APPLICATION OF GEOGRAPHIC INFORMATION SYSTEMS IN ASSESSING THE GEOECOLOGICAL CONDITIONS OF THE KHOREZM REGION

Olloyorov Shokirjon Ikrom o'g'li
National Pedagogical University of Uzbekistan named after Nizami
Master's student
Tashkent

Abstract: This article examines the geoecological conditions of the Khorezm Region, with particular emphasis on land use patterns and land cover characteristics. The study substantiates the changes in land cover that have occurred over time as a result of increasing anthropogenic impacts. Using Sentinel-2 Land Use/Land Cover satellite imagery with a spatial resolution of 10 m for the years 2017 and 2024, land cover dynamics during this period were identified and quantitatively assessed. The results highlight spatial and temporal variations in major land cover categories, reflecting the influence of human activities and environmental factors on the region's geoecological state. The applied GIS-based analysis provides a reliable framework for monitoring land cover transformations and supports informed decision-making in the management of land and natural resources under arid environmental conditions.

Key words: GIS, LULC, crops, built area, rangeland, Sentinel-2, Landsat, remote sensing, geoecological monitoring

ПРИМЕНЕНИЕ ГЕОГРАФИЧЕСКИХ ИНФОРМАЦИОННЫХ СИСТЕМ ДЛЯ ОЦЕНКИ ГЕОЭКОЛОГИЧЕСКИХ УСЛОВИЙ ХОРЕЗМСКОЙ ОБЛАСТИ

Оллоёров Шокирджон Икром угли
Национальный педагогический университет
Узбекистан имени Низами
Магистр,
Ташкент

Аннотация: В данной статье рассматриваются геоэкологические условия Хорезмской области с особым акцентом на модели землепользования и характеристики земельного покрова. Исследование обосновывает изменения земельного покрова, произошедшие с течением времени в результате усиления антропогенного воздействия. Используя спутниковые снимки Sentinel-2 с пространственным разрешением 10 м за 2017 и 2024 годы, была выявлена и количественно оценена динамика земельного покрова за этот период. Результаты показывают пространственные и временные изменения основных категорий земельного покрова,

отражающие влияние человеческой деятельности и факторов окружающей среды на геоэкологическое состояние региона. Примененный анализ на основе ГИС обеспечивает надежную основу для мониторинга трансформаций земельного покрова и поддерживает принятие обоснованных решений в управлении земельными и природными ресурсами в засушливых условиях.

Ключевые слова: ГИС, землепользование и земельный покров, сельскохозяйственные культуры, застроенные территории, пастбища, Sentinel-2, Landsat, дистанционное зондирование, геоэкологический мониторинг

The Khorezm region is located at the boundary of Uzbekistan's arid climatic zone, where oasis landscapes play a key role in ensuring agricultural production and maintaining ecological balance. Water resources in the region are limited; however, the livelihoods of the population and up to 70% of the region's agricultural output depend on these irrigated oases. In recent decades, oasis ecosystems have undergone significant changes as a result of increasing anthropogenic pressure, climate change, and the degradation of soil and water resources. According to data from Uzhydromet, over the past 30 years the average annual air temperature in Khorezm has increased by 1,2–1,5°C, while the annual discharge of the Amu Darya River—the main source of irrigation—has decreased by 15–20%. Under such conditions, Geographic Information Systems (GIS) have become an essential tool for monitoring the geoecological state of the region and for the early detection of adverse environmental changes. According to FAO projections, water scarcity in Central Asia may reach 30–40% by 2050, which necessitates the development of adaptive strategies for natural resource management [4]. In this context, the application of modern GIS technologies in geoecological monitoring has become increasingly relevant, as it provides a scientifically grounded approach to assessing land cover dynamics, forecasting desertification risks, and optimizing the allocation of water resources.

The aim of this study is to present a methodology for monitoring geoecological conditions in the Khorezm Region based on GIS and remote

sensing data. In particular, the study analyzes indicators such as land use and land cover (LULC) changes, anthropogenic pressure, and vegetation cover dynamics, and discusses the experience of cartographic modeling of these processes using the ArcGIS Pro software.

Remote sensing and GIS technologies provide a number of advantages for geoecological monitoring. Satellite imagery acquired through remote sensing enables regular and large-scale observation of the condition of regional landscapes. For instance, studies have demonstrated that changes in vegetation cover can be monitored with an accuracy of approximately 85–90% using data from the NASA Landsat 7–8 and Sentinel-2 satellite missions [4]. In addition, the application of vegetation indices such as the Normalized Difference Vegetation Index (NDVI) has been scientifically proven to be highly effective in detecting the early stages of desertification. GIS-based monitoring approaches make it possible to assess the dynamics of oasis ecosystems under the influence of both natural–climatic and anthropogenic factors. For example, in the case of the Khorezm oases, the analysis of satellite imagery combined with GIS-based cartographic modeling has made it possible to examine the spatial structure of oasis landscapes and to identify their transformations driven by natural and human-induced processes, thereby demonstrating the effectiveness of GIS technologies in land resource management. Geo-information data obtained through GIS tools allow not only the mapping of the current environmental state, but also the modeling and forecasting of landscape processes, as well as the anticipation of changes in the reclamation status of irrigated lands and the degree of desertification.

In the Khorezm Region, the structure of land use and land cover has undergone significant changes over recent decades. Automatic classification of remote sensing imagery enables a quantitative assessment of these transformations. As shown in Figure 1, within the framework of this study Sentinel-2 satellite images acquired between 2017 and 2024 were analyzed, and an LULC classification was performed. As a result, several major changes in

oasis landscapes were identified. Agricultural cropland areas decreased by 1.7% during the period 2017–2024, with the most pronounced reductions observed in the northern districts of the region (Yangiariq and Khazarasp). This trend is consistent with global desertification processes observed in arid regions. At the same time, a decline in the irrigation intensity of croplands has been recorded in recent years due to reduced water availability from the Amu Darya River. Consequently, an increase in soil salinity and a decline in soil fertility have been observed in certain agricultural areas.

In contrast, built-up and settlement areas increased by 10.18%, with particularly rapid urbanization observed around the regional center, Urgench city. This trend can be explained by the rapid growth of the region's population. In 2017, the permanent population of the Khorezm Region amounted to 1,781.9 thousand people, whereas by 2024 it had increased to 2,002.8 thousand. Rapid population growth and economic development inevitably lead to the expansion of urban areas, thereby intensifying anthropogenic pressure on natural ecosystems. As a result, the burden on water and land resources within the region has further increased.

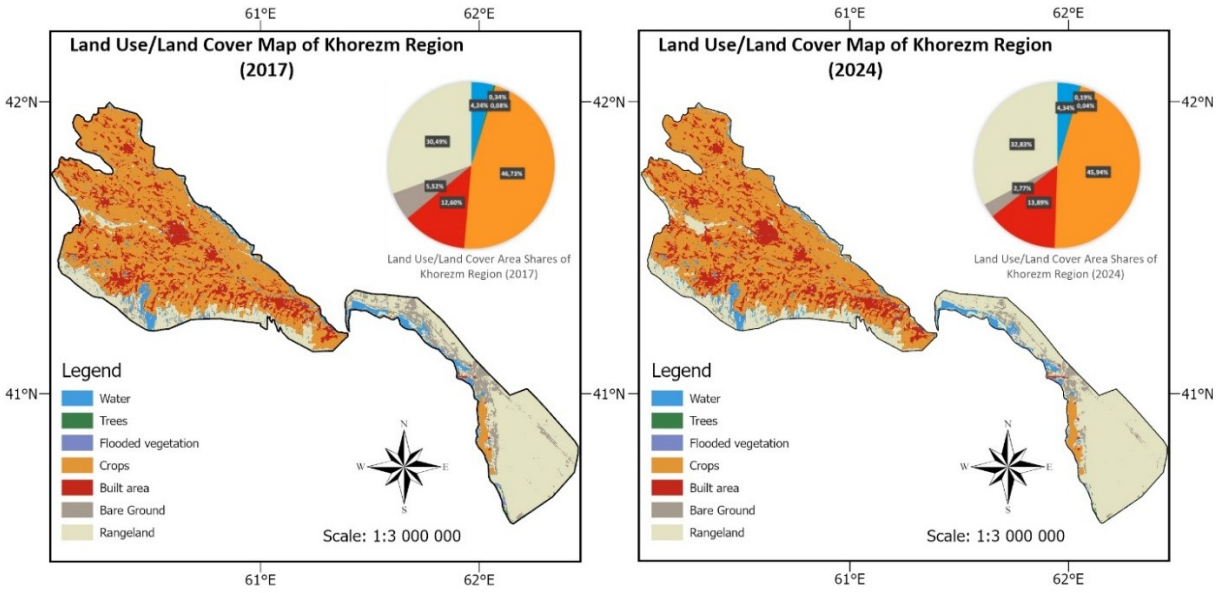

Figure 1. Map of land use/land cover changes in the Khorezm Region in 2017 and 2024.

Changes in water bodies were relatively minor. Variations in the area of water resources exhibit a pronounced seasonal character, and satellite images acquired at different times may therefore show certain discrepancies.

The area of bare ground decreased almost twofold (by 179.8 km²), while rangeland areas increased by 7.68% compared to 2017. This trend is also illustrated by the diagram presented in Figure 2. Rangeland areas are predominantly composed of desert vegetation and represent one of the key components in combating desertification within the region.

Forest areas in the region remain extremely limited. The main forested zones consist of tugai (riparian) forests along the Amu Darya River. However, in recent years, increasing demand for forest resources has led to a reduction in existing tree-covered areas. In 2017, forested land covered approximately 4.9 km², whereas by 2024 this figure had declined to 2.8 km².

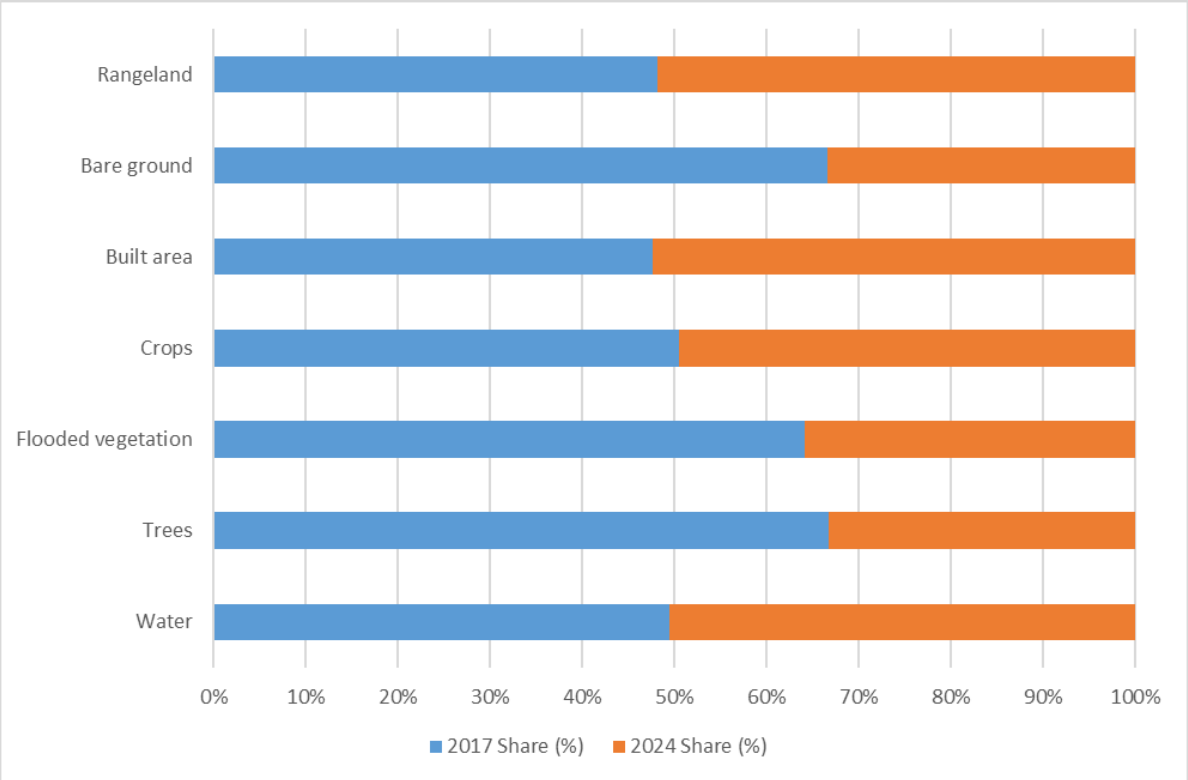

Figure 2. Changes in the Proportional Structure of Land Use/Land Cover in Khorezm Region (2017–2024)

To illustrate these changes more clearly, a table of LULC indicators was compiled (Table 1). The table presents the dynamics of the major land cover categories from 2017 to the present. Notably, while the proportion of vegetation-covered land has shown a steady decline, the share of urbanized areas has increased significantly.

Class (Name)	2017 Area (km²)	2017 Share (%)	2024 Area (km²)	2024 Share (%)	Change (km²)	Change (% relative to
Water	276,8931	4,24	283,7171	4,34	6,824	2,46
Trees	4,9721	0,08	2,8774	0,04	-2,0947	-42,13
Flooded vegetation	22,4187	0,34	12,5142	0,19	-9,9045	-44,18
Crops	3053,669	46,73	3001,731	45,94	-51,9375	-1,7
Built area	823,5752	12,6	907,4265	13,89	83,8513	10,18
Bare ground	360,5536	5,52	180,7518	2,77	-179,802	-49,87
Rangeland	1992,378	30,49	2145,441	32,83	153,0632	7,68

Table 1. Changes in the land cover structure of the Khorezm Region by years (percentage distribution of agricultural land, settlements, water bodies, and other land categories).

Maps derived from the results of the LULC classification effectively revealed the spatial distribution of the most significant changes within the study area. For instance, satellite image classification clearly demonstrated a reduction in bare ground areas in the southern districts of the Khorezm Region, while an expansion of salt-affected lands was observed in the south-western part of the region. These patterns were cartographically visualized, providing clear evidence of spatially differentiated land cover transformations.

The results of such spatial analyses serve as early-warning indicators for local authorities and environmental agencies, helping to identify areas where

reclamation measures should be intensified or where land-use practices require revision. For example, the previously noted 1.7% reduction in cropland represents a regional manifestation of global aridification trends. To mitigate this process, it is recommended to identify low-productivity agricultural areas and introduce water-saving technologies, such as drip irrigation systems.

Based on all results obtained in ArcGIS Pro, a comprehensive set of final maps and table-based indicators illustrating land cover and land use conditions in 2017 and 2024 was developed. This integrated cartographic framework provides a solid basis for assessing spatial patterns of geoecological change and supporting evidence-based decision-making in land and water resource management.

The study conducted using the Khorezm Region as a case study demonstrated the high effectiveness of applying GIS and remote sensing tools in geoecological monitoring. GIS technologies enable comprehensive, accurate, and timely assessment of the current state of landscapes and their change trends. The results obtained—such as the reduction of cropland areas, the expansion of saline lands, and the decline in vegetation indices—were all represented in the form of spatial maps and quantitative indicators. This approach made it possible to identify problem areas and risk zones based on their spatial distribution. In particular, the integrated maps developed using the ArcGIS Pro software provided an effective basis for optimizing agroecological and water management planning at the regional scale.

In conclusion, it can be stated that GIS and the ArcGIS Pro platform offer significant opportunities for the efficient organization of monitoring and forecasting activities in complex geoecological systems such as the Khorezm Region. These methods allow real-time monitoring of soil salinity, vegetation cover, and water resource conditions, enabling the early identification of problematic areas and processes. The findings of this study indicate that data and map products generated using geographic information systems constitute an essential tool for decision-making aimed at sustainable natural resource

management and the mitigation of environmental challenges at the regional level. Therefore, further development of GIS-based geoecological monitoring systems and their continuous enrichment with up-to-date data will provide a solid foundation for achieving sustainable development in the Khorezm Region.

References

1. Akramkhanov, A., Martius, C., Park, S. J., Hendrickx, J. M. H. Environmental factors of spatial distribution of soil salinity in Khorezm region, Uzbekistan. Environmental Earth Sciences, 63, 1177–1191. 2011
2. Boymurodov R., Matchanov M., Tajiyev Q., Amandurdiyev D., Mansourian A., Ashurov A.. Monitoring land use and land cover (LULC) in the Khorezm oasis using the Esri Sentinel-2 Land Cover Explorer database. E3S Web of Conferences 590, 04001 (2024).
3. Rakhmonov Sh., Umurzakov U., Rakhmonov K., Bozarov I., Karamatov O., Land Use and Land Cover Change in Khorezm, Uzbekistan, E3S Web of Conferences 227, 01002 (2021).
4. Ярашев К.С., Давранова Р.К. Некоторые вопросы изучения оазисных ландшафтов Хорезмской области с использованием ГИС-технологий. Экономика и социум, №9(135)2 2025б 449.