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# ANALYSIS OF LAND COVER DYNAMICS AND URBANIZATION PROCESSES BASED ON REMOTE SENSING AND GIS TECHNOLOGIES (ON THE EXAMPLE OF FERGANA REGION)

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**Abstract**

In recent years, as a result of the acceleration of urbanization processes, pressure on land resources has increased, and land cover change is becoming an urgent problem, especially in regions that are not rich in agricultural land. Fergana region is characterized by high population density and limited agricultural land resources, which requires in-depth study of the negative consequences of urban expansion.

In this study, land cover dynamics and urbanization processes were analyzed using Geographic Information Systems (GIS) based on Sentinel-2 space images from 2016–2026. Within the framework of the study, Land Use/Land Cover changes (LULC) analysis was carried out using the methodology of supervised classification based on multispectral images. The main categories of land cover were distinguished - urban areas, agricultural lands, vegetation cover, water bodies and Bare lands.

The results show that urban areas expanded significantly during 2016–2026, with intensive growth especially around large settlements. At the same time, a decrease in agricultural land was detected, indicating that urbanization pressure is increasing in the face of limited land resources in the region. LULC analysis confirmed that the land cover transformation is mainly due to the transition from agricultural land to urban areas.

The research results have important scientific and practical significance in regional planning, land resource management, and ensuring sustainable urban development, and will serve as a basis for developing strategies for the rational use of land resources in the future.

**Keywords**

urbanization, Agriculture, GIS, land resources management.

**Introduction**

In recent decades, urbanization processes have accelerated dramatically globally, causing significant changes in the structure of land use. As a result of population growth, increased economic activity and infrastructure expansion, urban areas are expanding, which in many regions is leading to a decrease in agricultural land. This process is especially pronounced in areas with limited land resources but dense populations. This reinforces the need for systematic study and assessment of land cover changes. Land Use/Land Cover (LULC) has a direct impact on environmental sustainability, food security and regional development strategies. Scientific studies show that the expansion of urban areas often occurs at the expense of a decrease in fertile agricultural land, which in the long term can lead to the degradation of agroecosystems (Seto et al., 2012; Foley et al., 2005). Therefore, determining the temporal change of land cover, assessing its trends and forecasting it is one of the current directions of modern science. While traditional land monitoring methods are often limited in covering large areas, Remote sensing and Geographic Information System technologies allow to effectively solve this problem. Based on space images, it is possible to analyze land cover in large areas and at different time intervals, detect changes and visualize them. In particular, using satellite data with high spatial resolution, such as Sentinel-2, it is possible to create detailed maps of land cover and assess their dynamics. Various methods are used to classify land cover and detect changes based on remote sensing data. Among them, supervised classification, machine learning algorithms, as well as vegetation and building indices (for example, NDVI, NDBI) are widely used (Jensen, 2015; Weng, 2012). These approaches can be used to identify urban areas, agricultural lands, vegetation cover, and other land types and assess how they are changing over time.

Land cover change and urbanization processes in Central Asia, particularly in Uzbekistan, have been attracting the attention of researchers in recent years. Scientific research is being conducted in the republic related to the expansion of urban areas, the reduction of irrigated land, and the intensification of environmental problems. Studies conducted by Uzbek scientists have widely highlighted the importance of remote sensing and GIS technologies in assessing land resources (Abdullayev et al., 2019; Karimov et al., 2021; Rasulov, 2020). In particular, studies on the degradation of irrigated lands, salinization processes, and land cover change have yielded important results in identifying regional problems. Fergana region is one of the most densely populated regions of Uzbekistan, and its geographical location and natural resources require a special approach to the use of land resources. Agriculture is one of the main economic sectors in the region, but limited land area and urbanization pressure complicate the use of these resources. In recent years, there has been a reduction in agricultural land as a result of the expansion of settlements, the construction of new residential areas and infrastructure facilities. This is a significant problem in terms of food security and environmental sustainability. In this regard, it is important to conduct a scientific analysis of land cover changes in Fergana region and identify the main directions of urbanization processes. In particular, analyses based on high-resolution space data for the period 2016–2026 can show a realistic picture of changes in the region. Such studies are important not only for assessing the current situation, but also for forecasting future development trends.

The scientific novelty of this work is that it provides a long-term (2016–2026) dynamic analysis based on modern space data, and a comprehensive assessment of land cover

transformation at the regional level. The results of the research are expected to be of practical importance in regional planning, land resource management, and the development of sustainable development strategies.

## DATA AND METHODS

### *Research area*

The Fergana region, located in the eastern part of the Republic of Uzbekistan, was chosen as the object of the study. This region is located in the central part of the Fergana Valley, covers an area of 6.8 thousand km², is characterized by high population density and intensive agricultural activity. The geographical location of the region, limited land resources and the intensity of urbanization processes make this region relevant for scientific research. Fergana region is bordered by complex relief and transboundary territories, and the processes of land resource use are formed under the influence of natural and anthropogenic factors. The boundaries of the study area are presented in Figure 1.

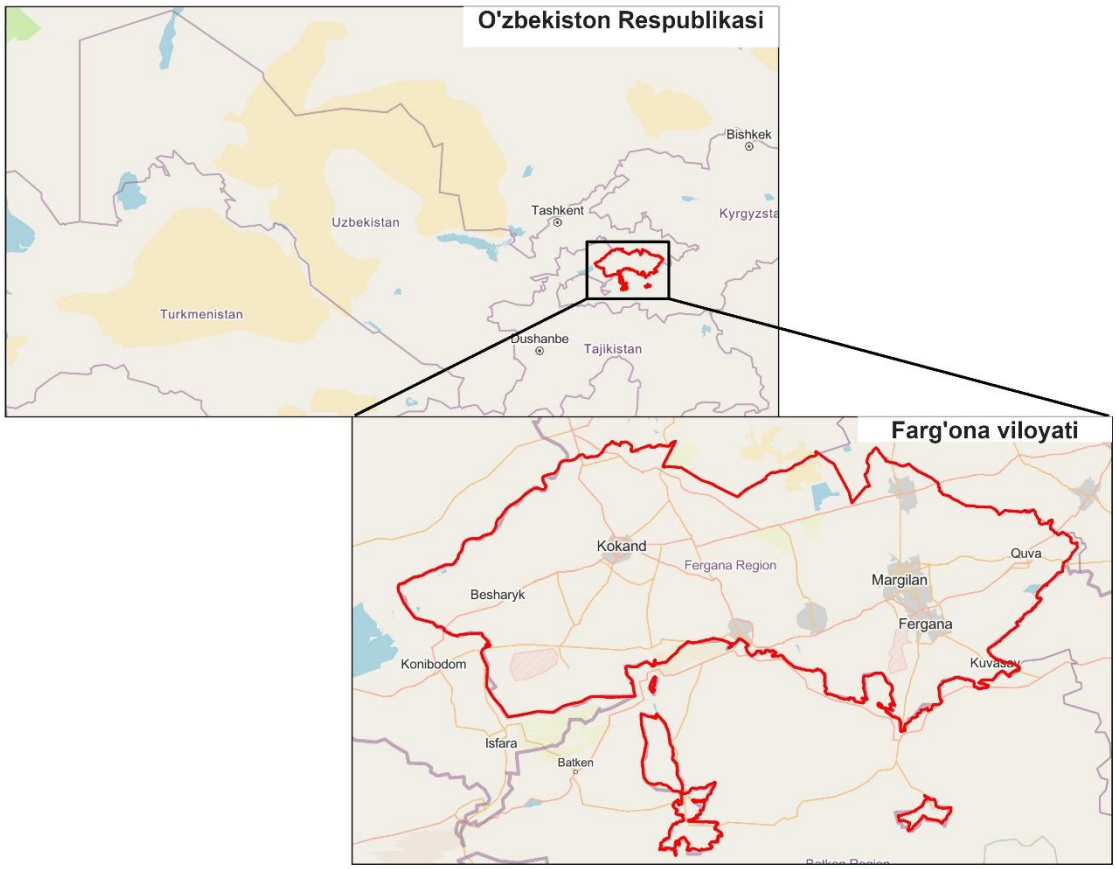


Figure 1. Location of Fergana region.

### *Data source and their processing.*

The study used high-resolution Sentinel-2 satellite imagery to detect land cover change. This satellite data covers the period 2016–2026 and provides multispectral images with a spatial resolution of 10 meters. The spatial data were downloaded and processed using the Google Earth Engine platform. Images with low cloud cover (cloud cover <10%) were selected.

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The study conducted a LULC (Land Use/Land Cover) analysis. Based on multispectral images, the following main land cover categories were distinguished:

- Urban areas (built-up areas)
- Agricultural land
- Trees and shrubs
- Water bodies
- Bare lands
- Water bodies
- Open space

The classification process used a supervised classification method. Training samples were selected based on visual interpretation and available cartographic data.

**RESULTS**

This study analyzed the land cover and land use (LULC) status for 2016 and 2025 based on remote sensing data. The results show that significant changes have occurred in the land use structure of Fergana region. Figure 1 and Figure 2 show the land cover maps created for 2016 and 2026, respectively, which reflect the spatial distribution of the main land categories in the region. (Figures 2-3)

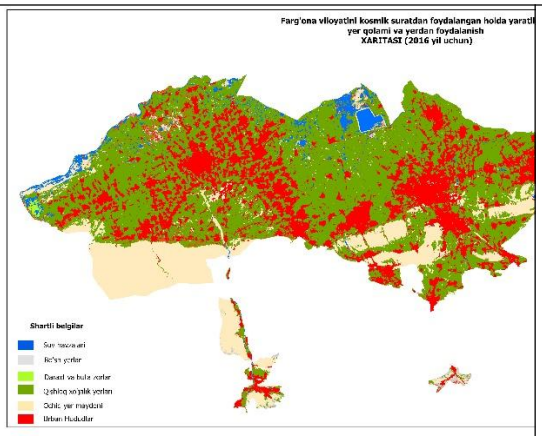


Figure 2 Land cover change 2016

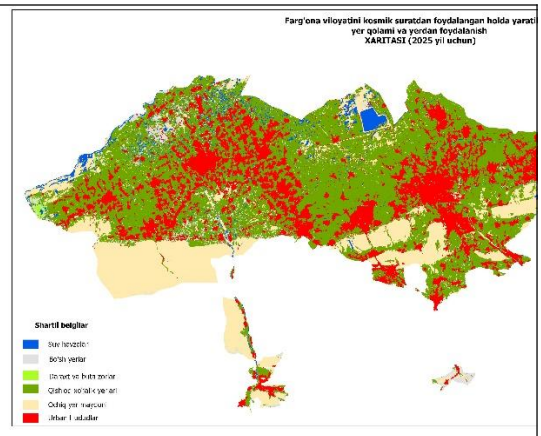


Figure 3 Land cover change 2026

According to the results of 2016, the share of agricultural land as the main land category in Fergana region is high, accounting for 52% (353,600 ha) of the total area. This indicator confirms the agrarian orientation of the regional economy. (Table 1) At the same time, urban areas account for 12% (81,600 ha), trees and shrubs for 14% (95,200 ha), open land for 14% (95,200 ha), Bare land for 7% (47,600 ha), and water bodies for 5% (34,000 ha). By 2026, significant transformations in land cover will be observed. Agricultural land will decrease to 45% (306,000 ha), a decrease of -7%. This is a very important indicator, indicating the increasing pressure of urbanization in the region. In contrast, urban areas increased by +8%, reaching 20% (136,000 ha). This increase is mainly explained by the expansion of new

residential areas, industrial zones and infrastructure facilities. The area of trees and shrubs increased slightly, reaching 15% (102,000 ha) (+1%). This may be due to the expansion of green areas or the restoration of natural vegetation in some areas. At the same time, open land areas decreased by 12% (-2%), Bare land by 5% (-2%), and water bodies by 4% (-1%).

Table 1: Land cover analysis of Fergana region for 2016-2026

| **Analytical table of land cover and land use of Fergana region** | | | | | |
|---|---|---|---|---|---|
| **Category** | **2016 (to)** | **2016 (%)** | **2025 (to)** | **2025 (%)** | **Change (%)** |
| Water bodies | 34,000 | 5% | 27,200 | 4% | -1% |
| Bare lands | 47,600 | 7% | 34,000 | 5% | -2% |
| Trees and shrubs | 95,200 | 14% | 102,000 | 15% | 1% |
| **Agricultural land** | **353,600** | **52%** | **306,000** | **45%** | **-7%** |
| Open spaces | 95,200 | 14% | 81,600 | 12% | -2% |
| **Urban areas** | **81,600** | **12%** | **136,000** | **20%** | **8%** |
| **Total** | **680,000** | **100%** | **680,000** | **100%** | |

These results show that the main transformation in land cover is taking place due to the transition from agricultural lands to urban areas. Analysis of maps also clearly confirms this process - especially around the cities of Kokand, Margilan and Fergana, intensive expansion of urban areas is observed. It can be seen that urban areas are expanding radially and linearly, developing along transport routes. These changes in land cover are closely related to the processes of demographic and economic development of the region. As a result of the increase in the population, the demand for housing increases, and part of agricultural lands is being allocated for construction. This may lead to a decrease in agricultural resources in the long term. The study also carried out a forecast analysis until 2070 based on the change in agricultural lands in 2016–2026. According to the results, if the current trend continues, the share of agricultural land could decrease to 33% (226,440 ha) by 2040, 26% (173,400 ha) by 2050, and only 14% (94,240 ha) by 2070.

This projection is very worrying and could lead to problems of food security and sustainable use of land resources in the region. Especially in an area of intensive agriculture such as the Fergana Valley, such a reduction would have serious socio-economic consequences.

The results show that if the urbanization process is not regulated, the reduction of agricultural land will continue. This requires the introduction of modern approaches to land resource management. In particular, it is necessary to widely use GIS and remote sensing technologies in territorial planning.

Table 2. Forecast of changes in agricultural land until 2070 based on changes in 2016-2025.

| **Forecast of changes in agricultural land until 2070 based on changes in 2016-2025** |
|---|

| Year | Percentage (%) | Area (ha) | Change (compared to 2016) |
|---|---|---|---|
| **2016** | 52% | 353,600 | |
| **2025** | 45% | 306,000 | -7% |
| **2040** | 33% | 226,440 | -18.70% |
| **2050** | 26% | 173,400 | -26.50% |
| **2070** | 10% | **67,320** | -42.10% |

## CONCLUSION

This study comprehensively analyzed land cover change and urbanization processes in Fergana region between 2016 and 2025 using remote sensing and GIS technologies. The results showed that significant transformations are taking place in the structure of land resource use in the region.

The analysis showed that, although agricultural land accounts for the majority of the region's territory, its area has been shrinking significantly in recent years. This indicator, which was 52% in 2016, decreased to 45% by 2025. On the contrary, the share of urban areas increased from 12% to 20%, clearly indicating the acceleration of urbanization processes in the region.

These land cover changes are mainly driven by population growth, economic development, and infrastructure expansion. However, these processes can lead to a reduction in agricultural land, which in the long term can have negative impacts on food security and environmental sustainability.

The results of the forecast analysis provide even more important conclusions. If the current trend continues, the share of agricultural land could sharply decrease, reaching 14% by 2070. This will lead to a sharp decline in the agricultural production potential of the region (Figure 2).

Therefore, rational use of land resources and management of urbanization processes in the region are urgent tasks. The following recommendations can be put forward:

- Urban development regulation and implementation of the compact city model
- Pursuing a strict policy on the protection of agricultural land
- Creating a continuous monitoring system based on GIS and remote sensing
- Widespread introduction of digital technologies in land resource management

Overall, the results of this study serve as an important scientific basis for developing regional planning and sustainable development strategies. Remote sensing and GIS technologies have been confirmed once again as effective tools for land cover monitoring.

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