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Comprehensive Monitoring Of Landscape Transformation In The Aydar–Arnasay Lake System Based On Remote Sensing And GIS Technologies

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Abstract: This article develops the scientific and methodological foundations for comprehensive monitoring of landscape transformation in the Aydar–Arnasay Lake System based on remote sensing and geographic information systems (GIS). The study integrates Landsat satellite data acquired between 1985 and 2024, a digital elevation model, and multispectral indices (EVI, NDWI, LST) to assess changes occurring in coastal, desert, and agro-irrigation landscapes. Long-term dynamic analysis enabled the identification of spatial configurations, development trends, and levels of geoecological risk associated with landscape transformation. The obtained results are proposed as a scientific basis for sustainable territorial management, early detection of degradation processes, and the development of environmentally optimized management measures.

Keywords: Remote sensing, GIS, Landsat, landscape monitoring, EVI, NDWI, land surface temperature, transformation index, geoecological risk, spatial modeling.

Introduction: Geographical and Natural-Landscape Characteristics of the Study Area

The Aydar–Arnasay Lake System is located in the central part of the Republic of Uzbekistan and administratively covers the territories of Jizzakh and Navoi regions. Geographically, the lake system represents a large inland hydro-geosystem situated between the southeastern margin of the Kyzylkum Desert and the northern foothills of the Nurata Mountain Range. The total area of the system has varied over time depending on hydrological conditions; at present, the lake surface and associated wetted landscapes occupy several thousand square kilometers.

The Aydar–Arnasay system consists of Aydarkul, Tuzkon, and Eastern Arnasay lakes, which are hydraulically interconnected and function as a single water body. The system was formed mainly due to inflows from the Syr Darya basin, particularly excess water discharged from the Chardara Reservoir. Consequently, the area represents a geo-system shaped by strong anthropogenic influence alongside natural processes.

From a geomorphological perspective, the study area is dominated by lowlands and plains, with absolute elevations around the lakes ranging between 230 and 260 m. Toward the Nurata Mountains, the relief gradually rises, forming piedmont proluvial and deluvial plains. Such relief differentiation directly affects water accumulation processes, groundwater distribution, and the degree of hydromorphization of landscapes.

The climate is sharply continental, characterized by very hot and dry summers and relatively mild winters. Annual precipitation averages 150–250 mm and mainly occurs during winter and spring. The formation and expansion of the lake system have led to noticeable changes in the local microclimate, including increased air humidity, reduced summer temperature extremes, and altered wind regimes, thereby creating new environmental conditions in coastal landscapes.

Soil cover exhibits high spatial variability. Hydromorphic and semi-hydromorphic soils, as well as saline and waterlogging-prone soils, are widespread near the lakes. At greater distances, typical gray soils dominate, while sandy and loamy-sand soils prevail in desert zones. Shallow groundwater levels in areas adjacent to the lakes constitute one of the main drivers of landscape transformation.

Vegetation cover has also undergone significant changes under the influence of the lakes. Formerly dominant desert species such as saxaul, saltwort, and ephemeral plants have been replaced in coastal areas by reed beds, hygrophilous grasses, and hydrophytes. While this has increased biological productivity, it has also caused secondary waterlogging and reduced ecosystem stability in certain locations.

Thus, the Aydar–Arnasay Lake System represents a highly dynamic and complex landscape-geoecological system shaped by the interaction of natural-geographical, hydrological, and anthropogenic factors. Studying this area using remote sensing and GIS technologies is essential for identifying spatio-temporal patterns of landscape transformation, scientifically assessing hazardous processes, and developing sustainable management decisions.

Landscape transformation driven by large inland lake systems constitutes one of the most pressing research areas in modern geography and geoecology. In such regions, changes in hydrological regimes, rising groundwater levels, and the redistribution of moisture and heat balances lead to profound alterations in landscape morphology, functional properties, and development trajectories. The Aydar–Arnasay Lake System is a prominent natural-anthropogenic geosystem that vividly demonstrates these processes, having evolved into one of Central Asia's largest inland water complexes within a relatively short historical period.

In highly dynamic areas, landscape transformation cannot be adequately assessed solely through traditional field-based studies, as such processes are spatially extensive, temporally continuous, and multifactorial. Therefore, establishing a continuous monitoring system based on remote sensing and GIS technologies is scientifically essential. The primary objective of this study is to assess landscape transformation in the Aydar–Arnasay region using integrated indicators, reveal its spatial patterns, and scientifically map geoecological risk zones.

Data and Methodological Approach

The study utilized Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, and Landsat 9 OLI-2 satellite imagery acquired between 1985 and 2024. All images were subjected to radiometric and atmospheric correction and standardized to a common projection and pixel resolution, ensuring comparability across different time periods.

To comprehensively assess landscape conditions, spectral, thermal, and morphometric data were integrated. Vegetation condition and biomass were evaluated using the Enhanced Vegetation Index (EVI), surface moisture and water body dynamics using the Normalized Difference Water Index (NDWI), and drying and desertification processes using Land Surface Temperature (LST). Additionally, the influence of relief, water accumulation zones, and hydrological flow directions was analyzed based on the SRTM digital elevation model.

All indicators were standardized and combined to calculate an integrated Landscape Transformation Index, which serves as a comprehensive criterion for simultaneously assessing hydromorphization, degradation, and stability conditions across the study area.

RESULTS

Long-term dynamic analysis revealed that landscape transformation within the Aydar–Arnasay region is spatially heterogeneous and follows distinct territorial patterns. In coastal lowlands, a stable increase in NDWI and EVI values accompanied by decreasing LST confirmed intensified hydromorphization processes. These areas exhibited expanding wetlands, reed beds, and the formation of new hydrobiocenoses.

In contrast, agro-irrigation zones located farther from the lakes displayed declining EVI values, increasing LST, and spectral signs of salinization, indicating agricultural landscape degradation, secondary salinization, and disrupted water–land relationships. Desert and piedmont landscapes showed relatively stable conditions overall; however, localized areas experienced biomass loss and intensified deflation processes.

Cluster analysis enabled the clear delineation of hydromorphic transformation zones, degradation zones, and relatively stable zones, providing a scientifically grounded characterization of the spatial configuration of landscape transformation.

Assessment of Geoecological Risks and Spatial Modeling

Based on the integrated transformation index, levels of geoecological risk were quantified. Areas with very high risk include low-lying coastal zones experiencing intensified waterlogging and salinization, as well as regions with severe pasture degradation. Moderate-risk zones encompass agro-irrigation areas, while low-risk zones correspond to relatively stable piedmont and elevated desert landscapes.

Geoecological risk maps developed from these results are proposed as a basis for functional zoning, optimization of resource use, and planning of land reclamation measures.

CONCLUSION

Landscape transformation within the Aydar–Arnasay Lake System is a highly dynamic, multifactorial process characterized by pronounced spatial differentiation. The comprehensive monitoring model developed using remote sensing and GIS technologies enables objective, continuous, and scientifically robust assessment of these processes. The study's findings provide a solid scientific foundation for early detection of degradation risks, development of sustainable management strategies, and rational use of natural resources.

REFERENCE

1. Jensen J. R. Introductory digital image processing: a remote sensing perspective. - New Jersey: Pearson Education, 2016. - 544 б.
2. Lillesand T. M., Kiefer R. W., Chipman J. W. Remote sensing and image interpretation. - New York: Wiley, 2015. - 736 б.
3. Huete A. R., Didan K., Miura T., Rodriguez E. P., Gao X., Ferreira L. G. Overview of the radiometric and biophysical performance of the MODIS vegetation indices // Remote Sensing of Environment. - 2002. - Vol. 83, № 1-2. - Б. 195 - 213.
4. McFeeters S. K. The use of the normalized difference water index (NDWI) in the delineation of open water features // International Journal of Remote Sensing. - 1996.- Vol. 17, № 7. - Б. 1425-1432.
5. Weng Q. Thermal infrared remote sensing for land surface temperature analysis // ISPRS Journal of Photogrammetry and Remote Sensing. - 2009. - Vol. 64, № 4. - Б. 335 - 344.
6. United States Geological Survey. Landsat 5 TM, Landsat 7 ETM+, Landsat 8 - 9 OLI/TIRS data user handbook. - Reston: USGS, 2024.- 102 б.
7. National Aeronautics and Space Administration. Landsat science products and algorithms. - Washington, DC: NASA, 2023.
8. Isachenko A. G. Ландшафтная структура Земли и закономерности ее формирования. - Ленинград: Наука, 1991. - 295 б.
9. Сочава В. Б. Введение в учение о геосистемах. - Новосибирск: Наука, 1978. - 319 б.
10. Мирзаев Т. Ш., Каримов А. А. Қурғоқчил ҳудудларда кўл тизимларининг геоэкологик мониторингида ГАТ технологияларини қўллаш // Ўзбекистон география ахборотномаси. - 2020. - № 2. - Б. 41 - 52.
11. Қаҳҳоров Б., Юсупов Ш., Ахмадов А. Айдар - Арнасой кўллар тизими ҳудудида ландшафтлар трансформациясини масофавий зондлаш асосида баҳолаш // География ва табиий ресурслар. - 2022. - № 4. - Б. 58 - 69.
12. Гоипов Б., Ахмадов А., Юсупов Ш. Марказий Қизилқум ҳудудида гидрологик омилларнинг ландшафтлар ривожланишига таъсири // Геология ва минерал ресурслар. - 2024. - № 1. - Б. 28 - 39.