

SOCIO-ECONOMIC FOUNDATIONS OF LANDSCAPE PLANNING ON THE NORTHEASTERN SLOPE OF THE LESSER CAUCASUS

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Abstract

The northeastern slope of the Lesser Caucasus is one of the regions of Azerbaijan distinguished by its natural-geographical diversity and socio-economic potential. The purpose of the study is to investigate the socio-economic basis of landscape planning in this zone, which includes the districts of Gazakh, Aghstafa, Tovuz, Shamkir, Gadabay, Dashkasan, Goygol, and the cities of Ganja and Naftalan, and to assess the optimal balance between the natural environment and anthropogenic activities. The research analyzes the region's natural-geographical conditions, landscape structure, economic activity sectors, and population settlement patterns, and identifies principles for aligning land and resource use with landscape potential.

The analysis shows that increasing anthropogenic pressure, land degradation, reduction of forest cover, uneven grazing load, and inefficient use of water resources have significant impacts on the region's ecological stability. The main directions of landscape planning include sustainable management of land and water resources, restoration of forest and grassland ecosystems, ecologically compliant organization of urban and industrial landscapes, development of ecotourism, and formation of a regional ecological network. A differentiated land - resource use model is proposed for each landscape type, ensuring the conservation of natural complexes and the sustainable development of socio-economic activities.

1. Introduction

The northeastern slope of the Lesser Caucasus occupies an important place within the natural-geographical system of Azerbaijan and is distinguished by its high landscape diversity, rich biological resources, and favorable economic-geographical position. The region's relief, climatic conditions, soil and vegetation cover create broad opportunities for the development of such sectors as agriculture, forestry, and tourism. However, in recent decades, increasing anthropogenic pressure, inefficient use of land and water resources, reduction of forest cover, erosion, and the intensification of other degradation processes have been observed across the area [6]. These processes negatively affect the natural stability of landscapes and the sustainability of socio-economic development.

At the present stage, the integration of ecogeographical and socio-economic approaches in regional management is of great importance. In this context, landscape planning serves as a scientifically grounded framework for spatial organization

and resource use [11; 13]. This approach is based on the principles of ecological stability and sustainable development, taking into account the interactions among landscape components, the carrying capacity of the natural environment, and the socio-economic needs of the population [2; 3].

The implementation of landscape planning on the northeastern slope of the Lesser Caucasus can contribute to the optimal use of the region's natural resource potential, the protection of land and water resources, and the ecological compatibility of tourism and agricultural activities. Research carried out in this direction serves both the theoretical development of ecogeographical planning and the practical improvement of regional management decisions [14].

The aim of the article is to determine the socio-economic foundations of landscape planning on the northeastern slope of the Lesser Caucasus, to assess the interaction between natural and anthropogenic factors, and to develop scientific and practical recommendations for the sustainable development of the region.

To achieve this objective, the following tasks have been defined:

- to analyze the natural–geographical characteristics of the study area;
- to assess the impact of socio-economic conditions on the landscape structure;
- to identify the scientific and methodological foundations of landscape planning;
- to substantiate ecologically and economically optimal planning directions for the region.

2. Analysis and Discussion

Physical–geographical conditions of the study area. The study area is located in the western part of Azerbaijan, on the northeastern slopes of the Lesser Caucasus, within the administrative territories of the Gazakh-Tovuz and Ganja-Dashkasan economic regions – covering the districts of Gazakh, Aghstafa, Tovuz, Shamkir, Gadabay, Dashkasan, Goygol, as well as the cities of Ganja and Naftalan. This zone is bordered by the Kur-Araz Lowland to the east and the Murovdag Range to the south. The total area exceeds 10,000 km² and is characterized by sharply dissected relief, altitudinal zonality, and significant geological–geomorphological diversity.

The relief of the region is characterized by complex mountainous and foothill forms. Elevations range from 200 to 3,700 meters above sea level. In accordance with altitudinal zonation, the climate varies from semi-desert and dry steppe

conditions in the lowlands to moderately warm and cold climatic types in the foothill and mountain zones. Below 1,000 meters, xerophytic dry steppe and arid forest landscapes predominate; the mean annual temperature is 10–12°C, and precipitation ranges between 350–400 mm. The humidity index (0.15–0.35) reflects an arid environment. At elevations of 1,000–2,200 meters, cooler and more humid conditions form within the mountain-forest and meadow-steppe zones, where annual precipitation reaches 600–700 mm and the humidity index ranges from 0.35 to 0.60. In the subalpine and alpine meadows at 2,200–3,300 meters, temperatures decrease sharply, precipitation totals 500–600 mm, and excessive moisture conditions develop (humidity index above 0.60). Above 3,300 meters, in the subnival zone, very low temperatures and minimal precipitation are observed, forming a harsh high-mountain climate (Table 1).

The main water artery of the area is the Kura River and its tributaries – Tovuzchay, Shamkirchay, Zayamchay, Goshgarchay, and others. Several reservoirs (Shamkir, Yenikand, Aghstafa, Shamkirchay) are located in the region, which are of great importance for both energy production and irrigation. In the mountainous parts, river flow is high and variable, which increases the hazard of erosion and flash flood processes.

Table 1

Main climate indicators of the northeastern slope of the Lesser Caucasus

Elevation belts a.s.l. (m)	Main landscape types	Air temperature, °C			Sum of temperatures above 10°C	Long-term mean precipitation, mm	Humidity index
		Annual mean	Mean January	Mean July			
Up to 1000 m	Xerophytic dry steppe and arid forests	10-12	0-1	22-24	2800-3300	350-400	Arid and semi-arid, 0.15–0.35
1000-2200	Mountain-forest and meadow-steppe	8-10	-2-0	15-20	2400-2800	600-700	Semi-humid and humid, 0.35–0.60
2200-3300	Mountain meadows, subalpine and alpine	4-8	-5 to -20	5-15	1500-2000	500-600	Excessive humidity, >0.60
Above 3300	Subnival rocky landscapes	0-2 or lower	Below -5	Below 5	Less than 1000	Less than 500	Excessive humidity, >0.60

Source: Indicators calculated by the author using the National Atlas of the Republic of Azerbaijan [12].

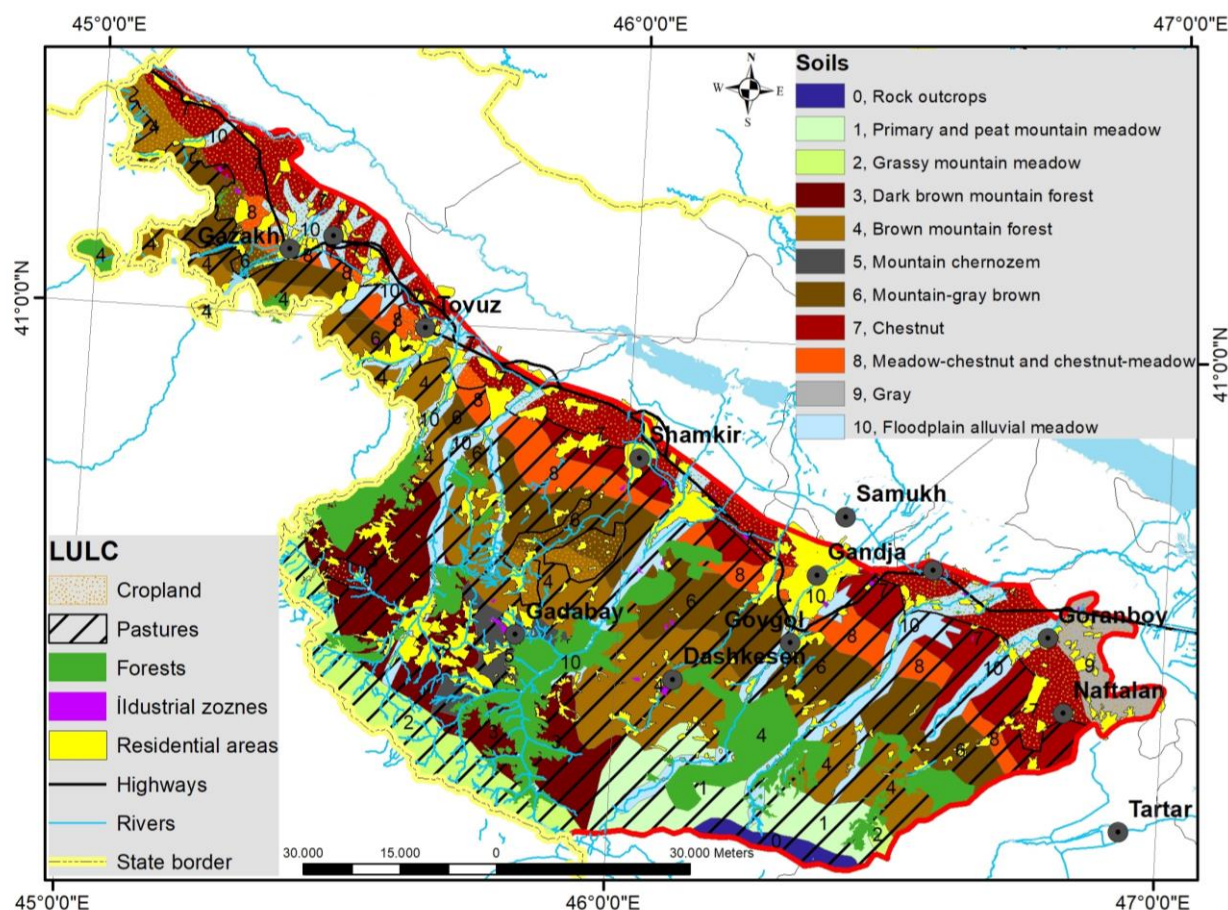


Figure 1. Soil and land use map of the northeastern slope of the Lesser Caucasus

According to soil cover, gray-brown and light gray-brown soils dominate the lowland and foothill zones, while mountain areas are characterized by mountain-forest brown soils, dark brown mountain-forest soils, and mountain-meadow soils [8] (Fig. 1). In recent years, soil erosion and degradation have intensified due to intensive agriculture and grazing pressure. The main natural landscape types in the area include lowland semi-desert and arid landscapes, foothill forest and shrub landscapes, middle-mountain forest landscapes, and subalpine and alpine meadows [7]. Oak, beech, and hornbeam species predominate in the forests [9]. In the foothill areas, orchards, cereal fields, and vineyards are widely distributed.

The landscapes of the region have been shaped by the interaction of natural factors (relief, climate, geological conditions) and human economic activities. Deforestation, grazing pressure, mining, and industrial operations have led to ecological stress. In the Gadabay and Dashkasan zones, the impact of the mountain-mining industry, and in the Tovuz–Shamkir zone, the intensive use of agricultural and irrigated lands, disrupt the natural balance of the landscapes [15]. Under these conditions, the implementation of landscape planning

is a necessary measure to protect the natural potential of the area and to ensure the ecological compatibility of socio-economic activities.

The study area, located in western Azerbaijan, has developed as one of the country's economic, cultural, and industrial centers. The region is distinguished by its favorable natural–geographical position, diverse economic activities, and rich natural resources [10]. The socio-economic development of the region directly affects the landscape structure, and consideration of these factors is of particular importance in the planning process.

Characteristics of the socio-economic conditions. The city of Ganja, as the main urban center of the region, plays a leading role in the economic and social life of the surrounding districts [4]. The majority of the population is settled in the foothill and lowland zones, while settlement in the mountainous areas is more sparse. In recent years, migration processes have been observed across the region, particularly the outflow of young people to large cities, which affects the structure of the labor force and the development potential of agriculture.

Table 2

Sown area of agricultural crops, 2024

Districts	Total area (thousand km ²)	Total sown area (ha)	Share of district area (%)
Aghstafa	1,50	17080.1	11.4
Gadabay	1,23	12497.2	10.2
Gazakh	0,70	18533.0	26.5
Shamkir	1,66	42568.8	25.6
Tovuz	1,94	24965.7	12.9
Ganja city	0,11	63.2	0.6
Naftalan city	0,04	278.5	7
Dashkasan	1,05	689.0	0.7
Goygol	0,92	5875.3	6.4

Source: State Statistical Committee of the Republic of Azerbaijan [1].

Three main types of activities dominate the socio-economic development of the region:

a) *Agriculture*. The districts of Gazakh, Aghstafa, Tovuz, and Shamkir are among the country's leading agricultural regions (Table 2). The main sources of income include viticulture, horticulture, cereal cultivation, vegetable growing, livestock farming, beekeeping, and others. In Shamkir and Tovuz, the presence of large agro-parks, greenhouse farms, and modern irrigation infrastructure facilitates the intensive development of agriculture.

b) *Industry and mining*. Dashkasan and Gadabay districts are major centers of metallurgy and mining industries. These districts engage in large-scale extraction of iron ore, copper, gold, and various metal-containing ores. In the city of Ganja, the chemical, machinery, food, and construction materials industries are well developed. The expansion of industrial activity is one of the main factors increasing anthropogenic pressure on the landscapes.

c) *Tourism and recreation*. In Goygol, Gadabay, and Shamkir districts, natural landscape resources have enhanced the potential for tourism and recreation. In particular, Goygol National Park, the region's mountains, summer pastures, and river valleys are attractive areas for tourists. The expansion of tourism is an area that requires both socio-economic benefits and careful ecological consideration in terms of landscape planning.

Land use in the region is highly diverse and varies according to the landscape structure: in the lowlands and foothill areas, agricultural activities such as crop cultivation, horticulture, and livestock farming predominate, while in the mountainous areas, livestock farming and, to a lesser

extent, crop cultivation are the main economic activities.

The impact of socio-economic activities on the landscape structure of the region manifests in the following ways:

- Anthropogenic pressure on natural landscapes due to the expansion of agriculture;
- Degradation and pollution of soil, water, and vegetation resulting from the mining industry;
- Alteration of landscape diversity through urbanization and industrial zones;
- New functional loads on recreational landscapes due to tourism development;
- Changes in relief, soil structure, and surface runoff as a result of infrastructure expansion.

Therefore, socio-economic factors must be considered an integral part of the landscape planning process.

The role of socio-economic factors in landscape planning. Landscape planning on the north-eastern slope of the Lesser Caucasus is not limited to the analysis of natural components alone; the level of socio-economic development, population distribution, economic structure, and dynamics of infrastructure development directly influence the potential, formation, and use of landscapes. Uneven population density in the area and the predominance of settlements oriented toward traditional agriculture are among the key social factors that must be considered in landscape planning.

The economic profile of the region is shaped primarily by agriculture, viticulture, vegetable growing, livestock farming, and partly by industrial activities. The operation of large agro-industrial complexes and processing enterprises in the Shamkir, Tovuz, and Ganja zones increases the demand for land resources and alters land-use patterns. Expansion of irrigation systems, the

growth of cultivation in erosion-prone areas, and the increasing share of anthropogenic landscapes are particularly notable. In the mountainous districts such as Gadabay and Dashkasan, the main economic activities include metallurgy, mining, and livestock farming. These factors intensify processes such as soil degradation, deforestation, and overloading of grassland ecosystems.

One of the most significant aspects of the influence of socio-economic factors is the level of infrastructure development. The expansion of transportation and energy infrastructure increases the economic activity of the region; however, it also leads to the differentiation of natural landscapes and the weakening of ecological connections. Therefore, comprehensive environmental impact assessments of infrastructure projects are essential in the landscape planning process. For this purpose, a set of adaptation measures has been developed to ensure the integration of road landscapes with surrounding ecosystems.

The social well-being of the population, employment levels, and agricultural incomes are also important factors determining the direction of landscape use. In the districts of Gazakh, Tovuz, and Shamkir - where population density is relatively high - pressures on land resources are stronger, and the tendency to expand individual household plots affects the stability of ecosystems. In mountainous areas, population outmigration reduces the use of productive lands, yet increases seasonal pressure on summer pasture

The development of tourism is also one of the significant socio-economic trends influencing landscape planning [5]. Goygol National Park, the historical and cultural heritage of Ganja city, and the mountain-forest landscapes enhance the region's ecotourism potential. The increase in tourist inflow leads to the expansion of infrastructure and service sectors. If this process is not properly regulated, the risk of environmental overloading increases. Therefore, landscape planning should ensure that tourism activities are organized in accordance with the ecological capacity of the area.

Ultimately, socio-economic factors act as the main determinants of the formation and transformation of landscapes on the northeastern slope of the Lesser Caucasus. The systematic consideration of these factors and the establishment of an optimal balance between economic development and ecological stability form the foundation of a sustainable development strategy for the region.

Principles of landscape planning on the northeastern slope of the Lesser Caucasus. The main directions of landscape planning on the northeastern slope of the Lesser Caucasus are determined by the region's natural-geographical diversity, socio-economic development dynamics, and environmental safety priorities (Table 3). The first direction concerns the sustainable management of soil and water resources. In the mountainous and foothill zones, strengthening anti-erosion measures, aligning land use with regulatory standards, modernizing irrigation systems, and ensuring the balanced management of water resources are of critical importance.

The second direction includes the protection of forest and mountain-meadow ecosystems, the implementation of ecological restoration programs, and the preservation of biodiversity and the natural gene pool. In the Dashkasan, Gadabay, and Goygol districts, the restoration of forest cover, the optimal regulation of pasture load, and the prevention of illegal logging are among the key priorities of landscape planning.

The third important direction concerns the efficient organization of anthropogenic landscapes - including urban, rural, industrial, and mining areas. In the Ganja, Shamkir, and Tovuz zones, conducting urban planning processes in accordance with environmental standards, expanding green belts, and ensuring environmental monitoring of industrial sites play a crucial role in landscape planning.

The fourth direction is related to the development of ecotourism in the region. Considering the recreational potential of Goygol National Park and the mountainous areas of Gadabay and Shamkir districts, adapting tourism routes to the ecological carrying capacity and harmonizing recreational infrastructure with natural landscapes constitute an essential component of planning.

The fifth direction involves the establishment of a regional ecological network (green corridors). Strengthening connections between natural ecosystems, integrating forest massifs, and creating ecological transition zones along water bodies and river valleys contribute to enhancing overall ecosystem stability.

Finally, the sixth direction involves improving the system of landscape monitoring and assessment. The application of Geographic Information Systems (GIS), dynamic monitoring of landscape changes, and the development of risk maps ensure the scientific justification of planning decisions across the region.

Table 3
Main directions of landscape planning on the northeastern slope of the Lesser Caucasus

№	Planning direction	Main content	Area of application (districts)
1	Management of land and water resources	Anti-erosion measures, modernization of irrigation systems, regulated and adapted land use	Gazakh, Aghstafa, Tovuz, Shamkir
2	Protection of forest and mountain-meadow ecosystems	Forest restoration, regulation of pasture load, conservation of biodiversity	Gadabay, Dashkasan, Goygol
3	Efficient organization of urban and industrial landscapes	Ecological urban planning, expansion of green belts, monitoring of industrial impacts	Ganja, Shamkir, Tovuz
4	Ecotourism and recreation planning	Adjustment of tourism routes to ecological carrying capacity, landscape-compatible organization of recreational facilities	Goygol, Gadabay, Shamkir
5	Creation of a regional ecological network	Green corridors, ecological transition zones, interconnection of forest massifs	Gadabay, Dashkasan, Goygol, Tovuz
6	Landscape monitoring and GIS-based assessment	Risk and conflict mapping, dynamic monitoring, landscape dynamic modeling	Entire region

Table 4
Recommendations for land and resource use in landscape planning

Landscape types	Characteristics	Recommended land and resource use
Plain semi-desert and dry steppe landscapes	High temperatures, low precipitation, arid soils	Implementation of drip irrigation systems; selection of drought-resistant crops; control of erosion and salinization; regulation of pasture areas
Foothill forest and shrub landscapes	Semi-arid climate, shrublands and sparse forests, mountain slopes	Agroforestry practices; terrace farming; restoration of forest and shrub areas; reduction of landslide and erosion risks
Mid-mountain forest landscapes	Dense forest cover, forest soils, abundant precipitation	Selective and sustainable forestry; forest restoration programs; development of ecotourism; use of forest resources in accordance with ecosystem services
Subalpine and alpine meadows	Cold climate, mountain-meadow soils, high altitudes	Balanced seasonal pasture use; regulation of grazing intensity; anti-erosion measures; protection of rare and endemic plants

The diversity of landscapes on the northeastern slope of the Lesser Caucasus necessitates optimal planning of land and resource use. In the plain semi-desert and dry steppe landscapes, the main priorities include the efficient use of water resources, erosion control, and the adoption of drought-resistant agricultural practices. In the foothill forest and shrub landscapes, land use should be aligned with forest conservation, agroforestry, and the application of modern cultivation systems. The mid-mountain forest landscapes are more suitable for maintaining ecological stability, implementing forest restoration, and developing selective forestry practices. In the subalpine and alpine meadow landscapes, balanced seasonal pasture use, regulation of grazing intensity, and preventing soil cover degradation are recommended (Table 4). These approaches ensure both the protection of the ecological capacity of each land-

scape type and the sustainability of socio-economic activities.

3. Conclusion and Recommendations

The northeastern slope of the Lesser Caucasus possesses a complex landscape system characterized by natural-geographical diversity, rich resource potential, and intensive socio-economic activities. The analysis shows that landscape planning in the region requires careful consideration of natural conditions, the intensity of anthropogenic impacts, and the area's economic development priorities. Across the wide zone extending from the plains to the mountainous areas, the ecological stability of landscapes is closely linked to the sustainable management of soil and water resources, the protection of forest and meadow ecosystems, the proper organization of anthropogenic landscapes, and the regulation of recreational loads. The study indicates that exceeding the

natural carrying capacity of landscapes, soil degradation, deforestation, and overgrazing present real risks to the region's sustainable development and underscore the importance of scientifically justified planning measures.

The recommendations for land and resource use developed within the framework of landscape planning highlight the need for a differentiated approach for each landscape type. In the plain semi-desert and dry steppe landscapes, water-saving practices and erosion control are optimal; in the foothill zones, agroforestry and slope cultivation are recommended; in the mid-mountain forest zone, ecological restoration is prioritized; and in the subalpine-alpine meadows, balanced seasonal pasture management is suggested. These strategies are crucial for ensuring both the ecological safety and the socio-economic sustainability of the region.

Based on the conducted research, the following integrated recommendations are proposed:

- The management of soil and water resources should be strengthened, and protective measures should be expanded on slopes with high erosion risk.
- Regional programs for the restoration of forest and meadow ecosystems should be developed; illegal logging should be prevented, and forest monitoring systems should be improved.
- In the placement of urban and industrial zones, the ecological load capacity of landscapes should be considered, and the expansion of green corridors along the Ganja–Shamkir–Tovuz line should be ensured.
- In the development of ecotourism, the load limits of natural landscapes should be observed, and tourist flows should be managed in specially protected areas.
- A regional ecological network and its management model should be established, forming green corridors that connect forest massifs and river valleys.
- GIS-based landscape monitoring should be strengthened, with risk maps, erosion hazard maps, and optimal land-use models regularly updated.
- Agricultural and other land-use activities should be adapted to specific landscape types, with particular attention to regulating grazing intensity in high-mountain zones.

Overall, implementing landscape planning on the northeastern slope of the Lesser Caucasus based on scientific and methodological principles will make a significant contribution to preserving

ecological stability, ensuring the efficient use of natural resources, and supporting the sustainable socio-economic development of the region.

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**KIÇİK QAFQAZIN ŞİMAL-ŞƏRQ
YAMACINDA LANDŞAFT
PLANLAŞDIRILMASININ SOSIAL-IQTISADI
ƏSASLARI**

F.Z. Zamanov

Xülasə. Kiçik Qafqazın şimal-şərq yamacı Azərbaycanın təbii-coğrafi müxtəlifliyinə və sosial-iqtisadi potensialına görə xüsusi əhəmiyyət daşıyan regionlardan biridir. Tədqiqatın məqsədi Qazax, Ağstafa, Tovuz, Şəmkir, Gədəbəy, Daşkəsən, Göygöl rayonlarını, Gəncə və Naftalan şəhərləri ərazilərini əhatə edən bu zonada landşaft planlaşdırılmasının sosial-iqtisadi əsaslarını araşdırmaq və təbii mühitlə antropogen fəaliyyət arasında optimal tarazlığı qiymətləndirməkdən ibarətdir. Tədqiqat zamanı regionun təbii-coğrafi şəraiti, landşaft strukturu, iqtisadi fəaliyyət sahələri və əhali

məskunlaşması təhlil edilmiş, həmçinin torpaq və resurs istifadəsinin landşaft potensialına uyğunluğu prinsipləri müəyyən edilmişdir.

Aparılan təhlil göstərir ki, antropogen yüklənmənin artması, torpaq deqradasiyası, meşə örtüyünün azalması, otlaq yüklənməsinin qeyri-bərabərliyi və su ehtiyatlarından səmərəsiz istifadə regionun ekoloji sabitliyinə ciddi təsir göstərir. Landşaft planlaşdırılmasının əsas istiqamətləri kimi torpaq və su ehtiyatlarının davamlı idarə olunması, meşə və çəmən ekosistemlərinin bərpa-sı, şəhər və sənaye landşaftlarının ekoloji normalara uyğun təşkili, ekoturizmin inkişafı və regional ekoloji şəbəkənin formalaşdırılması müəyyən edilmişdir. Hər bir landşaft tipi üçün diferensial torpaq-resurs istifadəsi modeli təklif olunmuşdur ki, bu da təbii komplekslərin qorunmasını və sosial-iqtisadi fəaliyyətlərin dayanıqlı inkişafını təmin edir.

Açar sözlər: landşaft planlaşdırılması, sosial-iqtisadi amillər, Kiçik Qafqaz, ekoloji sabitlik, ərazi idarəetməsi.