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STRUCTURAL-GENETIC CHARACTERISTICS OF LANDSCAPES OF THE SOUTHEASTERN SLOPE OF THE GREAT CAUCASUS AND STUDY OF THEIR MODERN STATE

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Abstract

The structural-genetic characteristics of landscapes have an important role in the formation of landscapes, the spread of agrocomplexes, the assimilation of landscapes and other directions. At present, these studies are conducted using modern methods, based on the processing of satellite images with the help of Geographical Information Systems. We also applied this practice for the first time in our country. In this regard, our research is relevant. Our goal is to determine the future development trends of landscape use by studying the structural-genetic characteristics of landscapes with modern methods. As a result of the analysis of the structural-genetic characteristics and morphometric elements of the modern natural landscapes in the studied area, three landscape sectors, which are sharply different from each other due to height differentiation and structure, were separated: 1. Atachay-Tughchay; 2. Pirsaatchay-Sumgayitchay; 3. Girdimanchay-Agsuchay.

It was determined that the spectra of natural terrain complexes, hypsometric levels, and tendencies of anthropogenic transformations in the high landscape sectors are different, and based on these calculations, map schemes and tables were drawn up. When examining the structural-genetic characteristics of the studied area, the strength of anthropogenic influences throughout history is clearly visible, considering that there are quite ancient settlements in the research area.

Key words: Greater Caucasus, structural-genetic feature, tendency, tectonics, anthropogenic effects

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Introduction. The genetic characteristics of landscapes mean the interaction and set of factors involved in their formation and modern dynamic state. It is correct to look at the genesis of the modern landscape in a dual aspect: natural and anthropogenic. Until the active influence of human society on nature, landscapes were genetically closely connected with leading natural factors, tectonic and climatic factors. Later, the role of anthropogenic factors in landscape formation increased with the economic activity of people [1, 2].

The differentiation of landscapes in the southeastern part of the Greater Caucasus as a result of erosion-gravitational processes is particularly different from other regions of Azerbaijan. Thus, the great height and steepness of the mountains in this region, the widespread distribution of clay and clay sediments in the area, the annual amount of precipitation and their regime, the intensity of deepening erosion, the presence of occasional earthquakes, and the economic activities of people lead to the widespread distribution of gravity relief forms; landslides and avalanches especially created favourable conditions. Landslides are most common in the area's Girdimanchay, Agsuchay, Chilgilchay, Gozluchay, Kandachay, and Atachay basins [3, 4]. It should be noted that both types of sliding (field and linear) are widespread here. Landslides spread mostly in the river basins of Girdimanchay, Pirsaatchay, Sumgaitchay, Atachay, etc., making large areas of land unusable, and destroying settlements and roads [5].

The southeastern slope of the Greater Caucasus has very different slopes and hilly characteristics according to the degree of inclination. Sharp divisions depending on inclination are evident in all three landscape sectors. These fragmentations and genetic characteristics have become even more acute due to anthropogenic effects, in addition to natural effects. The southeastern slope of the Greater Caucasus is an active tectonic zone, at the same time, there are quite a few mud volcanoes.

Material and methods. The natural landscapes of the southeastern part of the Greater Caucasus are genetically closely related to the large morpho-structural units that make up the area and the aerodynamic condition of the lower layer of the troposphere. Alizadeh [3] and Budagov and Mikailov [6] grouped and noted the interaction of modern landscapes of the research area with morpho-structural elements.

In the article, the degree of inclination, which is one of the structural-genetic characteristics of the area, was studied, and based on the obtained data, a 3D model and an inclination map were prepared; the change of inclination depending on the height and the landscape types formed based on these changes were reflected. During the research the methods of Alakbarov K. A., Ivanov P. V., Zaltser V. Y., Krylatov A. K., Shakuri B. Q., Jafarov M. A., Guliyev R. B. were used. Also, we used comparison, observation, mathematical-statistical methods, and ArcGIS software for calculating the morphometric indicators of the terrain. For the first time, we compiled hypsometric maps of the southeastern slope of the

Greater Caucasus and analyzed their role in the assimilation of the territory.

Analysis. The Tangi-Beshbarmaq, Gaytar-Goja, Niyaldag, Govdag mountain ranges in the southeastern part of the Greater Caucasus form an asymmetry. Mountain-forest landscape type is characteristic of all of the mentioned morpho-structures. However, the northern slope of the Tangi-Beshbarmaq and Gaytar-Goja morpho-structures, turned towards humid air currents, is covered with forest, and the southern slope consists of a desert landscape.

On the contrary, the forest landscape dominates the southern slope of the Niyaldag morpho-structure. Mountain-meadow and meadow-steppe landscapes were formed on the northern slope. This is because Tangi-Beshbarmaq and Gaytar-Goja morpho-structures are turned against the humid air mass from the north, and Niyaldag morphostructure from the south. A fertile subalpine landscape type was formed on the northern exposed slope of the Niyaldag morphostructure [7].

The landscape features of the Govdag and Niyaldag ridges differ sharply from each other. Covering the high parts of the middle highlands of the Govdag range, it is characterized by the dominance of mountain-meadow landscapes. Mountain meadows with high productivity have developed on the relatively levelled watershed and north-facing slopes of the ridges. Since the Govdag range is surrounded by valley depressions on all sides, its steep slopes in the southern, eastern, and southwestern directions have been subjected to intensive fragmentation. Accordingly, steppe, meadow-steppe, and forest-shrub landscapes were formed on the mentioned slopes of the ridge.

As a result of the research, it was determined that the formation of landscape complexes in different types of the morpho-structures characteristic of the southeastern part of the Greater Caucasus is contradictory. Thus, depending on the height of the abovementioned mountain massifs and ridges, the differentiation of landscapes as a whole is strengthened or weakened. Landscapes of mountainous plateau morpho-structures are characterized by a type of landscape compared to mountain range morpho-structures. This is due to the fact that the mountainous plateaus have a relatively smooth surface, as a result of which they do not create a barrier against air masses. Since intermountain depressions are surrounded by morpho-structures of different genesis from all sides and have different absolute heights, they create special landscape types and subtypes. For this purpose, an electronic map of the studied area in 3D format was prepared (Fig. 1).

The analysis of the orotectonic characteristics of the studied area allows distinguishing here a number of longitudinal and transverse morphotectonic stages and their corresponding landscape types [8]. According to the opinion of various scientists [3, 6] who have conducted research in the southeastern part of the Greater Caucasus for many years, the transverse and longitudinal morphotectonic steps in the area are the main landscape-forming factor, which determines the absolute height and creates conditions for the formation of climatic conditions of the

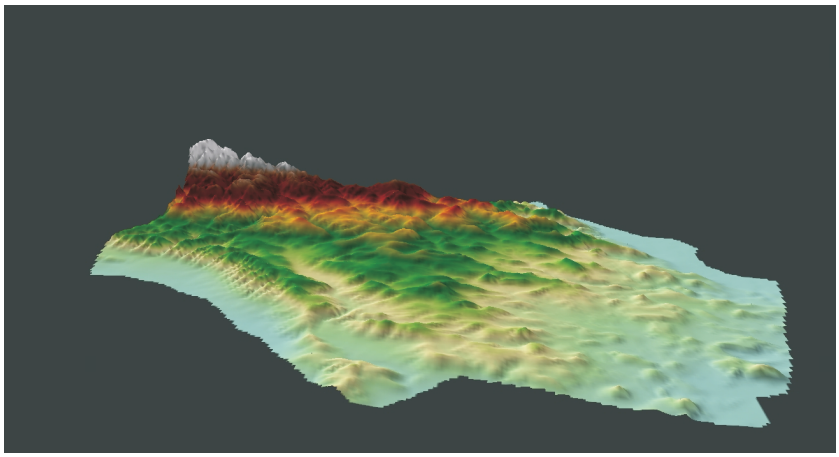


Fig. 1. Map of the southeastern part of the Greater Caucasus in 3D format

known area.

The Shamakhi-Gobustan longitudinal morphotectonic step in the southeastern part of the Greater Caucasus covers the low mountainous-foothill belt of the area [4, 9]. The Shamakhi-Gobustan longitudinal morphotectonic steppe landscape step is bordered by the Tufan rocky meadow-forest step from the north, and the Shirvan step from the south. Along this tectonic fault, the relief is characterized by steep slopes with a relative height of 400–600 m. This stage is characterized by low mountainous arid forest-bush, desert, and dry-desert landscapes that replace each other from west to east.

The landscapes of the Shamakhi-Gobustan step change from north to south. Desert landscapes spread north of the Shamakhi-Maraza line are replaced by semi-desert landscapes at absolute heights of 400—500 m in the southern direction.

The nature of the hypsometric level and geological structure existing in the Shamakhi-Gobustan step created conditions for the formation of the mountain steppe landscape type, which is the dominant landscape type for the area. In the relatively high areas of Gobustan (Yurfandag, Shifandag, Giceki, Shikhzahirli anticlinal ridges), dry-desert landscapes were formed, and in relatively buried areas (Ceyrankechmez, Shikhan, Western-Kandi depressions) semi-desert landscapes were formed.

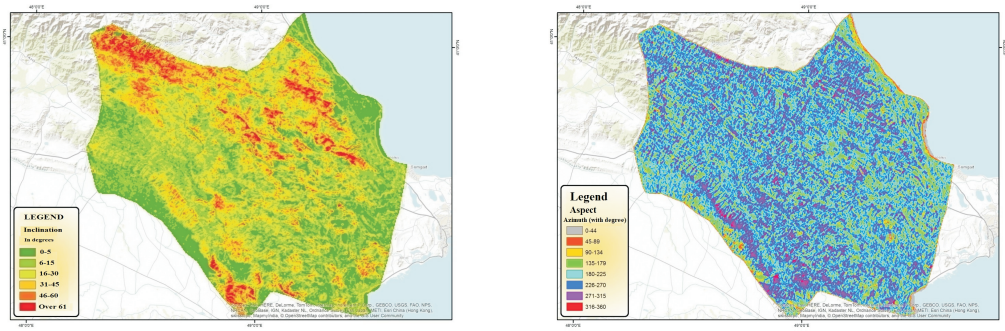
The tendency of the Shamakhi-Gobustan step to be buried in the direction of the Transcaucasia and the lowering of the transverse step to the north and south from the general ascent line led to the replacement of landscape types. As mentioned above, from northwest to southeast, the landscapes are replaced by mountain steppes and dry deserts with semi-desert landscape complexes.

Analysis of relief features and differentiation of new tectonic movements in the southeastern part of the Greater Caucasus: there are two transverse landscape morphotectonic steps in the area. This allows to separate Dubrar and Gobustan.

They are separated from each other by a buried flexure, which is clearly visible in modern relief [6]. Desert and semi-desert landscape complexes are separated within the boundaries of these transverse steps. The boundaries of the landscape complexes completely coincide with the boundaries of the morphotectonic steps. It should be noted that in the east of the buried flexure that separates the transverse landscape-morphotectonic structure of Dubrar and Gobustan, semi-desert landscape complexes covering the entire territory of Gobustan were formed. In addition, morphosculpture relief forms such as ravines, gobos, valleys and depressions, protruding slopes, wide and narrow watersheds, pseudokarst hollows, etc. are characteristic of the mentioned area [10]. The abrupt change of relief creates complexity and leads to differentiation of landscapes. Accordingly, it can be noted that the dry-desert landscape, which is mainly characteristic of the area, is found not only in the upper part of the low highlands, but also at the bottom of a number of depressions in the middle highlands.

The role of morphometric elements of relief in the formation of landscapes in any mountainous area has been widely studied by researchers. However, depending on the planetary and regional position of mountains, the role of morphometric elements in landscape formation can change to a unique extent.

For example, in the Azerbaijani part of the Greater Caucasus, its southern slope region receives more precipitation mainly because it is turned towards humid westerly air currents, and mountain-forest landscapes are widespread here. In the southeastern part of the Greater Caucasus involved in the study, the relief inclination is low. Southern slopes are dominant and are therefore affected by southerly air currents. For this reason, the landscapes of semi-desert and dry steppe and arid sparse forests and bushes in the southeastern part of the Greater Caucasus are naturally stretched towards the middle highlands. Taking this into account, an electronic trend map of the relief of the southeastern part of the



(a) (b)

Fig. 2. Slope (a) and aspect (b) maps of the relief of the southeastern part of the Greater Caucasus

Table 1

The effect of the degree of inclination of the relief on the structural and functional characteristics of landscapes in the southeastern part of the Greater Caucasus

Number	The inclination of the terrain in degrees	Area, km^2	According to the total area, the distribution of inclination in %	Assessment of inclination	Structural and functional changes occurring in natural landscapes
1	$0^\circ-5^\circ$	1874.0	21.3	Relatively smooth field	The predominance of accumulation, increased salinization tendency, deflation, very weak erosion, irrigated agriculture, partial cattle ranching
2	$6^\circ-15^\circ$	1881.8	21.4	Very weak	Very weak erosion and denudation, not irrigated, partially irrigated agriculture, livestock
3	$16^\circ-30^\circ$	2647.7	30.2	Weak	Moderate level of erosion, partially arid-denudation, weak landslide, not irrigated agriculture and livestock
4	$31^\circ-45^\circ$	1238.9	14.1	Medium	Intensive erosion, arid-denudation and landslides, animal husbandry, terrace agriculture
5	$46^\circ-60^\circ$	810.1	9.2	High	Strong erosion and arid denudation, badlands dense network of ravines, partially barren areas, pastures, livestock
6	Over 61°	327.1	3.7	Very high	Severe erosion, arid-denudation, landslide, avalanche, formation of badlands

Greater Caucasus was prepared by the ArcGIS program [11] (Fig. 2). The results obtained from the analysis of the map are presented in Table 1.

From the analysis of Table 1, it can be seen that the inclination varies between 16°–30° in the main part of the territory in the southeastern part of the Greater Caucasus. Such areas make up 30.2% of the total area (2647.7 km^2). Relatively smooth areas make up 21.3% of the area (1874.0 km^2) and are found mainly in the south of the study area, in the coastal areas, in the depressions and levelling areas. 21.4% (1881.8 km^2) of the remaining area is very poor, 14.1% (1238.9 km^2) is medium, 9.2% (810 km^2) high, only 3.7% (327.1 km^2) are areas with a very high inclination. A histogram of the changes in the structural-functional characteristics of mountainous landscapes depending on the inclination of the relief was drawn up.

The areas with medium inclination cover most of the total area. In the southeastern part of the Greater Caucasus, the general orientation of the relief is in the southeast direction. However, the appearance of the slopes of relatively small relief forms has an important role in the formation of structural and functional characteristics of landscapes, as well as in determining their morphological structure.

At the same time, slope processes within the landscape and their role in morphological differentiation were evaluated as important factors [5]. Taking these into account, a large-scale (1:100000) electronic map of the slopes in the southeastern part of the Greater Caucasus was compiled (Fig. 2).

Based on the slope map a relief distribution table was drawn up in the studied area (Table 2).

Table 2

The territorial distribution of the aspect of the relief in the southeastern part of the Greater Caucasus

No.	Elevation in azimuth (degrees)	Aspect	Area, ha	Area, km^2	According to the total area, in %	Impact on landscape structure
1	0–44	North, northeast	8873	88.7	1.0	Reduction of solar radiation, dense vegetation in low and medium highlands
2	45–89	East, northeast	17515	175.2	2.0	Relative reduction of solar radiation, relatively dense vegetation
3	90-134	East, southeast	72881	728.8	8.3	—
4	135–179	South, southeast	155178	1551.8	17.7	Intense solar radiation, erosion, bare rock, poor vegetation
5	180–225	South, southwest	203893	2038.9	23.2	—
6	226–270	Southwest, west	217118	2171.2	24.7	Relative reduction of solar radiation, relatively dense vegetation
7	271–315	West, northwest	150798	1508.0	17.2	Mainly reduction of solar radiation, dense vegetation, weak erosion
8	316–359	Northwest, north	51859	518.6	5.9	Significantly less solar radiation, dense vegetation, weak erosion

From Table 2 and the analysis of the mentioned map, it can be seen that in most of the area (24.7%) the relief of the terrain is in azimuths of 225–270°, i.e. south and southwest (180–225° azimuth), 17.7% (1551.8 km^2) southeast and

south (135–180° azimuth), 17.2% (1508.0 km^2) west and northwest (270–315° azimuth), only 6.9% (607.3 km^2) oriented to the north, northwest and northeast (azimuths 0–45° and 315–360°). The structure and functional characteristics of the landscape also change depending on the steepness of the slopes at different heights. Table 2 shows the changes in the landscape depending on the direction of the slopes at different heights during the field research. So, within the hilly relief boundaries of Gobustan, salt flats are spread in a number of flat depressions, but in the relatively high borders adjacent to it, salt marshes and other shrub plants are found. As can be seen here, even a slight change in the height of the relief leads to the differentiation of landscapes.

In the southeast of the Greater Caucasus, when the slope of the relief is 0–10°, it is mainly used for agriculture, when it is 10–15°, it is used for mowing, and in the areas with more than 15°, it is mainly used as pasture. In general, the agricultural parts of the studied area are spread at an altitude of 200–1500 m above sea level. For this reason, this part of the territory is subject to more exploitation, especially in the direction of agriculture. The existing land resources in the study area are mainly used in agriculture, partly in horticulture and animal husbandry.

Compared to 1980, in 2017, arable land increased by 31%, irrigated land by 50.5%, grain growing by 21%, fruit growing by 37.7%, grape growing by 52%, and fallow land decreased by 51.3%. The area of grape growing, which is typical for the southeastern slope of the Greater Caucasus, has decreased significantly. So, after the collapse of the former Soviet Union, the existing vineyards here were destroyed. At the same time, the wineries operating in the area were also forced to close. However, thanks to the attention paid to viticulture in the years of independence "State Program of Socio-Economic Development of the Regions of the Republic of Azerbaijan 2004–2008", "State Program of Socio-Economic Development of the Regions of the Republic of Azerbaijan in 2009–2013", "State Program for poverty reduction and sustainable development in the Republic of Azerbaijan in 2012—2020", and "State Program for the development of viticulture in the Republic of Azerbaijan in 2012–2020" this area began to revive [3, 4].

Part of the land suitable for agriculture is decreasing as a result of the expansion of settlements and road infrastructure. During the research period, the area of settlements increased by 21% to 352 km^2, and the area of roads increased by 34% to 41.64 km^2. If this trend continues, the loss of agricultural land will be inevitable.

In 1980, 12.2% of the agricultural lands of the studied area belonged to high-quality lands. However, this indicator was 7.1% in 2007 and slightly decreased to 6.7% in 2017. In 1980, 34.7% of the soils of the studied area were of good quality, 51.3% of medium and 1.8% of poor quality. At the moment, 29.6% of the lands suitable for agriculture in the southeastern slope of the Greater Caucasus are of good quality, 40.6% are of medium quality, and 2.6% are of poor quality.

The development of agriculture in the studied area has led to the activation of the soil erosion process. Here, 63% of the land has been eroded to varying degrees [6]. 46.9% of it is severely eroded, 23.8% is moderately eroded, and 29.3% is weakly eroded.

According to statistical data, there is a considerable increase in the number of large and small-horned animals compared to 1980. During 1980–2017, the area of pastures and meadows decreased by 5.6%, and the area of hayfields decreased by 32%. In 1980, the total area of these lands was 15.8 thousand ha, in 2007 it was 7.3 thousand ha, and now it is 6.6 thousand ha. Medium and low quality soils of areas used for grazing are more widespread in Shamakhi and Gobustan regions. There are few available soils in the territory of these regions that belong to the I quality group.

The complex differentiation characteristics of the natural landscapes of the southeastern part of the Greater Caucasus have also influenced the methods and approaches of the research conducted here. In the natural differentiation of territorial landscapes, the influence of the absolute height of the relief, the diversity of the lithological composition and filtration capacity of the rocks, the exposure and inclination of the slopes, the exogenous geo-morphological processes, and the climate are very large. In connection with the favourable relief and climatic conditions of the region, the role of natural landscapes in the structural territorial differentiation of the intensive anthropogenic activity here was not small. Due to these features, different landscape types with complex structure have been formed in the Southeastern Caucasus. Isachenko [8] considers the vertical and horizontal differentiation of natural landscapes in mountainous areas as a complex result of the interaction of all natural components. He also notes the main leading role of geological conditions and geo-morphological zoning of the relief in the distribution of landscapes in the mountainous areas along vertical belts.

Conclusions. As a result of field studies, it was determined that the existing morphostructures in the region created the asymmetry of the landscape. Both natural and anthropogenic influences manifest themselves in the southeastern slope of the Greater Caucasus not only in large landscape complexes, but also within the boundaries. In addition to all natural indicators, climatic features also play an important role in the formation of landscape complexes of mountainous areas. Forest, forest-shrub and steppe complexes are formed depending on the exposure of the slopes. In addition to the natural features listed above in the study area, anthropogenic influences are also clearly evident in many areas.

It was determined that in recent decades, as a result of the intensive exploitation of the lands of the mountain geosystems of the northeastern slope of the Great Caucasus in agriculture, in 2017, compared to 1980, the arable land increased by 31% to 140 thousand ha. During this period, the increase of the cultivated area and also the non-observance of agrotechnical rules led to a decrease in the quality of the soil cover. Thus, during these years, high-quality lands decreased by 5.5%,

good-quality lands by 5.1%, average-quality lands by 10.7%, and low-quality lands increased by 0.8%.

The development of animal husbandry in the studied area and the increase in the number of animals led to the weakening of the natural fodder base of summer and winter pastures, and overloading of hayfields and meadows. Also, as a result of non-observance of grazing rules and the intensification of this process, the area of pastures and meadows decreased by 5.8% to 172.8 thousand ha, and the area of hayfields decreased by 32% to 3.8 thousand ha. Therefore, agrotechnical rules should be strictly observed during the development of both areas of agriculture in the studied area, and special attention should be paid to alternating grazing of large and small cattle in summer and winter pastures with more fragile soil cover.

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