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GROUPING OF GEOSYSTEMS ACCORDING TO THE DEGREE OF ECOLOGICAL TENSION AND ORGANIZATION OF ECOLOGICAL MANAGEMENT IN LANDSCAPE PLANNING

Aim: This article aims to assess the ecological situation in the Gudyalchay-Samurchay interfluve area to support landscape planning and socio-economic management. The study focuses on identifying natural-anthropogenic effects, sustainability, natural resources, socio-economic functions, and natural-anthropogenic conflicts in the area.

Methodology: The study employs landscape-ecological planning and analysis techniques to evaluate the ecological condition of landscapes in the area. The tension level of the ecological situation is categorized into five levels: satisfactory, dangerous, stressed, crisis, and catastrophic. The assessment considers various landscape types and their structural and functional characteristics, as well as the impact of natural and anthropogenic factors.

Results: The study reveals that landscapes with satisfactory ecological conditions are predominantly found in nival and subnival rock-glacial ecosystems. However, other landscape types show limited areas with satisfactory conditions. Dangerous, stressed, crisis, and catastrophic ecological situations are observed in different landscape types, with varying degrees of ecological stress and irreversible changes in the landscape components.

The ecological assessment and the implementation of the ecological carcass concept are crucial for landscape planning and the sustainable development of the Gudyalchay-Samurchay interfluve area. The findings provide valuable insights for policymakers and land managers in balancing socio-economic activities with ecological considerations, protecting natural resources, and improving the overall ecological situation in the region.

Scientific Novelty: The article highlights the concept of the ecological carcass as a framework for nature protection and management. It emphasizes the importance of specially protected natural areas, ecological corridors, natural forest ecosystems, and ecological education for local communities. The ecological carcass approach aims to ensure the ecological balance, prevent biodiversity loss and landscape degradation, and promote sustainable coexistence of humans and natural resources.

Keywords: Greater Caucasus, efficient use of nature, landscapes, degree of ecological tension, ecological carcass.

Intraduction. The implementation of landscape planning and the correct organization of socio-economic management, including activities such as economy, recreation, etc., are closely related to the proper and scientific assessment of the ecological situation in the studied area [2]. The rich natural and ecological potential of the research area between the Gudyalchay-Samurchay rivers has created the need to implement a number of infrastructure projects that meet modern requirements. The implementation of these types of projects or measures is closely related to the landscape-ecological balance of the area in terms of achieving positive results, especially in intensively populated and urbanized areas [6].

The application of landscape-ecological planning requires consideration of the ecological condition of landscapes in the area at different levels [5]. Therefore, the implementation of analysis and generalization between the stages that determine the ecological status of landscapes increases the objectivity of the obtained result. The following factors reflecting the real state of landscapes in the area should be identified: 1. Natural-anthropogenic effects on landscapes; 2. Sustainability; 3. Natural resources and ecological potential; 4. Socio-economic function of the geosystem; 5. Natural-anthropogenic conflicts. Depending on the purpose of spatial planning, these are used in the implementation of landscape programs (at 1:500000 and smaller scales), in the preparation of framework landscape plans (at scales from 1:200000 to 1:100000), in large-scale landscape planning (1:25000) and it should also be used in the preparation of integrated measures and organization of environmental management. [11].

Currently, one of the main directions of landscape research is the assessment of the ecological state of geosystems against the background of intensively increasing anthropogenic influences [3; 10]. Based on the conducted studies, it can be noted that the tension level of the ecological situation increases with the rise of anthropogenic load on landscapes.

Analysis and discussion. Favorable natural conditions of the landscapes of the studied area have historically led to the increase of anthropogenic loading and the formation of various levels of transformations. The fact that there is a close relationship between the transformation and stability of landscapes in the area and ecological stress requires that this factor be taken into account in the assessment of the ecological situation. For example, the grass-steppe and shrub-steppe landscapes of Yerfi, Gonaqkend,

Khinalig, etc. mountain depressions in the study area were degraded in a short time with the development of animal husbandry and led to the formation of badland landscapes on steep slopes due to their weak stability. As a result, consideration of the optimal ratio of heat and humidity is considered one of the main factors.

Depending on the level of anthropogenic loading in the studied area, the landscapes were evaluated in five categories according to the tension level of the ecological situation: 1. Satisfactory (Sa); 2. Dangerous (D); 3. Stressed (St); 4. Crisis (Cr); 5. Catastrophic (C) (table 1).

Table 1

Grouping of landscapes according to the degree of ecological tension

Landscapes	*Environmental tension level of landscapes*	*Current ecological state of the landscape and the level of self-recovery*	*Demographic load (D) and change in socioeconomic function*	*The impact of natural-anthropogenic environmental risks on human activity*	*Measures for improvement*
Nival and subnival	Sa – 95% D – 5%	Decline of glaciers, normal self-recovery	D=0 people, partial reduction in water supply	High	Self-restoration processes
Alpine meadows	Sa – 70-75% D – 10-15% St – 8-10%	Transformation below 30%, vegetation degradation, soil erosion	D=1-3 people/km^2, Decrease of seasonal feed stock and biodiversity, landslides	Relatively high	Grazing rate, sowing plant seeds, protection of steep slopes, fight against landslides
Subalpine and post-forest montane meadows	Sa – 10-15% D – 15-20% St – 10-15% Cr – 25-30% C – 5-10%	Transformation 40-50%, vegetation degradation, biodiversity loss, landslides, etc.	D=10-20 people/km^2 A decrease in the potential and productivity of the soils, a decrease in population income, an increase in migration	Medium and high	Erosion, combating the decline of useful plant species, protecting valuable species, planting trees and shrubs, ecosystem services
Mountain forests	Sa – 25-30% D – 20-25% St – 7-10% Cr – 30-35%	Transformation 40-45%, grazing, felling or damage to trees, landslide in deforested area, high and medium self-recovery	D=20-25 people/km^2 population intervention in the forest ecosystem, decrease in settlements, decrease in income, migration, etc.	Medium, weak and very weak	Forest planting, reforestation and forest planning works, basing the economy on ecosystem services, transition to "green economy", landscape planning
Forest steppes of the foothill slope	Sa – 15-20% D – 10-15% St – 25-30% Cr – 20-25% C – 8-10%	Transformation 50-60%, deforestation, soil erosion	D=60-70 people/km^2, increase of cultivated areas, increase of effects on ecosystems	High	Implementation of meliorative measures, optimization of economic activities
Forest and forest-steppe landscapes of the plains	Sa – 20-30% D – 15-25% St – 15-20% Cr – 10-15% C – 12-20%	Transformation up to 50%, deforestation, negative impacts on biodiversity	D=30-40 people/km^2, impact of tourism activity on ecosystems, increase of settlements	High and medium	Landscape planning, nature protection measures, reforestation
Dry steppe and xerophytic-steppe landscapes of the plains	Sa – 8-10% D – 25-30% St – 8-10% Cr – 30-35% C – 10-15%	Transformation 70-75%, soil degradation, erosion and salinization	D=160-170 people/km^2, strengthening of irrigated agriculture, increase of population and economic systems	Very high	Investing in farming systems, taking reclamation measures, organizing a framework landscape plan

Due to their ecological condition in landscapes that are *satisfactory*, there are no serious changes in the structural and functional characteristics of geosystems due to the influence of natural and anthropogenic

factors and they have sufficient self-recovery capabilities. Anthropogenic disturbances are observed in these types of landscapes with the disappearance or reduction of some plant and animal species.

At the type level landscapes with satisfactory ecological conditions are more widespread in nival and subnival rock-glacial ecosystems. Under the influence of natural factors, only 5% of this landscape is subject to the melting of glaciers due to climate change [7] Therefore, water resources in this landscape are likely to decrease in the near future. Although the mentioned landscape has a satisfactory ecological condition, it is unfavorable for people's life activities due to natural climatic conditions and harsh natural regimes. In other landscape types, natural complexes with a satisfactory ecological structure cover very small area.

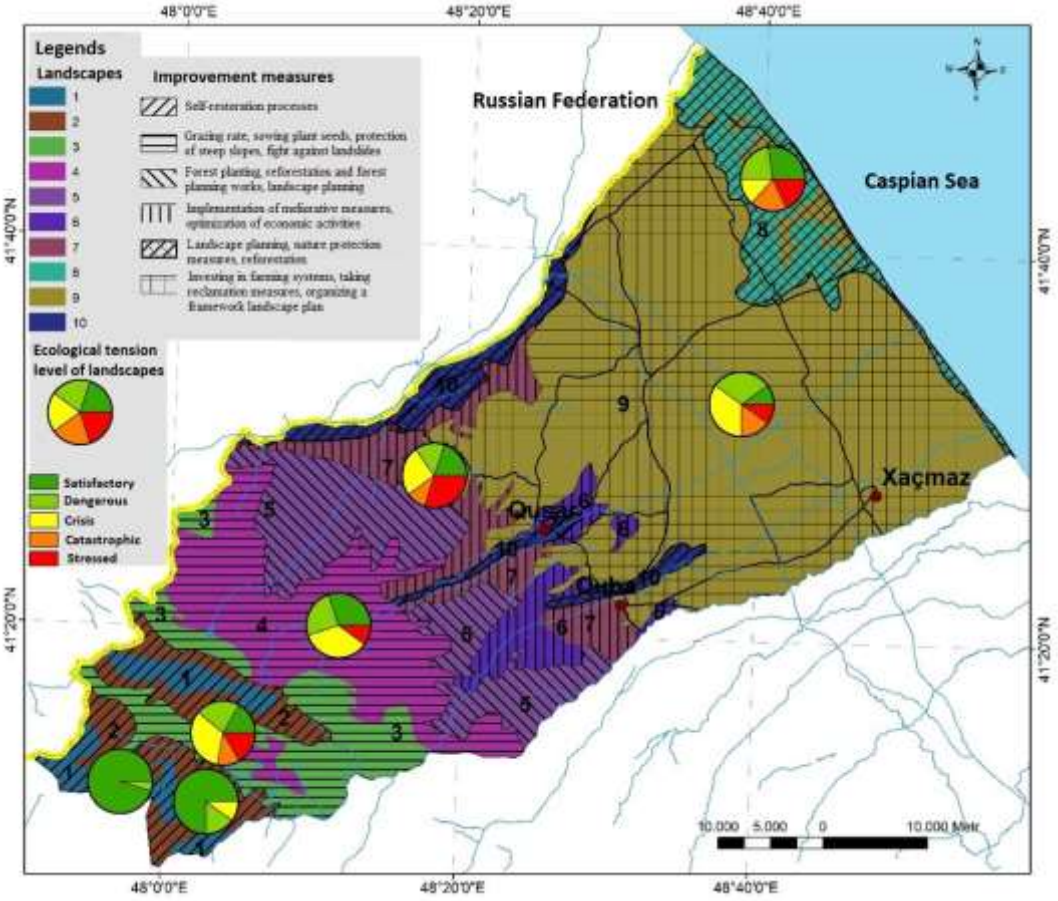

Figure 1. Assessment of the ecological condition of natural-anthropogenic landscapes

Critical changes in one or more dynamic natural components are observed in landscapes with a *dangerous* ecological situation. Mountain forest and mountain meadow landscapes are more widespread in the area. The main ecological problem is the trampling of the forest floor, the increase in soil density, the occurrence of injuries and diseases in trees, the cessation of reforestation, the activation of erosion and local landslides in mountain grassland landscapes, etc.

Landscape areas with *stressed* ecological tension cover 25-30% of the subalpine and post-forest mountain-meadow complexes, 20-25% of the forest steppe, and 30-35% of the plain dry-steppe and xerophyte steppes. This type of landscape is characterized by the expansion of agrolandscapes, agricultural land, and road communication systems, there are noticeable changes in the relief and soil cover.

Areas characterized by a crisis ecological situation are most widespread in the forest-steppe of the foothill sloping plains (25-30%) and in the forest and forest-steppe of the plains (15-20%). Here, the demographic load reaches 60-70 people per square meter. The main sign of ecological stress is the occurrence of irreversible changes in the relatively stable components of the landscape, the reduction of landscape-ecological diversity with the expansion of agro-ecosystems, the pollution of surface water, the increase of industrial waste, etc. Improving the ecological situation in such areas requires considerable funds.

Areas whose ecological condition has reached a catastrophic level are spread in all-natural complexes in the area, except for nival, subnival, and alpine meadow landscapes. Landscapes with catastrophic

environmental conditions, although occupying a small area, have a leading force in the overall landscape structure. In these areas, the natural components have fundamentally changed in an undesirable direction.

Application of ecological carcass in landscape planning and ways of its improvement. At the modern stage of society's development, along with the sharp increase of all kinds of anthropogenic influences, the increase in the value of natural resources requires the regulation of the use of nature and the development of new procedures and mechanisms. The concept of the ecological carcass is a set of ecosystems that protect the ecological balance of the area, prevent the loss of biodiversity and landscape degradation, and determine the mode of nature use [8]. The functions of the ecological carcass are performed by appropriate legal, economic, and managerial mechanisms, which must be coordinated with the current level of economic infrastructure and nature management technologies. The purpose of the ecological carcass is to ensure the ecological balance of the entire area or its separate parts with maximum efficiency, maintaining a flexible system of differential management of nature. [9]. Ecological framework is not only a form of nature protection, but also a method of nature management that ensures long-term and sustainable coexistence of human and natural resources and increases economic efficiency.

Specially protected natural areas and ecological corridors connecting the elements of nature are the basis for the formation of the ecological carcass [12]. At the same time, economic structures, pastures and meadows, forest ecosystems, as well as unique natural monuments, which influence the management of modern nature and its formation, are also considered as important elements. In this regard, studying the elements of nature as a whole system is very important in ensuring sustainability. It should be noted that in Azerbaijan it is considered appropriate to group the structural elements of the landscape-ecological frame into 4 levels [4]. These are: a) specially protected natural areas where anthropogenic impacts are limited at the country level; b) protected natural complexes on state fund lands at the regional level, including natural forest ecosystems; c) areas where anthropogenic loading is regulated at the local level (natural monuments, areas where greening measures are taken, etc.); d) improvement of land use at the individual farmer level - compliance with grazing rules, areas covered by erosion control measures.

First of all, national parks were mentioned as the main elements for building a model of the ecological carcass of the Samurchay-Gudyalchay interfluve, which is the study area. There are two national parks in the area - Shahdag National Park and Samur-Yalama National Park. Shahdag National Park, which is the largest specially protected natural area of Azerbaijan, covers the highlands of Guba and Gusar districts in the study area. The highest mountain peaks of the country - Bazarduzu (4466 m), Shahdag (4243 m), Tufandag (4191 m) and others. located in the territory of the national park. The national park, characterized by its rich biodiversity, protects mountain ecosystems, including forest ecosystems of the middle highlands, nival-glacial and rocky ecosystems of the highlands, and a number of rare species of fauna and flora. The checkpoints of the national park are located near Laza village of Gusar district and Khinalig village of Guba district. In recent years, significant progress has been made in the development of mountain tourism. Thus, the main reasons for using the tourism potential of the area are the fact that the tourist routes to the main high mountain peaks pass through the territory of Khinalig and Laza villages and the increasing interest in mountaineering sports in recent years.

Samur-Yalama National Park is another specially protected natural area located in the study area. The national park was established in 2012 in the territory of Khachmaz administrative district [1]. The main goals of its creation are the protection of the environment, including biodiversity, its effective use, the improvement of environmental knowledge and education of the population, conducting scientific research, the restoration of natural and historical-cultural objects, etc. Unique intrazonal lowland forest ecosystems are protected in Samur-Yalama National Park. In the territory of the national park, there are several tourist routes, such as Yalama-Salimoba, Tel Bulaghi-Shimal village, etc., to observe the natural monuments. At the same time, there are a number of conflicts in terms of the impact of the population living around the national park and the tourism-recreation facilities on the environment. In order to seriously protect the national park from external influences, it is necessary to take additional measures and organize environmental education with local communities.

Natural forest ecosystems contained in state forest fund lands and managed by the Forestry Development Department should also be considered important elements of the ecological carcass. These areas are spread both in the middle mountainous zone and in the plains. In recent decades, the impact of human activity is more pronounced in natural forests and forest thickets that are not under special protection. Since these areas are suitable for settlement, they have been affected by farming systems for centuries. As an example, it is possible to show the serious effects on the ecosystems located in the southwest of Galajig village of Gusar district (Fig. 2). Thus, it can be observed with satellite images that the natural forests and thickets spread here have been destroyed in an area of 12 km^2 during the last 3 years.

In this regard, the precise identification of the structural elements of the ecological carcass allows the creation of territorial standards for the use of nature and the designation of ecosystems to be protected. The ecological carcass created to protect and improve the functional integrity of both natural and socio-economic systems has an important role.

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Figure 2. Anthropogenic effects on natural ecosystems near Galajig village, Gusar district

Another important element of the ecological carcass is ecological corridors. Ecological corridors play a very important role in facilitating the migration of fauna and flora species and connecting natural components with each other. Disruption of migration processes and coordination systems causes an imbalance in the natural environment. During the determination of ecological corridors in the study area, river systems, and valley depressions were taken as the basis. The valleys of rivers such as Samur, Gudyalchay, Gusarchay, and Agchay, which flow in the region, were considered more favorable for the fulfillment of the corridor function in the ecological network (Fig. 3).

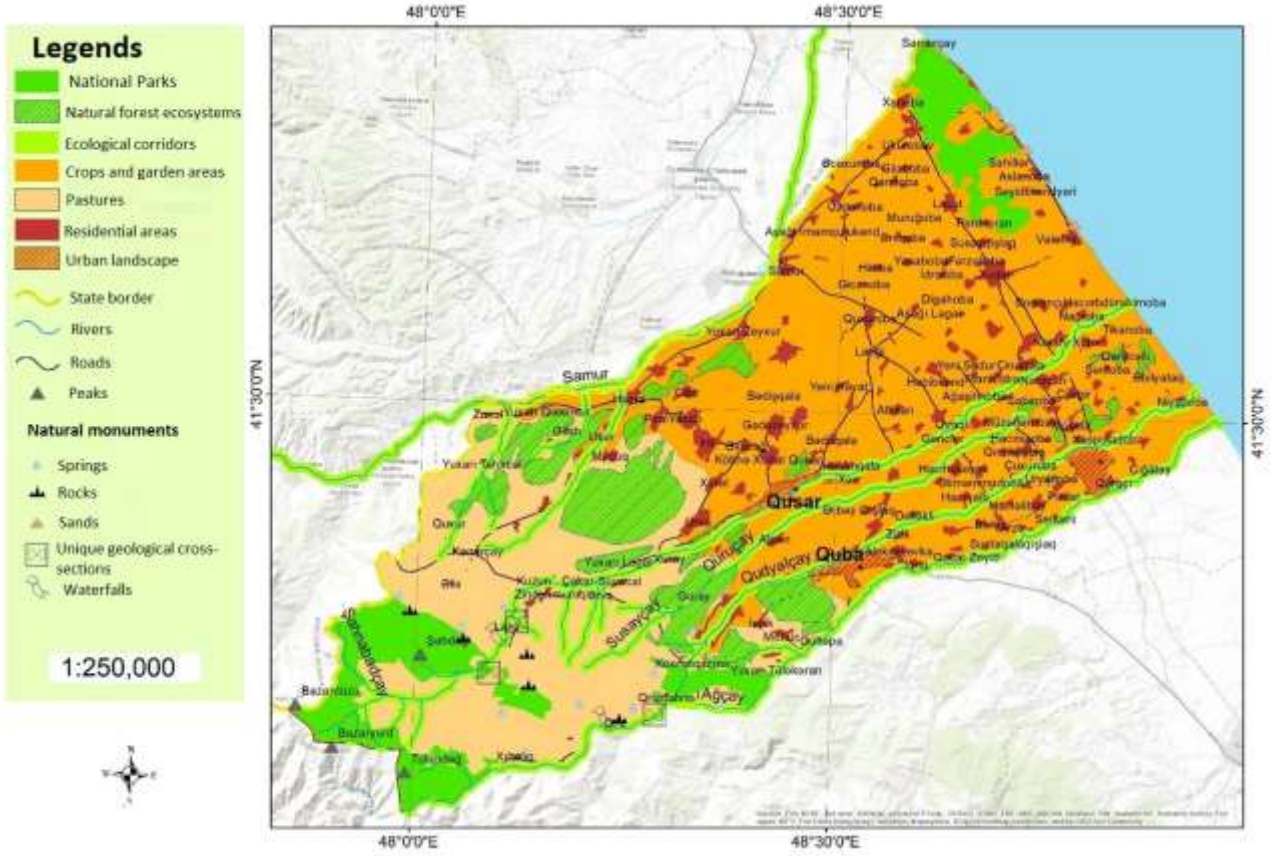

Figure 3. Ecological carcass model of geocomplexes between Samurchay-Gudyalchay rivers

However, at the regional level, the elements of the ecological carcass cannot be considered only as natural systems. In this process, it is important to take into account the geocomplexes that have emerged from nature and social relations. Land resources in the study area from the foothills to the coasts of the

Caspian Sea are complexes where agricultural culture has been formed since ancient times. Favorable soil-climate conditions for the development of settlement and economic systems led to the rapid and dynamic development of the appropriation processes. From this point of view, it is very necessary to determine the boundaries of settlements and cultivated and garden areas formed in the surrounding areas and ways of improvement as an element of the ecological framework (Table 2).

Table 2

Directions for improving the ecological carcass

Elements of the ecological carcass	*Directions for improvement and development*
National parks	Protecting ecosystems and supporting ecotourism.
Forest ecosystems	Creation of conditions for the reforestation process, strengthening of protection conditions.
Ecological corridors	Organization of protection, limitation of athropogenic effects.
Residential areas	Measures to combat natural disasters; development of socio-economic infrastructure; conducting environmental education.
Plantation and garden areas	Application of modern technologies in planting and irrigation systems; implementation of local economy stimulation measures.
Pasture areas	Regulation of loading on pastures; development strategies based on ecological norms
Natural monuments	Taking protective measures, limiting external interventions, organizing monitoring, supporting ecotourism activities.

Pasture fields play an important role in the development of animal husbandry, which is the main field of agriculture. Throughout history, experience shows that the optimal development of animal husbandry is to keep and graze cattle in high mountain pastures in summer, and in wind-protected river valleys, intermountain depressions, and mountain slopes in winter. Determining pasture areas as an element of the ecological carcass and defining development prospects will create conditions for increasing livestock productivity and rational use of pasture resources. As in other areas of the republic, soil erosion and degradation are observed as a result of intensive grazing processes in the research region. It should be noted that the quality indicators of the soil are taken into account when assessing the demand for pasture land according to the rules of "Renting, using, and grazing, of pastures and mowing areas" stipulated in the legislation. According to those rules, up to 4 heads of sheep are allowed to graze on one hectare in winter pastures, and up to 8 heads in summer pastures. Our observations in the research area show repeated violations of these norms. For this reason, there is a need to develop special programs and plans for the development of pastures.

Natural monuments are relatively small areas of state importance represented by rare, unique, and highly aesthetic ecosystems, specific geographical and hydrological objects, individual plant samples, or remains of living organisms. Rocks of geological value in the study area, as well as natural monuments such as unique geological cuts, waterfalls, springs, sand dunes, etc., are registered as important elements of the ecological carcass (Fig. 4.2.2). These objects include sand dunes on the shores of the Caspian Sea, Gryz and Laza waterfalls, canyon-type geological formations in the upper reaches of the Gudyalchay and Gusarchay rivers, rocky geocomplexes located in the Shahdag and Gizilgaya massifs, as well as natural springs in villages such as Gryz, Gryzdahne, Kusnetgazma, Laza, etc. Taking protection measures in natural monuments, limiting or regulating extraneous anthropogenic influences, and regular monitoring should be planned as the main directions of action from the point of view of management. Another important point is to support ecotourism activities for natural monuments and organize environmental promotion mechanisms through public education.

Thus, the socio-economic development of the region depends on the ecological balance and stable functioning of all components of nature. The ecological carcass concept of the territory is a form of environmental management for solving the problems of optimal organization of geocomplexes and rational use of natural ecosystems.

Conclusion

- For the first time in the research area, landscapes were grouped according to the degree of ecological tension caused by the influence of ecodynamic processes in geocomplexes with complex structures. It was found that there is a direct correlation between the anthropogenic loading and transformation of natural complexes and the spatial difference in their ecological tension level.

- According to the degree of ecological tension, landscapes are divided into five groups: satisfactory, dangerous, stressed, crisis and catastrophic. Landscapes with satisfactory ecological tension are found in nival-subnival (95%), alpine meadows (70-75%), and mountain-forest (25-30%) complexes, and landscapes with catastrophic ecological tension are mostly found in forest steppes of sloping plains (15-20%) and in dry-steppe and xerophyte-steppe complexes of accumulative plains.

- For the first time, there was proposed a landscape-ecological framework model of ecological management for the study area. The elements of the landscape-ecological carcass are classified according to their spatial structure and differential characteristics.

References

1. Arnegger, J., Dieterich, T., Rodina, V. Local awareness, acceptance, and tourism development: challenges and opportunities for protected area management in post-Soviet countries-the Samur-Yalama National Park, Azerbaijan // Proc. of the 7th International Conference on Monitoring and Management of Visitors in Recreational and Protected Areas, Tallinn: – 2014. – V. 20. – № 23. – pp. 148-150.
2. Bolshakov, A.G., Lonshakov, D.A. Landscape planning principles for organizing recreation on the basis of a ravine-pond landscape in the Belgorod suburban area // Bulletin of the Irkutsk State Technical University. – 2014. – №2 (85). – pp. 117-126 (in Rus.).
3. Guliyeva, S.Y. Natural and anthropogenic factors in hazard assesment of the Alpine–Himalayan montane ecosystems (at the example of the Azerbaijan Caucasus) / S.Y.Guliyeva, I.Y.Kuchinskaya, S.A.Tarikhaser [et al.] // Comptes rendus de l'Académie bulgare des Sciences, – 2019, – 72(9). – pp. 1227-1233.
4. Ismayilov, M., Jabrayilov, E. Protected areas in Azerbaijan: landscape-ecological diversity and sustainability // Ankara Üniversitesi Çevrebilimleri Dergisi. – 2019. – V. 7. – № 2. – pp. 31-42.
5. Ismayilov, M.J. Study of the ecological diversity of the landscapes of the northeastern slopes of the Greater Caucasus // Proceedings of the Azerbaijan Geographical Society –V. 8 , –Baku: – 2003. – pp. 98-101 (in Aze.).
6. Ismayilov, M.J., Dadashova, Kh.D. Study of the landscape-ecological basis of the formation of urbanized areas in Azerbaijan with GIS technologies // – Baku: Ministry of Education of the Republic of Azerbaijan, Baku State University, Geography: Theory, Practice and Innovation, – 2015. – pp. 119-124 (in Aze.).
7. Ismayilov, M.J., Jabrayilov, E.A. The dynamics of the nival-glacial ecosystems of Azerbaijan in the conditions of climate change and its expected results // Geography and natural resources, – Baku – 2022. – №1(16), – pp. 16-21 (in Aze.).
8. Kolbovsky, E.Yu. Regional ecological carcass: problems of formation and development // Probl. region. ecology. – 1999. – № 4. – pp. 78-91 (in Rus.).
9. Ponomarev, A.A., Baibakov E.I., Rubtsov V.A. Ecological framework: analysis of concepts. Scientific Notes of Kazan University. Series Natural Sciences. – 2012. – V. 154. – № 3. – pp. 228-238 (in Rus.).
10. Preobrazhensky, V.S. The essence and forms of manifestation of geoecological ideas in domestic science. Proceedings of the Russian Academy of Sciences. Geographic series. –1992, – №4, – pp. 5-11. (in Rus.).
11. Sazonov, K.N. Land management design. / K.N. Sazonov - M .: L .: Selkhozizdat, - 193 p. (in Rus.).
12. Voronov, B.A., Narbut, N.A. Ecological carcass of the territory and its systemic properties // Geography and natural resources. – 2013. – №3. – pp. 171-177 (in Rus.).

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