuracy assessment results, including Overall Accuracy and Kappa coefficient values, confirmed that the classification outputs are scientifically reliable and suitable for long-term LULC monitoring studies. The results demonstrate that remote sensing and GIS techniques provide effective tools for long-term monitoring of LULC dynamics in semi-arid environments such as Yozgat Province. Furthermore, this study contributes to the existing literature by providing a long-term multi-temporal assessment of land cover dynamics in Yozgat Province using GIS and remote sensing techniques. The findings may support sustainable land management, environmental planning, and regional development strategies.

Future studies may integrate higher-resolution satellite imagery, machine learning algorithms, and climate-related datasets to improve the monitoring and interpretation of land cover dynamics in the region.

Acknowledgments

We would like to thank our reviewers and editor who contributed to the enrichment of the article with their opinions, suggestions and comments.

Author Contributions

Author1: Article writing, Conceptualization, Data, Research.

Author2: General checking, Methodology, Literature, Grammar.

Author3: Conceptualization, General checking, Methodology, Research, Article Editing and Grammar.

Statement of Conflicts of Interest

*"*There is no conflict of interest among the authors*."*

Statement of Research and Publication Ethics

The study was declared to contain no violations of research and publication ethics principles, and it was confirmed that the scope of the research did not require ethical committee approval.

Data Availability Statement

"Data related to this study is not publicly available due to confidentiality, institutional, or technical restrictions."

References

Bozkurt, S.G., Kuşak, L. & Akkemik, Ü. Correction to: Investigation of land cover (LC)/land use (LU) change affecting forest and seminatural ecosystems in Istanbul (Turkey) metropolitan area between 1990 and 2018. *Environ Monit Assess 195*, 399 (2023). https://doi.org/10.1007/s10661-023-10975-7

Celik, M. O., & Yakar, M. (2023). Arazi kullanımı ve arazi örtüsü değişikliklerinin uzaktan algılama ve cbs yöntemi ile izlenmesi: Mersin, Türkiye örneği. *Türkiye Coğrafi Bilgi Sistemleri Dergisi, 5*(1), 43-51. https://doi.org/10.56130/tucbis.1300704

Coppin, P., Lambin, E., Jonckheere, I., & Muys, B. (2002). Digital change detection methods in natural ecosystem monitoring: A review. *Analysis of multi-temporal remote sensing images*, 3-36. https://doi.org/10.1142/9789812777249_0001

Cağlıyan, A., & Dagli, D. (2022). Monitoring land use land cover changes and modelling of urban growth using a future land use simulation model (FLUS) in Diyarbakır, Turkey. *Sustainability, 14*(15), 9180. https://doi.org/10.3390/su14159180

Ding, H., & Shi, W. (2013). Land-use/land-cover change and its influence on surface temperature: a case study in Beijing City. *International Journal of Remote Sensing, 34*(15), 5503-5517. https://doi.org/10.1080/01431161.2013.792966

Dutta, D., Rahman, A., Paul, S. K., & Kundu, A. (2020). Estimating urban growth in peri-urban areas and its interrelationships with built-up density using earth observation datasets. *The Annals of Regional Science, 65*(1), 67-82. https://doi.org/10.1007/s00168-020-00974-8

DESA (Department of Economic and Social Affairs). 2019. World Urbanization Prospects: the 2018 Revision. United Nations, New York, USA. Retrieved June 21, 2026, from https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

Earthexplorer. (2024). Earthexplorer. Retrieved August 26, 2024, https://earthexplorer.usgs.gov/

Erbaş, N. (2021). Comparative economic analysis of farms in Turkey and a critical assessment of the annual profitability: The case of Yozgat Province. *Custos e agronegocıo on lıne, 17*(1), 332-460.

Erbaş, N. (2023). Sabit Sermaye Yatırımlarının Genel Ve Kırsal İstihdam Yönünden İncelenmesi: Yozgat İli Örneği. 13 th International Conference on Agriculture, Animal Science and Rural Development, https://www.ispecongress.org/tarim, November 28-29, 2023 Uşak / Türkiye. https://doi.org/10.5281/zenodo.10406033

Erbaş, N., & Çınarer, G. (2024). Abandonment of Agricultural Lands, Reasons and Sustainability: Evidence from Turkey. *Cuadernos de Desarrollo Rural, 21*. https://doi.org/10.11144/Javeriana.cdr21.aalr

Ergene, E. M., Bektaş Balçık, F., & Balik Şanlı, F. (2024). Trends analysis of agricultural drought in Central Anatolian Basin, Turkey. The International Archives of the Photogrammetry, *Remote Sensing and Spatial Information Sciences, 48*, 141-148. https://doi.org/10.5194/isprs-archives-XLVIII-4-W9-2024-141-2024

Ellis, E. C. (2011). Anthropogenic transformation of the terrestrial biosphere. *Philosophical Transactions of the Royal Society A, 369*(1938), 1010–1035. https://doi.org/10.1098/rsta.2010.0331

Ferynandari, A. M., Suhartanto, E., & Prasetyorini, L. (2026). Remote Sensing for Sustainable Development: Multi-Temporal Landsat Analysis of Land-Use Change and Urbanization in the Rejoso Watershed (2005–2024). *Jurnal Penelitian Pendidikan IPA, 12*(1), 93-101. https://doi.org/10.29303/jppipa.v12i1.13639

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., et al. (2005). Global consequences of land use. *Science, 309*(5734), 570–574. https://doi.org/10.1126/science.1111772

Guler, M., Yomralıoğlu, T., & Reis, S. (2007). Using landsat data to determine land use/land cover changes in Samsun, Turkey. *Environmental Monitoring and Assessment, 127*(1), 155-167. https://doi.org/10.1007/s10661-006-9270-1

Gulersoy, E. A. (2013). Çorum merkez ilçede arazi kullanımının zamansal değişimi (1987-2011) ve çevresel etkileri. *Coğrafi Bilimler Dergisi, 11*(2), 169-194. https://doi.org/10.1501/Cogbil_0000000148

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., et al. (2013). High-resolution global maps of 21st-century forest cover change. *Science, 342*(6160), 850–853. https://doi.org/10.1126/science.1244693

Hatab, A.A.; Cavinato, M.E.R.; Lindemer, A.; Lagerkvist, C.J. Urban Sprawl, Food Security and Agricultural Systems in Developing Countries: A Systematic Review of the Literature. *Cities* 2019, 94, 129–142. https://doi.org/10.1016/j.cities.2019.06.001

Kadak, M. K. (2025). Spatiotemporal Assessment of LULC Changes Using Remote Sensing Approaches. *Journal of Agricultural Production, 6*(3), 186-196. https://doi.org/10.56430/japro.1777194

Karakus, C. B., Cerit, O., & Kavak, K. S. (2014). Determination of Land Use/Cover Changes and Land Use Potentials of Sivas City and its Surroundings Using Geographical Information Systems (GIS) and Remote Sensing (RS). *Procedia Earth and Planetary Science, 15*, 454-461. https://doi.org/10.1016/j.proeps.2015.08.040

Lambin, E. F., Geist, H. J., & Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. *Annual Review of Environment and Resources, 28*, 205–241. https://doi.org/10.1146/annurev.energy.28.050302.105459

Lu, D., Mausel, P., Brondizio, E., & Moran, E. (2004). Change detection techniques. *International Journal of Remote Sensing, 25*(12), 2365–2407. https://doi.org/10.1080/0143116031000139863

Meydan Yıldız, S. G., Bahçeci Başarmak, H. I., & Akın, E. S. (2022). Social and Administrative Dimensions of Urban Transformation andUrban Identity: Sample of Yozgat (Turkey). *Optimum Ekonomi ve Yönetim Bilimleri Dergisi, 9*(1), 93-114. https://doi.org/10.17541/optimum.997034

Ministry of Environment, Urbanization and Climate Change. (2024). Yozgat Province Geography. Yozgat Provincial Directorate. Retrieved June 21, 2026, from https://yozgat.csb.gov.tr/ilimiz-cografyasi-2341

Naboureh, A., Bian, J., Lei, G., & Li, A. (2021). A review of land use/land cover change mapping in the China-Central Asia-West Asia economic corridor countries. *Big Earth Data, 5*(2), 237-257. https://doi.org/10.1080/20964471.2020.1842305

Oli, D., Gyawali, B., Neupane, B., & Oshikoya, S. (2025). Assessment of land use land cover change and its impact on variations of land surface temperature in Atlanta, USA. *Environmental and Sustainability Indicators, 26*, 100712. https://doi.org/10.1016/j.indic.2025.100712

Ologunde, O. H., Kelani, M. O., Biru, M. K., Olayemi, A. B., & Nunes, M. R. (2025). Land use and land cover changes: a case study in Nigeria. *Land, 14*(2), 389. https://doi.org/10.3390/land14020389

Pirzada, M., Turi, K.H., Mari, I.H. & Lashari, O.A. (2025). Land Use Land Cover Changes: Conversion of Agricultural Land in District Hyderabad, Sindh, Pakistan. *Social Sciences & Humanity Research Review 3*(4). https://doi.org/10.63468/sshrr.162

Roy, D. P., Wulder, M. A., Loveland, T. R., Woodcock, C. E., Allen, R. G., Anderson, M. C., et al. (2014). Landsat-8: Science and product vision for terrestrial global change research. *Remote Sensing of Environment, 145*, 154–172. https://doi.org/10.1016/j.rse.2014.02.001

Saha, M., & Saaj, M. S. S. (2026). Spatial and Temporal Analysis of Landsat Images to Explore LULC, LST, NDVI and NDWI Changing Pattern Using Geospatial Techniques: A Case Study of Dhaka Dıstrıct, Bangladesh. 8th International Conference on Civil Engineering for Sustainable. Proceedings of the 8th International Conference on Civil Engineering for Sustainable Development(ICCESD 2026), 5-7 February 2026, KUET, Khulna, Bangladesh

Seto, K. C., Fragkias, M., Güneralp, B., & Reilly, M. K. (2011). A meta-analysis of global urban land expansion. *PloS one, 6*(8), e23777. https://doi.org/10.1371/journal.pone.0023777

Singh, A. (1989). Review article digital change detection techniques using remotely-sensed data. *International Journal of Remote Sensing, 10*(6), 989-1003. https://doi.org/10.1080/01431168908903939

Sivrikaya, F., Başkent, E. Z., Şevik, U., Akgül, C., Kadıoğulları, A. İ., & Değermenci, A. S. (2010). A GIS-based decision support system for forest management plans in Turkey. *Environmental Engineering & Management Journal (EEMJ), 9*(7), 929-937.

Turan, İ. D., Dengiz, O., & Kaya, N. S. (2021). Arazi örtüsü/arazi kullanım değişimlerinin farklı zamanlı landsat uydu görüntüleri ile belirlenmesi: Çarşamba delta ovası örneği. *ÇOMÜ Ziraat Fakültesi Dergisi, 9*(1), 141-152. https://doi.org/10.33202/comuagri.857787

Turner, B. L., Lambin, E. F., & Reenberg, A. (2007). The emergence of land change science for global environmental change and sustainability. *Proceedings of the National Academy of Sciences, 104*(52), 20666–20671. https://doi.org/10.1073/pnas.0704119104

Turk, S. T., & Balcik, F. B. (2023). Rastgele orman algoritması ve Sentinel-2 MSI ile fındık ekili alanların belirlenmesi: Piraziz Örneği. *Geomatik, 8*(2), 91-98. https://doi.org/10.29128/geomatik.1127925

Turkes, M., Koc, T., & Sarıs, F. (2009). Spatiotemporal variability of precipitation total series over Turkey. *International Journal of Climatology, 29*(8), 1056–1074. https://doi.org/10.1002/joc.1768

Turkes, M., & Akgunduz, A. S. (2011). Assessment of the desertification vulnerability of the Cappadocian district (Central Anatolia, Turkey) based on aridity and climate-process system. *Journal of Human Sciences, 8*(1), 1234-1268. https://j-humansciences.com/index.php/IJHS/article/view/1694

Turkish Statistical Institute (TURKSTAT). (2023). Regional agricultural and population statistics for Yozgat Province. Retrieved April 13, 2026, from https://data.tuik.gov.tr

Verburg, P. H., Crossman, N., Ellis, E. C., Heinimann, A., Hostert, P., Mertz, O., Nagendra, H., Sikor, T., Erb, K., Golubiewski, N., Grau, R., Grove, M., Konaté, S., Meyfroidt, P., Parker, D. C., Chowdhury, R. R., Shibata, H., Thomson, A., & Zhen, L. (2015). Land system science and sustainable development of the earth system: A global land project perspective. Anthropocene, 12, 29-41. https://doi.org/10.1016/j.ancene.2015.09.004

Weng, Q. (2012). Remote sensing of impervious surfaces in the urban areas: Requirements, methods, and trends. *Remote Sensing of Environment, 117*, 34–49. https://doi.org/10.1016/j.rse.2011.02.030