

Optimization of the use of natural landscapes in the northeastern part of the Lesser Caucasus

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Abstract. *The purpose of this article is to study the issues of optimization of the use of natural landscapes of the north-eastern part of the Lesser Caucasus. It is noted that at present, sustainable development, efficient use, protection and assessment of natural landscapes are among the most important problems of landscape science and, at the same time, physical geography. It is indicated that a number of aspects of these problems are also observed in Azerbaijan. Since research on this issue is being conducted by a number of Azerbaijani ecologists, biologists, soil scientists and geographers, however, the study of a number of ecogeographical problems is still at an insufficient level. The methodology and methods of the study include cartographic methods, field research methods, methods of geographical forecasting, mathematical and statistical methods. Scientific works on the topic, maps, Internet resources, statistical indicators were used. The main novelty of the article is that it studies anthropogenic processes occurring in the natural landscape of the selected geographical unit and the issue of its optimization based on the latest data, which will allow further use of new scientific information and analyses in the field of studying landscape changes occurring on the north-eastern slopes of the Lesser Caucasus. Result of the study. Summing up, it is noted that the nature of quantitative and qualitative changes in the studied natural complexes should be determined in advance in the process of nature management. If the trends in the development and dynamics of natural complexes, their resistance to anthropogenic impacts, etc. are not sufficiently studied, this leads to disruption of the landscape-ecological balance and normal functioning of the geosystem. That is why, in order to determine the development trends of modern landscapes, it is necessary to forecast and optimize a number of parameters of various landscape complexes of the studied territory. Given the great recreational and tourist potential of the studied territory, it is important to carry out thorough melioration measures and use environmentally friendly industrial technologies in this group of anthropogenic landscapes.*

Keywords: Lesser Caucasus, natural landscape, optimization, technogenic factors, anthropogenic factors.

Оптимізація використання природних ландшафтів північно-східної частини Малою Кавказа

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Анотація. *Мета цієї статті вивчення питань оптимізації використання природних ландшафтів північно-східної частини Малою Кавказу. Наголошується, що в даний час сталий розвиток, ефективне використання, охорона та оцінка природних ландшафтів є одними з найважливіших проблем ландшафтознавства та одночасно фізичної географії. Вказується, що низка аспектів зазначених проблем спостерігається і в Азербайджані. Оскільки дослідження з вивчення цього питання ведуться поруч азербайджанських екологів, біологів, ґрунтознавців та географів, проте вивчення низки екогеографічних проблем все ще перебуває на недостатньому рівні. Методологія та методи дослідження включають картографічні методи, методи польових досліджень, методи географічного прогнозування, математико-статистичні методи. Використані наукові праці на тему, карти, інтернет-ресурси, статистичні показники. Основна новизна статті полягає в тому, що в статті вивчаються антропогенні процеси, що відбуваються в природному ландшафті обраної географічної одиниці, та питання його оптимізації на основі новітніх даних, що дозволить надалі*

використовувати нову наукову інформацію та аналізи у галузі вивчення ландшафтних змін, що відбуваються на північно-східних схилах Малою Кавказу. Результат дослідження. Підсумовуючи, зазначається, що характер кількісних і якісних змін у природних комплексах, що вивчаються, повинен бути визначений заздалегідь у процесі природокористування. Якщо недостатньо вивчені тенденції розвитку та динаміки природних комплексів, їх стійкість до антропогенних впливів тощо, то це призводить до порушення ландшафтно-екологічної рівноваги та нормального функціонування геосистеми. Саме тому визначення тенденцій розвитку сучасних ландшафтів необхідне прогнозування і оптимізація низки параметрів різних ландшафтних комплексів досліджуваної території. Враховуючи великий рекреаційний та туристичний потенціал території, що вивчається, важливим є проведення в цій групі антропогенних ландшафтів ґрунтовних меліоративних заходів та застосування екологічно безпечних промислових технологій.

Ключові слова: Малий Кавказ, природний ландшафт, оптимізація, техногенні, антропогенні фактори.

Introduction. Currently, the sustainable and resilient development, efficient use, protection, and assessment of natural landscapes are among the most important issues in landscape science and physical geography. Several aspects of these problems are also observed in Azerbaijan. Research on this issue has been carried out by various Azerbaijani ecologists, biologists, soil scientists, and geographers. However, the study of certain eco-geographical problems is still insufficient. The rapid increase of anthropogenic impacts in the geographical area under investigation makes the optimization of the landscape as quickly as possible inevitable. In our view, the most suitable medium- and long-term forecasting approach for the optimization of landscapes within a specific time frame is the one that takes into account the natural, socio-economic, and technogenic factors affecting landscape changes during these periods.

The main scientific innovation presented in this article is that the anthropogenic processes occurring in the natural landscape of the selected geographical unit and their optimization have been studied based on the latest data. This will provide an opportunity for the future use of new scientific information and analyses in the study of landscape changes occurring on the northeastern slopes of the Lesser Caucasus.

In recent years, various aspects of the problem under study have been addressed in publications related to the topic. The sustainable and resilient development, efficient use, protection, and assessment of natural landscapes are among the most significant problems in landscape science and physical geography. Although several aspects of this problem have been partially studied by the ecologists, biologists, soil scientists, and geographers of our country, the study of a number of eco-geographical problems is still insufficient.

The landscapes and physical geographical potential, evaluation, transformation, and ecological problems of the northeastern slope of the Lesser Caucasus have been studied in recent decades by experts such as B. Budagov (Budaqov, 1996), A. Mikayilov (Mikayilov, 2008), M. Musayyibov (Musayyibov, 1998, Musayyibov, 2018), M. Suleymanov (Suleymanov, 2005), Y. Garibov (Garibov, 2010, Garibov, 2011, Garibov, 2012), T. Verdiyeva (Verdiyeva, 2009) among others. However, the transformation of the eco-geographical potential of the region's landscapes, the assessment of factors contributing to the ecological situation's tension, and other related issues have not yet been thoroughly studied as a distinct research topic.

According to M.A. Musayyibov's calculations (Musayyibov, 1998, p. 51), more than 55% of Azerbaijan's lands were covered by various modifications of mountain-forest and plain-forest landscapes during the mid-1st millennium BC. Currently, forests cover 11.8% of the country's territory. As a result of extensive deforestation in the mountain slopes and foothills, the soil cover in the northeastern part of the Lesser Caucasus has been significantly disturbed, fragmented by ravines, and the bedrock has emerged on the surface. In modern mountain-steppe landscapes, the area of landscapes that have been degraded due to anthropogenic influences and lost their recreational

potential now encompasses 4.5-5.0% of the territory (Müseyibov, 2018, p. 142).

Optimization of the Use of Natural Landscapes. In the area selected as the research object, there are classifications of plain and mountainous landscapes, which in turn group a number of types (Budaqov, 1996, p. 73):

- Mountain landscape class;
- High mountain-meadow;
- Low and middle mountain-steppe;
- Mountain-forest complex or mountain-forest;
- Mountain-forest steppe-meadow-shrub complexes.

Each landscape type is subdivided into subtypes, groups, and species according to its ecological, geographical, and transformation characteristics. The dissertation elaborates on the ecological risks and hazards occurring in each of these landscapes, describes their manifestation features, and proposes preventive measures to mitigate the negative outcomes caused by these processes.

In modern times, the preservation of the natural recreational potential of landscape types and their further improvement is primarily related to the planned agricultural activities of the population. By utilizing modern scientific and practical achievements, the preservation and optimization of the natural recreational potential of landscape types in the sustainable development of rapidly increasing production have been sufficiently addressed in the existing scientific literature. Several successful studies have been conducted on the optimization of anthropogenic and natural landscape types. However, there is still a lack of specific and unified scientific-methodological foundations for the scientific research conducted in this direction (Süleymanov, 2005, p. 94).

In the modern era, the widespread development of mass tourism and productive forces, as in other regions, demands the effective use of mineral, biological, water, and soil resources in the northeastern region of the Lesser Caucasus, as well as environmental protection and efficient optimization of landscapes, considering the specific landscape-ecological conditions of the area.

Three main directions of optimizing the natural environment are noted by researchers (Qəribov, 2012, p. 27):

1. Balancing the natural environment with its exploitation;
2. Implementing ameliorative measures for favorable regulation of natural processes;
3. Preservation (conservation) of the natural environment.

The mentioned measures, which broadly reflect the optimization of natural landscapes, undergo significant changes according to the landscape-typological units in the specific area. Special attention must be given to the natural-territorial differentiation of landscapes in the area, as well as the variety, characteristics, and regularity of anthropogenic activities. The study and application of ways to improve the effectiveness of natural landscape types will enhance their recreational potential and also enable their favorable use in the future.

Optimization of the Use of Natural Landscapes on the Northeastern Slopes of the Lesser Caucasus. The complex relief and climate of the study area, the variety of soil-vegetation cover, the diverse lithological composition, and the clearly distinguishable altitudinal landscape zones complicate the necessary measures for optimizing anthropogenic, natural, and natural-anthropogenic landscape types. These factors create challenges for implementing effective optimization strategies in the region.

Nevertheless, based on the research works mentioned earlier, we have identified three main directions for optimizing the landscapes of the northeastern part of the Lesser Caucasus for recreational purposes (Qəribov, 2011, p. 142):

1. Assessment of the natural-ecological balance and systematic organization of ecological monitoring;
2. Normalization of anthropogenic load on landscape types;
3. Successfully preserving natural components or complexes by converting specially protected

areas into national parks, nature reserves, or sanctuaries.

The implementation of measures in these directions will allow for optimizing the future development trends of anthropogenic landscape types, enhancing ecological diversity, and increasing the recreational potential of the area (Figure 1).

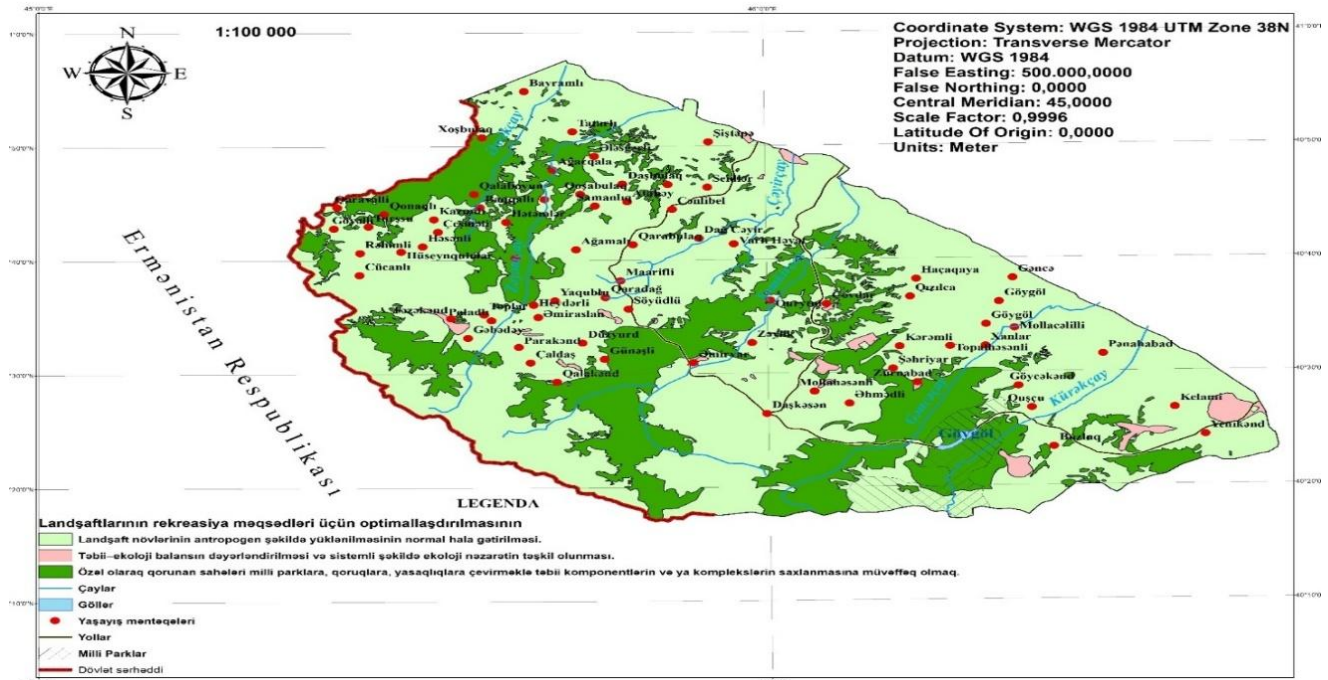


Figure 1. Map of the Optimization of the Landscapes of the Northeastern Slope of the Lesser Caucasus for Recreational Purposes.

As seen in Figure 1, the majority of the area, specifically 3,357.9 thousand km², or 65.9%, is considered suitable for the normalization of anthropogenic load on landscape types. These areas primarily include residential settlements and lands appropriated for various agricultural sectors. The zones mentioned, such as agricultural fields, summer and winter pastures, hayfields, and tourism-recreation facilities, currently undergo anthropogenic load. If the proper balance of this load is ensured and the land is used in an organized and systematic manner, the process of landscape degradation will slow down, leading to their sustainable use in the future (Mikayılov, 2008, p. 28-29).

We may succeed in preserving natural components or complexes by converting 368.1 km² of the studied area into specially protected areas, such as national parks, nature reserves, and sanctuaries. These areas primarily include forest, forest-steppe, and mountain-steppe landscapes. The protection of these regions, which are regularly deforested and whose area is steadily decreasing, is extremely important. The mass cutting down of trees would lead to the widespread occurrence of issues such as soil degradation and erosion. Additionally, this could trigger the activation of processes such as landslides, mudflows, floods, and other exodynamical processes, which would result in an increase in ecological problems within ecosystems.

Out of the total area of 1,364 km² on the northeastern slope of the Lesser Caucasus, we prioritize the optimization of natural-ecological balance assessment and the systematic organization of ecological monitoring. This area includes regions where the mining industry is currently developing, and waste materials from these activities are dispersed, along with zones where exodynamical processes such as landslides, mudslides, and erosion are actively occurring. In this zone, to maintain the ecological balance of landscapes, it is necessary for industrial sectors to adopt waste-free technologies, ensure the proper use of waste materials, carry out slope stabilization work in areas where various exodynamical processes frequently occur, and generally conduct periodic

monitoring. If these measures are implemented in a timely manner, we can return the lands we have lost due to degradation back into productive use.

One of the main events causing ecological problems in the northeastern part of the Lesser Caucasus is desertification and steppe formation, which result from anthropogenic interventions. One of the most pressing issues currently being studied is global warming and the hazardous consequences it generates. Based on calculations by researchers, it is expected that the average annual temperature will increase by more than 4°C in the 21st century (Verdiyeva, 2009, p. 56). As a result, this phenomenon may be accompanied by negative situations such as desertification, reduced precipitation, increased soil erosion, and the degradation of natural landscape types. These changes are already manifesting their consequences in the study area.

If the current dynamics and uncontrollability of anthropogenic interventions continue, it is expected that this area will expand by 2-3 times in the near future. To assess the natural-ecological status of the studied region, the level of relief fragmentation, slope steepness, and the characteristics and continuity of anthropogenic interventions were considered. In accordance with these factors, we have classified the natural landscapes based on their level of ecological degradation into the following types:

- I. Natural landscape zones with preserved ecological integrity;
- II. Natural-anthropogenic landscape zones with partially altered ecological integrity;
- III. Anthropogenic landscape zones with altered ecological integrity;
- IV. Anthropogenic landscape zones with predominantly altered ecological integrity;
- V. Anthropogenic landscape zones with ecologically critical degradation.

I. Natural Landscape Zones with Preserved Ecology. Natural landscape types with preserved ecology are found in subalpine and alpine meadows, nival and subnival landscapes, and mountainous meadow and forest landscape types in areas that are sparsely populated or subject to occasional or temporary anthropogenic interventions. These landscapes are more common in areas that are difficult to access. In the northeastern part of the Lesser Caucasus, such landscapes cover 11.8% of the area (Qaribov, 2010, p. 244). The territory of natural landscape types with preserved ecological conditions increases as one moves higher up the mountains. However, the ecological diversity of these landscapes sharply decreases in this direction. This reduction is associated with the increased fragmentation of the region's relief and the harsher climate conditions.

This landscape group is found in the Gobustan State Reserve area, the northern and northeastern slopes of the Shahdagh and Murovdagh mountain ranges near the watershed, the upper reaches of the Shamkirchay, Zayemchay, Goranchay, and Kurekchay river basins, as well as in the areas of Chinqildagh and Gaflangala mountain ranges in the northern part of the Bashkend-Dastafur depression, which are characterized by rugged, steep slopes. Notably, in the Gobustan State Reserve, the mountain forest, mountain meadow, and mountain steppe landscapes have been able to preserve their ecological diversity and natural landscape structure after strict protection measures were implemented.

II. Natural-Ecological Balance of Moderately Altered Natural-Anthropogenic Landscape Zones. These types of landscape zones include areas such as hayfields, grazing lands, many of the forests on relatively steep slopes, and so on. In the studied region, the area covered by natural-anthropogenic landscapes has been calculated to be 409,935 hectares. This area is distributed as follows across administrative districts: Dashkesen (44,952 ha), Goranboy (78,377 ha), Gadabay (32,320 ha), Tovuz (66,706 ha), Gazakh (20,536 ha), Agstafa (14,447 ha), Goygol (47,545 ha), and Shemkir (90,025 ha). The natural ecological state of these partially altered natural-anthropogenic landscapes and the overall landscape loading factor of the studied area is 0.4 (Haqverdiyev, 1977, p. 32). The rich natural landscape resources of the Lesser Caucasus have historically contributed to the development of pasture and grazing land complexes in the region. Unlike other anthropogenic landscape zones, the pasture and grazing land complexes in the studied area have managed to retain their natural ecological structure from ancient times to the present day. The development of livestock

farming here has been accompanied not only by the transformation of the natural landscapes of the mountainous and flat grazing lands but also by changes in the forest, forest-shrub, and other types of landscapes. In the region's modern grazing-pasture systems, it is crucial to strictly adhere to grazing norms and, at times, implement rotational grazing. Additionally, measures must be taken to prevent changes in plant communities in the pastures caused by overgrazing. To preserve the fertility of pasture areas, it is essential to establish cultural hayfields, including pastures in arid steppes and semi-desert regions, over extensive areas.

III. Anthropogenic Landscape Zones with Altered Natural Ecology. This category includes anthropogenic landscape types in which the natural ecological conditions have been significantly modified. Such landscapes consist of irrigated and rain-fed croplands, orchards, and garden-plot systems. In these areas, the soil-vegetation cover has undergone considerable transformation, the ecological state of fauna has been severely disrupted, and natural biodiversity has, in many cases, been entirely lost. The development of these landscape zones along integrated typological lines has accelerated across extensive territories.

To enhance ecological sustainability within these anthropogenically transformed landscapes, it is essential to focus on preserving and expanding ecotones - such as inter-field forest belts, irrigation canals, shrublands, unused plots, ponds, water reservoirs, and remnants of natural forests (Kerimov, 2005, p. 18). Additionally, the application of crop rotation practices, adherence to agro-technical standards, and the expansion of unused buffer zones within cultivated areas are necessary to mitigate further ecological degradation.

IV. Anthropogenic Landscape Zones with Significantly Altered Natural Ecology. This category includes anthropogenic landscapes in which the natural ecological structure has been predominantly transformed. These landscapes encompass partially urbanized areas, residential settlements, artificial aquatic complexes, and transportation and communication infrastructure. A key characteristic of such landscape types is the pronounced presence of technogenic surfaces, a fundamental disruption of the natural ecological framework, and the near-total loss of biological diversity. In the studied region, these anthropogenically dominated landscapes cover approximately 10.5% of the total area. Specifically, in the northeastern part of the Lesser Caucasus, residential complexes (seliteb) account for 12.6 thousand hectares, which represents about 1.0% of the territory. Water reservoirs and canal systems occupy 56.1 thousand hectares (1.5%), while roads and various built-up structures cover an additional 7.5 thousand hectares (0.8%) (Abbasova, 2022, p. 139).

Anthropogenic landscapes, whose natural ecology has been drastically altered, are distributed according to the vertical zonation of the region. Their spatial extent is significantly broader in foothill areas, gently sloping plains, wide river valleys, and intermountain depressions, while in high mountain zones and steep slopes, their presence is considerably reduced. It should be noted that in recent years, the area occupied by road networks and residential (seliteb) landscapes has been increasing rapidly. Therefore, a comprehensive set of measures must be developed and implemented in these complexes to improve the ecological condition of the landscapes.

V. Natural Ecology of Landscape Zones Severely Altered by Anthropogenic Factors. This group of anthropogenic landscapes includes areas degraded by mining and quarrying industries, zones polluted with industrial and household waste, barren rocky sites, gullies and ravines, areas rendered unproductive due to erosion, and locations contaminated by industrial facilities, among others. These landscapes are characterized by significant alterations to their natural ecological balance, leading to ecological crises and severe environmental degradation.

Conclusion. An analysis of the trends in the natural and anthropogenic alterations of the landscapes on the northeastern slope of the Greater Caucasus reveals that, in recent years, the process of xerophilization of landscapes has been ongoing across all elevation zones of the region. As a result, due to anthropogenic impacts, the majority of the semi-desert, steppe, mountain-steppe, forest, forest-shrub, subalpine, and alpine meadow complexes in the studied area have been significantly altered. Research indicates that the primary direction of landscape changes on the northeastern slope of the

Lesser Caucasus is the recent intensive development of various economic sectors, particularly the mining industry, which is characteristic of industrial areas, as well as agriculture, silviculture, recreation, and other complexes. The intensive anthropogenization of natural landscapes gradually leads to the expansion of agricultural land, the construction of roads, the creation of hydro-technical and industrial structures, and the establishment of new settlements. As a result, forest and forest-shrub areas have decreased, degraded areas in pastures have expanded, and the process of slope erosion has intensified. The nature of quantitative and qualitative changes in natural complexes must be determined in advance during the use of natural resources. If the trends of development and dynamics of natural complexes, their resistance to anthropogenic impacts, and other characteristics are not sufficiently studied, it can lead to the disruption of the landscape-ecological balance and normal functioning of the geosystem. Therefore, to identify the development trends of modern landscapes, it is necessary to predict and optimize several parameters of the various landscape complexes in the studied area. Considering the significant recreational and tourism potential of the studied area, it is essential to implement comprehensive reclamation measures in these anthropogenic landscapes and apply ecologically clean industrial technologies.

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