

Differentiation characteristics of the modern anthropogenic landscapes of the North-East slope of the Great Caucasus

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Abstract

The study of the differentiation characteristics of modern anthropogenic complexes is one of the main issues of landscape science. The dynamics and forecasting of anthropogenic landscapes have an important role in the effective placement and proper management of regional farms, as well as in the organization of natural environment protection. Within the Republic of Azerbaijan, the modern anthropogenic landscapes of the northeastern slope of the Great Caucasus were formed under the influence of complex long-term geographic-historical-economic factors. Compared to the other regions of Azerbaijan, the modern anthropogenic complexes of the northeastern slope of the Greater Caucasus are distinguished by their unique differentiation characteristics. The study of these regularities based on Geographical Information Systems (GIS) and satellite images (Landsat 7 ETM+, Landsat 8, CNES/Airbus) is of scientific and practical importance. The natural landscapes of the north-eastern slope of the Greater Caucasus have undergone fundamental transformation and have been replaced by various anthropogenic complexes during historical periods. From the coastal plains of the Caspian Sea to the Main Caucasus Range, the following anthropogenic complexes alternate: agro-irrigated landscapes of plains-lowlands (Samur-Devachi lowland), winter pastures and meadows, dry and episodic irrigated agrolandscapes of sloping plains (Gusar sloping plain), episodic highlands summer pastures and meadows of used subalpine-alpine meadows, subnival-nival landscapes of the highlands that are not changed experimentally. The differentiation and structural-functional characteristics of the North-Eastern slope of the Great Caucasus were studied by us on the basis of satellite images with the application of GIS. Regional satellite images show the intensity, extent of anthropogenic impacts, distribution over the area, etc., using the NDVI analysis method (unsupervised classification). Modern anthropogenic landscapes of the north-eastern slope of the Greater Caucasus are distributed along the vertical belt: 1) sharply changed natural complexes of lowlands and foothills; 2) fundamentally changed natural complexes of the middle highlands 3) natural complexes of the highlands that maintain their original state (practically unchanged). According to our analysis based on GIS, 98% (40,000 ha) of perennial crops, 93% (41,351 ha) of mowed areas, and 95.4% (107,900 ha) of cultivated areas are located at the altitude level of -28 m and -1000 m. 62% (272,740 ha) of the hypsometric step of the north-eastern slope of the Greater Caucasus up to 1000 m has been assimilated through agrolandscapes, and up to 10% (43,416 ha) through seliteb complexes.

Keywords

Anthropogenic landscapes, northeastern slope of the Greater Caucasus, satellite images, landscape differentiation, Geographical Information Systems (GIS), NDVI

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Диференційна характеристика сучасних антропогенних ландшафтів північного схилу Великого Кавказу

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Реферат

Вивчення диференційної характеристики сучасних антропогенних комплексів є одним із основних питань ландшафтознавства. Динаміка та прогнозування антропогенних ландшафтів відіграють важливу роль в ефективному розміщенні та правильному веденні регіонального господарства, а також в організації охорони довкілля. У межах Республіки Азербайджан сучасні антропогенні ландшафти північно-східного схилу Великого Кавказу сформувалися під впливом складних довготривалих географічних та історико-економічних факторів. У порівнянні з іншими регіонами Азербайджану сучасні антропогенні комплекси північно-східного схилу Великого Кавказу відрізняються унікальними характеристиками їхньої диференціації. Дослідження цих закономірностей на основі геоінформаційних систем (ГІС) та супутникових знімків (Landsat 7 ETM+, Landsat 8, CNES/Airbus) має наукове і практичне значення. Природні ландшафти північно-східного схилу Великого Кавказу в історичний час зазнали докорінної трансформації і змінювалися різноманітними антропогенними комплексами. Від узбережних рівнин Каспійського моря до Головного Кавказького хребта чергуються такі антропогенні комплекси: агрозрошені ландшафти рівнинних низовин (Самур-Девачівська низовина), зимові пасовища і луки, сухі та епізодично зрошені агроландшафти схилових рівнин (Гусарська похила рівнина), епізодично використовувані високогірні літні пасовища та луки і використовувані субальпійсько-альпійські луки, незмінні ландшафти субнівального рівня високогір'я. Диференціація та структурно-функціональна характеристика ландшафтів північно-східного схилу Великого Кавказу вивчена нами на основі супутникових знімків із застосуванням ГІС та за методом аналізу NDVI (неконтрольована класифікація). Регіональні супутникові знімки відображають інтенсивність і масштаби антропогенних впливів, їхній розподіл за площею тощо. Сучасні антропогенні ландшафти північно-східного схилу Великого Кавказу мають таку вертикальну поясність: 1) різко змінені природні комплекси низовин і передгір'їв; 2) принципово змінені природні комплекси середньогір'я; 3) природні комплекси високогір'я, що зберігають свій первісний стан (практично незмінні). Згідно з нашим аналізом на основі ГІС, 98 % (40 000 га) багаторічних насаджень, 93 % (41 351 га) площ сінокосів і 95,4 % (107 900 га) орних площ розташовані на висотному рівні -28 м – 1000 м. На гіпсометричній ступіні північно-східного схилу Великого Кавказу висотою до 1000 м агроландшафти займають 62 % (272 740 га), а селітебні комплекси до 10 % (43 416 га).

Ключові слова

Антропогенні ландшафти, ландшафтна диференціація, північно-східний схил Великого Кавказу, супутникові знімки, геоінформаційні системи (ГІС), NDVI

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1. Introduction

Anthropogenic landscapes are territorial complexes within the landscape sphere, whose natural balance is constantly protected or changed by human activity, depending on its economic type [13]. They are formed on the basis of natural complexes being reshaped and significantly changed by human impact [12]. At present, anthropogenic complexes are found to a greater or lesser extent in all geographical zones. Each physical-geographic zone has a total spectrum of anthropogenic landscapes. The issues of formation and grouping of anthropogenic landscapes have been studied by F. N. Milkov [12], L. I. Kurakova [13] and others, who studied the formation periods of anthropogenic landscapes. D. L. Beruchashvili [10] studied the geophysical properties of natural-anthropogenic complexes. Modern anthropogenic landscapes of the Republic of Azerbaijan have been studied since the 70s and 80s of the 20th century by B. A. Budagov [11], M. A. Museyibov [14], M. A. Suleymanov [8], Y. E. Garibov [3,4,11], Yunusov M. I. [1,9], Ismayilov M. C., Mammadbayov E. Sh [1], N. S. Ismayilova [4], Hajiyeva A. Z. [2], Guliyeva S. Y. [5], R. R. Sadullayev [6,7,15] and other researchers.

Taking into account the regional characteristics of the Republic of Azerbaijan and the types of anthropogenic influences, the natural landscapes of the northeastern slope of the Greater Caucasus are divided into 5 groups, according to the degree of anthropogenicization: 1) practically unchanged; 2) weakly anthropogenic; 3) moderately anthropogenic; 4) strongly anthropogenic; 5) fundamentally transformed [3]. It was shown that the morphological units of the natural landscapes of the region undergo fast changes under anthropogenic process. Depending on the degree of impact of economic activity, the changed (weakly, strongly and fundamentally changed) and conventionally unchanged landscapes of the northeastern slope of the Greater Caucasus are distinguished [4].

2. Methodology

The differentiation, dynamics and modern state of the anthropogenic landscapes of the northeastern slope of the Greater Caucasus were monitored using the NDVI (The Normalized Difference Vegetation Index) that is unsupervised classification method of multispectral satellite images (Landsat 7 ETM+, Landsat 8). The modern natural landscapes of the north-eastern slope of the Great Caucasus have been fundamentally changed during historical periods, and, as a result, they have been replaced by various anthropogenic complexes. In recent years, we have been monitoring the anthropogenic complexes of the region on the basis of GIS and satellite images.

3. Results

The modern natural-anthropogenic landscapes of the northeastern slope of the Greater Caucasus are distributed

according to the vertical zonality. The semi-desert, dry steppe, xerophytic thickets, arid sparse forest-shrub complexes of the Samur-Devachi Lowland have been fundamentally changed, replaced by various intensively used anthropogenic complexes, large-area urban agglomerations and other man-made landscapes. In the meadow-shrub, forest-shrub, and forest landscapes of the low mountains and smooth plateaus, agrolandscapes (pasture and livestock complexes) were formed, which were mainly related to sorghum farming and animal husbandry. The anthropogenic transformation of the natural landscape types and subtypes of these areas has a maximum indicator. So, at least 50% of the forests here were gradually turned into meadow [3], forest-shrub, sparse bush, etc. Thus, natural complexes has turned into their anthropogenic derivatives. At the same time, in the following years, a large part of the bushy landscapes were replaced by agrocenoses or other anthropogenic landscapes.

The modern natural landscapes of the mountainous and plain areas of the north-eastern slope of the Greater Caucasus have been fundamentally changed and replaced by anthropogenic complexes. As a result of the development of agriculture in the Samur-Devachi lowland and the Gusar sloping plains, small-area agrocomplexes and seliteb landscapes became scattered in the wide valleys with favorable melioration conditions of the Gusarchay, Gudyalchay, Karachay and Valvalachay, in the yield crops gradually began to grow [4], expanding towards the foothill plains. Forests were suppressed by bush formations. Palaeogeographic studies have proven that most of the forests in the plains and foothills of the region were subjected to anthropogenic influences in the first centuries of common era and gradually turned into agro-landscapes [3, 8]. (Figure 1).

The modern anthropogenic landscapes of the northeastern slope of the Greater Caucasus were formed by the influence of long-term historical-geographical processes. According to the GIS data, it has been shown that the anthropogenic landscapes of the region consists of agricultural land (16.2%), orchards and vineyards (5.8%), urban and rural complexes (6.8%), as well as transport, communication and industrial infrastructure of various functions (3,6 %). The analysis based on satellite images shows that the natural landscapes of the region, especially at the hypsometric level of -28 – 1000 m, have been changed by human impact and transformed into diverse anthropogenically modified areas (Figure 2).

The development of agriculture, horticulture, and animal husbandry in the Greater Caucasus region has strongly impacted characteristics of natural landscapes. The anthropogenic complexes [2], which are irrigated and used in the form of rice fields to varying degrees, change dramatically both natural landscape types and administrative-territorial units. Apart from Khachmaz region, all administrative regions of the northeastern slope of the Greater Caucasus are divided into two parts according to geomorphological and soil-climatic characteristics: first of all – mountains; foothill sloping plains and lowlands.

In the Landsat 7 ETM+ and Landsat 8 satellite images of the northeastern slope of the Greater Caucasus, landscape contours of various geometric shapes reflect the

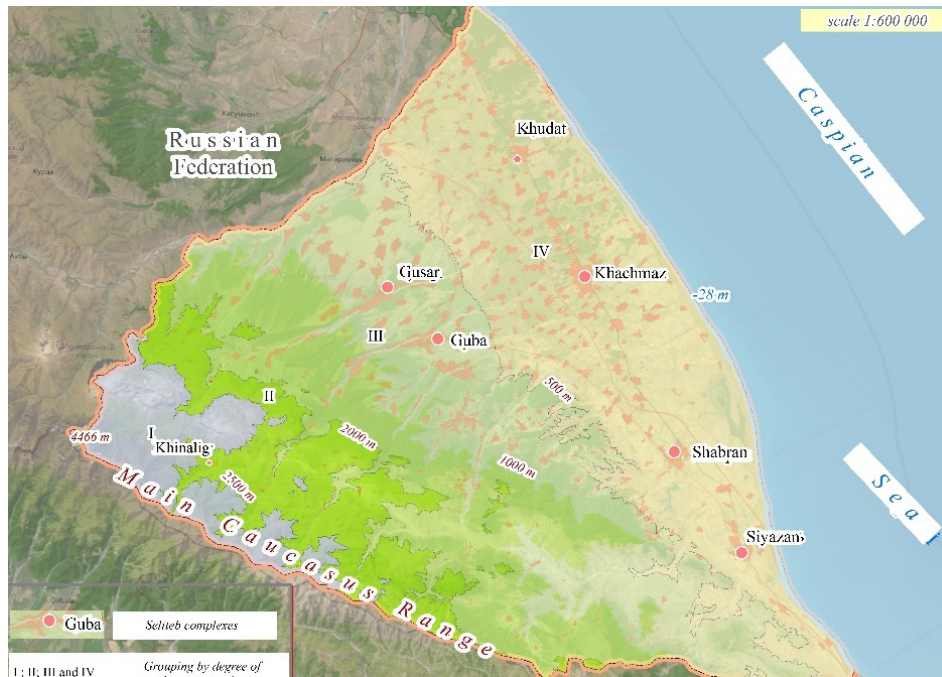


Fig. 1. 1a – Landscape differentiation, according to the degree of anthropogenic change [16]: I – Practically unchanged landscape complexes preserving their natural development; II – Weakly modified summer pastures and mowing areas subjected to irregular economic impacts; III – Moderately altered natural complexes exposed to irregular economic effects; IV – Natural landscapes subjected to drastic changes and regular economic impacts [3,4].



Fig. 2. Differentiation of anthropogenic landscapes (from the shores of the Caspian Sea to the peak of Shahdag) [16]

features of intensity of anthropogenic impacts (Figure 2). The agro-irrigation landscapes, formed in the semi-deserts on intensively used alluvial, alluvial-proluvial, and marine plains, are characteristic of the Samur-Devachi lowland [4]. The agro-irrigation complexes representing the grain and vegetable crops and garden-plantations on the slopes, foothills, and undulating plains of the region are typical for the Gusar sloping plain. The winter pastures of the mountainous dry steppes and arid sparse forest-shrubs of the north-eastern slope of the Greater Caucasus spread on the gray-brown soils of the fragmented low mountains and plateaus in the Khizi and Siyazan regions. Against the background of these winter pastures, small-areas of sorghum crops, episodically irrigated agrolandscapes, grape plantations and hayfields have been developed.

The analysis of the northeastern slope of the Greater Caucasus based on GIS shows that the main part (94.6%, i.e. 189,251 hectares) of the region's agro-landscapes

(mowing, perennial planting and sowing) belongs to the foothill plains and lowlands up to 1000 m in hypsometry [15]. The analysis of the regional distribution of agrolandscapes based on GIS shows that among agrolandscapes of different economic functions, irrigated and unirrigated garden-plantation, silage-garden, mowing and pasture agro-irrigation landscapes are prevail [3]. In the structure of the mentioned anthropogenic complexes, the irrigated fields differ both in terms of economic importance and productivity. The following main signs are observed in the distribution of modern anthropogenic landscapes of the region: the increase of the area of grain and perennial crops in the structure of agro-irrigation landscapes, and the decrease of the area of low-yielding pastures and hayfields. Also, in the economic functions of the agrolandscapes of the Greater Caucasus region, the replacement of small-area vegetable and melon plantations and scattered patches by large-area grain and perennial crops fields is observed [4,11].

Anthropogenic complexes are dominant in the Gusar sloping plain. Thus, in this sloping plain, the total area of seliteb landscapes is 19,000 ha (11.5%), and the area of forest landscapes is 50,000 ha (30.2%). The share of agrolandscapes is 86,325 ha (52%), of which 36,637 ha (22%) are cultivated, and 16,916 ha (10.2%) are perennial crops. The share of agrolandscapes in the natural-anthropogenic landscape structure of the Samur-Devachi lowland is 136,100 ha (62%), the total area of seliteb complexes is 22,810 ha (11.2%), and the sandy areas of economically poorly used coasts, swamps, and river beds are 14.5% [15]. The area of the hypsometric level up to 1000 m on the north-eastern slope of the Greater Caucasus is 438,400 ha, of which 272,740 ha (62%) have been assimilated through agro-landscapes. About 10% (43,416 ha) of this hypsometrical level is made up of seliteb complexes. 94.6% (139,571 ha) of the total cultivated area of the region is concentrated in favorable hypsometric conditions up to 1000 m.

Settlement-seliteb anthropogenic landscapes on the northeastern slope of the Greater Caucasus are the complexes with geometric configurations (linear-chain, circular-radial, ball, scattered, grid, etc.). For comparison, we can say that in the areas of Jeyranchol and Gobustan, the share of seliteb complexes in the total landscape background is 1.5% [3], and in the Samur-Devachi plain it reaches 11.2% (22,810 ha). Based on the analysis of satellite images, we have determined that the total area of seliteb complexes in the region is 47,229 ha (6.7%). The areas of these types of complexes within the vertical belt (-28 – 4466 m) and their impact on natural landscapes are gradually weakening (Figure 3).

Due to the influence of historical-geographical factors, an important part of the settlement-seliteb complexes of the region is concentrated in the lowlands, sloping plains and foothills. Depending on the relief and climate conditions, both the area and the number of village seliteb complexes gradually decrease towards the middle and high mountains of the northeastern slope of the Greater Caucasus. Thus, the share of this type of landscapes up to 1000 m hypsometry is 90.7%, 8.1% between 1000-2000 m, and 1.2% above 2000 m [6]. Extreme relief-climatic conditions in the hypsometrical level above 2500 m (absolute height) determine that the settlements here are temporary or seasonal.

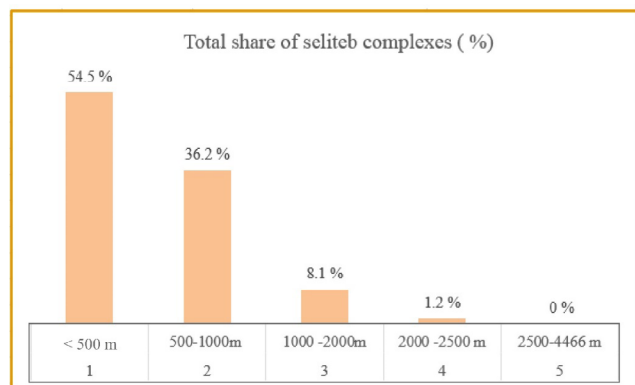


Fig. 3. Hypsometric differentiation of seliteb complexes of the northeastern slope of the Greater Caucasus.

4. Conclusion


Within the Republic of Azerbaijan, we observe a clear landscape differentiation on the north-eastern slope of the Greater Caucasus. Here we find landscape units from the fundamentally transformed agro-irrigation complexes of the plain-lowland areas to the practically unused nival-glacier complexes of the highlands. On the northeastern slope of the Greater Caucasus (heights up to 1000 m), substantial agrolandscape impact is observed: 98% of perennial planting (40,000 ha), 93% of mowed areas (41,351 ha), and 94.6% of cultivated areas (139,571 ha) is concentrated in this zone. In total, 62% (272,740 ha) of this area (up to 1000 m) is occupied by agrolandscapes, and 10% (43,416 ha) consists of seliteb complexes.

Settlement-seliteb anthropogenic landscapes on the northeastern slope of the Greater Caucasus are complexes with geometric configurations (linear-chain, circular-radial, ball, scattered, grid, etc.). Based on the analysis of satellite images, we determined that the total area of seliteb complexes in the region is 47,229 ha (6.7%). The area of these complexes along the vertical transect (from -28 m to 4466 m) and their impact on natural landscapes are gradually weakening.

The main network of seliteb complexes within the region is concentrated in the Samur-Devachi plain, sloping plains and foothills. Depending on the relief-climate conditions towards the middle and high mountains, the number and areas of village seliteb complexes gradually decreases (90.7% up to 1000 m, 8.1% between 1000-2000 m, 1.2% above 2000 m). Above 2500 m, the settlements are temporary and seasonal.

The natural landscapes of the north-eastern slope of the Great Caucasus have undergone various degrees of transformations. Modern anthropogenic complexes have been formed under the influence of complex geographical-historical-economic factors. From the coastal plains of the Caspian Sea to the Main Caucasus Range, the following anthropogenic complexes alternate: agro-irrigated landscapes of plains-lowlands (the Samur-Devachi Lowland), winter pastures and meadows, dry and episodically irrigated agrolandscapes of sloping plains (the Gusar sloping plain), episodically used highland summer pastures and subalpine-alpine meadows, and subnival-nival landscapes that are not changed anthropogenically. Therefore, modern anthropogenic landscapes of the region are distinguished by specific signs of differentiation. These signs are analysed in the paper on the basis of Geographical Information Systems (GIS) and satellite images (Landsat 7 ETM+, Landsat 8, CNES/Airbus, etc.).

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