



Research of Modern Structural-Functional Characteristics and Differentiation Regulations of Anthropogenic Landscapes

Sadullayev Rashad Rahib^{1*}, Mammadova Shakar I², Humbatova Shafiq Y³ and Ahlimanov Ramiz M³

¹Baku State University, Department of Geography, Baku, Azerbaijan

²Baku State University, Doctor of sciences in Geography, Baku, Azerbaijan

³Baku State University, Phd in Geography, Baku, Azerbaijan

***Corresponding Author:** Sadullayev Rashad Rahib, Baku State University,

Department of Geography, Baku, Azerbaijan.

DOI: 10.31080/ASAG.2024.08.1345

Received: December 26, 2023

Published: January 21, 2024

© All rights are reserved by **Sadullayev Rashad Rahib., et al.**

Abstract

The research of anthropogenic complexes is considered one of the fundamental problems of contemporary landscape science. It is no coincidence that the dynamics and forecasting of anthropogenic landscapes have become one of the paramount issues in the protection of the natural environment, the efficient placement, development and proper management of regional economic areas.

Within the Republic of Azerbaijan, the anthropogenic complexes of the northeastern slope of the Great Caucasus have formed under the influence of complex geographical-historical-economic factors. In comparison to other regions of the Republic of Azerbaijan, the modern anthropogenic landscapes of this region have specific structural-functional characteristics and patterns of differentiation. The research of these features based on Geographical Information Systems (GIS) and satellite images (CNES/Airbus, Landsat 7 ETM+, Landsat 8, etc.) bears both scientific and practical importance.

The natural landscapes of the northeastern slope of the Greater Caucasus have undergone fundamental changes and have been replaced by various anthropogenic complexes throughout historical periods. The following anthropogenic landscape complexes alternate from the Caspian coastal plains-lowlands of the region to the Main Caucasus Range: agroirrigated landscapes of the lowlands, winter pastures and mowing fields, not-irrigated and episodic irrigated agrolandscapes of sloping plains, summer pastures and meadows of subalpine-alpine meadows used episodically in the highlands, experimentally unaltered subnival-nival complexes of the highlands.

The modern structural and functional characteristics of the anthropogenic landscapes of the northeastern slope of the Great Caucasus have been performed by us in recent years with the use of GIS and satellite images. Satellite images of the northeastern slope of the Greater Caucasus have been investigated using the NDVI analysis method (unsupervised classification). Consequently, various geometrical landscape contours have been obtained, indicating numerous characteristics of anthropogenic influences, such as intensity, distribution, etc.

The conducted analyses reveal that the modern anthropogenic landscapes of the region are distributed according to the law of vertical belt: 1. fundamentally changed natural complexes of lowlands and foothills 2. altered natural complexes of the middle highlands and 3. natural complexes of highlands which maintain their original state (experimentally unchanged). Our analyses based on GIS and satellite images show that 98% of perennial plantings (40,000 ha) are located at an altitude of -28 m -1000 m, 93% of mowed areas (41 351 ha), and 95.4% (107900 ha) of cultivated areas are concentrated. 62% (272,740 ha) of the hypsometric step of the northeastern slope of the Greater Caucasus up to 1000 m has been assimilated through agro-landscapes, up to 10% (43416 ha) consists of seliteb complexes.

Keywords: Northeast Slope of the Greater Caucasus; Anthropogenic Landscapes; Satellite Images; Landscape Differentiation; Geographical Information Systems (GIS)

Introduction

Anthropogenic landscapes are natural-productive terrain complexes that have been altered by human activity and their natural balance is constantly maintained [19], as a part of the landscape sphere, it is formed on the basis of natural complexes depending on economic activity [5]. Anthropogenic landscapes are the genetic sequence of natural-local systems, reshaped and fundamentally changed natural complexes [15,16].

Currently, anthropogenic landscapes are found to a greater or lesser extent in all geographical zones. Each physical-geographic zone has a total (spectrum) of anthropogenic landscape complexes [11]. With the issues of formation and grouping of anthropogenic landscapes, Y.Q. Saushkin [21], D.V. Bogdanov [8], V. S. Zhekulin [10], V.I. Prokayev [18], A.M. Ryabchikov [19], N.I. Akhtirseva [6], F.N. Milkov [15,16], A. G. Isachenko [11-13] and others. specialists were engaged. L.I. Kurakova [14] formation periods of anthropogenic landscapes, V. M. Chupakhin [22] studied the research methods of anthropogenic landscapes, D. L. Beruchashvili [7] investigated the geophysical characteristics of natural-anthropogenic complexes.

The purpose of the work and the current status of the issue

The modern anthropogenic landscapes of the Republic of Azerbaijan have been systematically studied since the 70s and 80s of the 20th century. In this field, B.A. Budagov [9], M.A. Museyibov [17], M.A. Suleymanov [5], Y.A. Garibov [1,2], N.S. Ismayilova [2], R.R. Sadullayev [2,3,4,20] and other researchers have played a role. A. G. Isachenko for research and mapping of anthropogenic landscapes on a global scale [13] and the division proposed by A.M. Ryabchikov [19] according to the degree of use of the area is more appropriate.

In the process of anthropogenesis, the morphological units of the natural landscape undergo faster changes. Depending on the degree of impact of economic activity, it is necessary to distinguish between changed (weakly, strongly and fundamentally changed) and conventionally unchanged landscapes [11,12,16].

Taking into account the characteristics of the regions of the Republic of Azerbaijan and the direction of anthropogenic influences, natural landscapes are classified into 5 groups according based on the the degree of anthropogenicity: 1) practically unchanged, 2) weakly anthropogenic 3) moderately anthropogenic 4) strongly anthropogenic və 5) fundamentally transformed [1]. As a result of a systematic study of the northeastern slope of the Great Caucasus based on GIS and satellite images, three important differentiating

features of modern anthropogenic landscapes were determined by us: 1) fundamentally changed natural complexes of lowlands and foothills 2) altered natural complexes of the middle highlands 3) the natural complexes of the highlands that preserve their original state.

Research Methodology

The modern(contemporary) natural landscapes of the north-eastern slope of the Great Caucasus underwent fundamental changes throughout historical periods, ultimately being replaced by diverse anthropogenic complexes. In recent years, we have been monitoring the anthropogenic complexes of the region based on GIS and satellite images. In order to study the spread, density, modern condition and dynamics of anthropogenic landscapes of the northeastern slope of the Greater Caucasus, multispectral images were monitored using the NDVI (The Normalized Difference Vegetation Index) unsupervised classification method.

The content of the work

Modern natural-anthropogenic landscapes of the northeastern slope of the Great Caucasus are distributed according to the law of vertical belt. The semi-desert, dry steppe, xerophytic thicket, arid sparse forest-shrub complexes of the Samur-Devachi lowland have been fundamentally changed, replaced by miscellaneous intensively used anthropogenic and man-made complexes, large-area urban agglomerations and other selective landscapes. In the meadow-shrub, forest-shrub, forest landscapes of the low mountains and smooth plateaus, agrolandscapes and livestock complexes were formed, which were mainly related to dryland farming and animal husbandry. The anthropogenic transformation of the natural landscape types, subtypes, and categories in these areas has a maximum indicator. So, at least 50% of the forests here [1,2] have gradually transformed into meadow, forest-shrub, sparse shrub, etc. what is considered natural has evolved into derivative landscapes. At the same time, in the subsequent years, a significant portion of the bushes was replaced by agrocenoses or other recurring landscapes.

The contemporary natural landscapes of the mountainous and plain areas of the north-eastern slope of the Great Caucasus have been fundamentally changed and replaced by re-derived landscapes and anthropogenic complexes. As a result of agricultural development in the Samur-Devachi lowland, the sloping plains of Gusar, the small-area agrocomplexes and seliteb landscapes [2] scattered in the wide valleys of Gusarchay, Gudyalchay, Karachay, Valvalachay with favorable melioration conditions, in the yield cones [2] gradually began to expand, expanding towards the foothill plains and suppressed the forests and thickets. Most of the for-

ests in the flat plains and the sloping plains at the foot of the mountains were subjected to anthropogenic influences and transformed

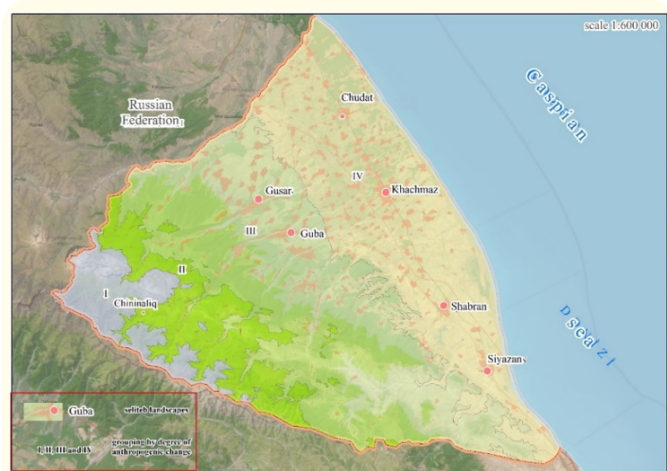


Figure 1: Differentiation of the landscapes of the northeastern slope of the Greater Caucasus according to the degree of anthropogenic change.

into agro-landscapes in the first centuries of our era (Figure 1).

1. Complexes that are practically unaltered and retain the characteristics of thier natural development
2. Poorly modified, summer pastures and hayfields subject to irregular farm impacts
3. Complexes subjected to moderately altered irregular economic effects
4. Complexes subject to significant changes and regular economic effects.

The contemporary natural-anthropogenic complex of the northeastern slope of the Greater Caucasus was shaped by the influence of long-term natural-historical processes. The foundation of the modern anthropogenic loads of the region are cultivated fields, gardens and plantations, artificial forests, urban and rural sewage complexes, distinct functional infrastructures - roads, canals, reservoirs, pipelines, power lines and surface degradation. The analysis of the north-eastern slope of the Greater Caucasus based on satellite images reveals that the natural landscape cover of the region (especially the hypsometric step up to 1000 m) has

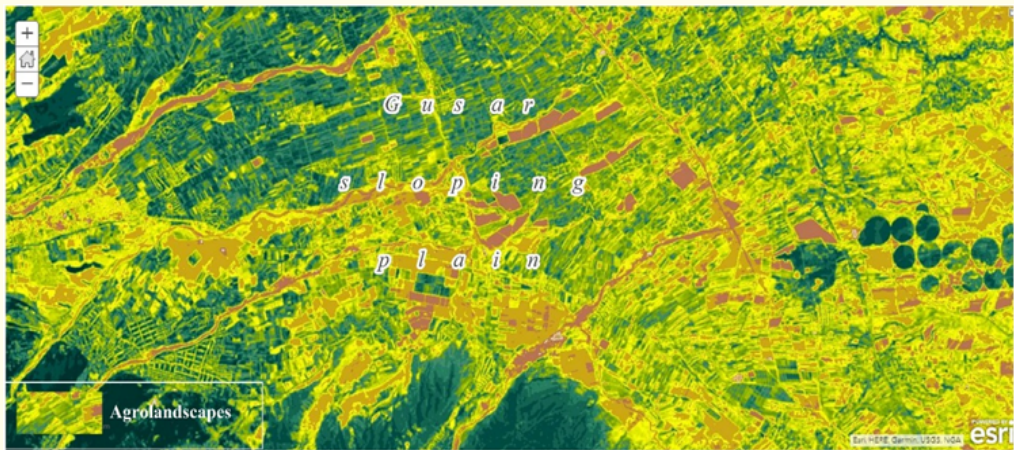


Figure 2: Intensively used and drastic transformed agro-irrigation landscapes of the Gusar sloping plain [23].

been excessively fragmented by anthropogenic modifications and divided into numerous areas (Figure 2).

The development of agriculture, horticulture, and animal husbandry in the Greater Caucasus region is closely linked to the characteristics of natural landscapes. The anthropogenic complexes [1,2], which are irrigated and used in the form of dry-farming (not irrigated) fields to varying degrees, are fundamentally changed both by natural landscape types and by administrative-territorial units. Except for Khachmaz region, all administrative regions of the northeastern slope of the Greater Caucasus are divided into two

parts based on geomorphological, soil-climatic characteristics: 1. mountainous zone; 2. foothill sloping plains and lowlands.

Landscape contours of disparate geometric shapes (ball, scattered, grid, etc.) in the satellite images of the northeastern slope of the Greater Caucasus reflect the features of assimilation and the intensity of anthropogenic influences. Agro-irrigation landscapes formed in semi-deserts of intensively utilized alluvial, alluvial-proluvial, sea plains are characteristic of the Samur-Devachi lowland [1,2]. The agro-irrigation complexes representing the vegetable and garden-plantation crops of the sloping, foothills and undulat-

ing 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 northeastern slope of the Greater Caucasus are distributed in the gray brown soils of the fragmented low mountains and plateaus in the Khizi and Siyazan regions. In the backdrop, there are small-area paddy fields, episodic irrigated agro-landscapes, grape plantations and hayfields.

Analysis of the northeastern slope of the Greater Caucasus based on GIS shows that 95.4% of the region's agro-landscapes (mowing, perennial planting and sowing), i.e. 189,251 hectares,

Nº	Altitudes m	Arable land, ha	Total share of arable land %
1	to 500	80798	71
2	500-1000	26646	23.6
3	1000 -2000	3300	3.4
4	2000 -2500	2181	2
5	2500-4466	0	0
Total		112925	100

Table 1: Differentiation of arable agricultural landscapes of the northeastern slope of the Great Caucasus by altitudinal interval.

are part of the foothill plains and lowlands with an altitude of up to 1000 [4,20] (Table 1).

As a result of the analysis of the regional distribution of agro-landscapes, it was determined that among the agrolandscapes with diverse economic functions, irrigated and semi-cultivated, garden-plantation, selebit-garden, mowing and pasture agro-irrigation landscapes prevail. In the structure of the aforementioned anthropogenic complexes, the irrigated fields are distinguished by their significant advantage both in terms of their economic importance and their productivity. [1,2].

The following main features are observed in the distribution of modern anthropogenic landscapes on the northeastern slope of the Greater Caucasus : The most vital qualitative change in the structure of agroirrigated landscapes in recent years is the increase in the area of grain and perennial crops and the decrease in the area of low-yielding pastures and hayfields.

Poorly anthropogenic landscapes are a minority in the Gusar sloping plain. Thus, the total area of seliteb complexes in the Gusar sloping plain is 19,000 ha (11.5%), and the area of forest landscapes is 50,000 ha (30.2%). The proportion 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 underutilized coasts, swamps, and river beds are 14.5% [4,20].

Within the economic functions of the agrolandscapes of the Greater Caucasus region, the replacement of small-area vegetable and melon plantations and scattered complexes with large-area grain and perennial crops is observed [1]. The hypsometric zone 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. Approximately 10% of this level (43 416 ha) is made up of seliteb complexes. 94.6% (139,571 ha) of the entire cultivated area of the north-eastern slope of the Caucasus is concentrated in favorable hypsometric conditions up to 1000 m.

In the northern-eastern slope of the Great Caucasus, settlement seliteb complexes are more prevalent , representing landscape units with networked areas. Their chain, circular-radial, ball, scattered, etc. Diverse configurations are available. The proportion of seliteb complexes in the overall landscape background is 1.5% in the areas of Jeyranchol and Gobustan [2], this quantity reaches 11.2% (22,810 ha) in the Samur-Devachi plain. Based on the analysis of satellite images, we can say that the total area of seliteb complexes in the region is 47,229 ha (6.7%). Both the area of the seliteb

№	Altitudes	Area of seliteb complexes, ha	Total share of seliteb complexes,
			%
1	to 500 m	25 782	54.5
2	500-1000 m	17 131	36.2
3	1000 -2000 m	3 809	8.1
4	2000 -2500 m	547	1.2
5	2500-4466 m	0	0
Total		47 269	100

Table 2: Features of differentiation of seliteb complexes by altitude zones.

complexes of the region along the vertical belt (-28-4466 m) and the impact on the surrounding landscapes are gradually weakening (Table 2).

The primary network of Seliteb complexes is concentrated in plains, sloping plains and foothills. Depending on the terrain and climatic conditions, the area and number of village seliteb complexes gradually decreases towards the middle and high mountains

(90.7% up to 1000 m, 8.1% between 1000-2000 m, 1.2% above 2000 m). Settlement in zones with an absolute altitude of 2500 m and above is temporary or seasonal in nature.

Result

Within Azerbaijan, all landscape units are found on the north-eastern slope of the Great Caucasus, from the sharply evolved agro-irrigation complexes of the plain-lowland areas to the practically untouched nival-glacier complexes of the highlands. Substantial agro-landscape loading is observed at an altitude of up to 1000 m on the northeastern slope of the Greater Caucasus. Thus, 98% of perennial planting (40,000 ha), 93% of mowed areas (41,351 ha), and 94.6% of cultivated areas (139,571 ha) are concentrated in this area. Overall, 62% (272,740 ha) of the hypsometric level up to 1000 m is occupied by agrolandscapes, 10% (43,416 ha) comprises seliteb complexes.

On the northeastern slope of the Greater Caucasus, seliteb complexes are chain, circular-radial, ball, scattered, etc. distinct configurations are available. Based on the analysis of satellite images, we can say that the total area of seliteb complexes in the region is 47,229 ha (6.7%). Both the area of the seliteb complexes of the region along the vertical belt (-28-4466 m) and the impact on the surrounding landscapes are gradually weakening.

The fundamental 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 of village seliteb complexes and the area covered gradually decreases (90.7% up to 1000 m, 8.1% between 1000-2000 m, 1.2% above 2000 m %), the absolute height of which is 2500 m and above, the settlement is temporary and seasonal.

Discussion

The natural landscapes of the north-eastern slope of the Greater Caucasus have been subjected to miscellaneous degrees of changes, and the anthropogenic landscapes we are currently observing have been formed under the influence of intricate geographical-historical-economic factors. Hence, contemporary anthropogenic landscapes of the region are distinguished by specific structural-functional and differentiation characteristics. In the article, these features are explored on the basis of Geographic Information Systems (GIS) and satellite images (CNES/Airbus, Landsat 7 ETM+, Landsat 8, etc.), which are scientifically and practically important. The natural landscapes of the region from the Caspian coastal plains to the Main Caucasus range according to the nature of an-

thropogenic changes are distributed like this: sharply, moderately, weakly changed and practically unchanged landscapes (subnival and nival complexes of highlands).

Bibliography

1. Garibov Y.A. "Anthropogenic transformation of modern landscapes of the Republic of Azerbaijan". Baku, "Mars Print" (2011): 299.
2. Garibov Y.E., *et al.* "Study of anthropogenic transformation of the natural landscapes of the Greater Caucasus with GIS technology" (Monograph), Baku, "Teacher" publishing house (2020): 190.
3. Sadullayev R.R. "The application of Geographic Information Systems (GIS) and the study of the differentiation characteristics of seliteb complexes based on satellite images (in the example of the northeastern slope of the Greater Caucasus), II International Science and Technology Conference, Baku (2021): 151-154.
4. Sadullayev R.R. "Study of the transformation and dynamics of contemporary landscapes based on Geographical Information Systems (CIS)" of the 14th International Scientific and Practical Conference "Global Science And Innovations 2021: Central Asia". Nur-Sultan (Astana)), Kazakhstan (2021): 18-22.
5. Suleymanov MA and Aliyeva IS. "Basics of landscape science, textbook/Baku (2008): 400.
6. Akhtyrtseva NI. "On the classification of anthropogenic landscapes". Questions of Geography 106 (1977): 53-57.
7. Beruchashvili NL. "Four dimensions of landscape. M.: Mysl (1986): 182.
8. Bogdanov DV. "Cultural landscapes of the valleys of the north-western Pamirs and the possibilities of their transformation / In the book: Questions of geography 24 (1951): 300-321.
9. Budagov B.A and Garibov Y.A. "The influence of anthropogenic factors on the formation of landscapes in Azerbaijan // Reports of the Academy of Sciences of Azerbaijan. SSR 12 (1980): 62-66.
10. Zhekulin VS. "On the question of the methodology for studying the structure of landscapes for the purposes of typology / In the book: Geographical collection 6 (1961).

11. Isachenko AG. "Fundamentals of landscape science and physical-geographical zoning. M (1965).
12. Isachenko AG. "Applied landscape science. Part 1. L (1976).
13. Isachenko AG. "Landscape science and physical-geographical zoning. M.: Higher. School (1991). 366.
14. Kurakova LI. "Anthropogenic landscapes. M.: Publishing house Mosk. Univ (1976): 216.
15. Milkov FN. "Man-made landscapes M (1978): 86.
16. Milkov FN. "Anthropogenic landscape science, subject of study and current state / In the book: Questions of geography. Sat 106 (1977).
17. Museibov MA. "Landscapes of the Republic of Azerbaijan. Baku, ed. BSU (2011): 138.
18. Prokaev VI. "Accounting for anthropogenic differentiation of natural conditions in physical-geographical zoning / V.I. Prokaev // Vestn. Moscow University 5 (1965): 47-54.
19. Ryabchikov AM. "The structure and dynamics of the geosphere, its natural development and changes by man. M (1972).
20. Sadullaev RR. "Study of the features of differentiation of anthropogenic landscape complexes based on remote sensing data and Geographic Information Systems (GIS) (On the example of the northeastern slope of the Greater Caucasus), Moscow: "Universum: chemistry and biology". *Scientific Journal* 1-3.105 (2023): 5-11
21. Saushkin YuG. "Cultural landscape. Questions of geography". M.: Mysl. collection (1946): 1.
22. Chupakhin VM. "Fundamentals of landscape science". M.: Agropromizdat (1987): 169.
23. <https://hub.arcgis.com/maps/esri:landsat-8-ndvi>