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GEOMORPHOLOGY

ASSESSMENT OF THE DEVELOPMENT OF DANGEROUS EXOGENOUS PROCESSES ON THE HIGHWAYS OF THE KARABAKH AND EASTERN ZANGAZUR ECONOMIC REGIONS (in the case study for “Zafaryolu”)

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Abstract

One of the current ecological problems is the development of a methodology for assessing the risks and damage caused by hazardous exogenous processes on road surfaces and the compilation of ecological risk maps. Based on the geomorphological research materials, as well as references, the geomorphological characteristics of hazardous processes were scrutinized and provided a complete geomorphological description of the area through which the “Zafaryolu” highway passes in the research paper.

In order to determine the general background of the fragmentation of the modern relief on which the “Zafaryolu” highway is being built, a 5-point scale was developed and adopted for assessing morphometric stress, which reflects the degree of horizontal and vertical fragmentation of the area, slope inclination, etc. Analysis of various quantitative indicators of the relief and the compiled synthetic map of morphometric stress makes a way to determine the dependence of the intensity and direction of development of hazardous exogenous processes on the scale and nature of the fragmentation of the relief, as well as a high indicator.

1. Introduction

The cumulative deepening of the ecological crisis in the 21st century, that is, the crisis of the relationship between society and nature, has necessitated radical changes in the development goals and priorities of humanity.

The safety of human life and economic activities, as well as infrastructure facilities, in areas where dangerous natural and natural-anthropogenic processes develop is one of the main socio-ecological problems of our time [9].

The properties of Azerbaijan’s transition to sustainable development are primarily related to the need for comprehensive solutions to environmental, economic, and social problems. Despite the fact that some recent improvements have been made in certain environmental indicators in the republic, the ecological situation in the liberated territories of Karabakh and Eastern Zangezur remains critical. The military aggression carried out by the enemy during the 30-year occupation of these lands has led to numerous and various ecological problems, including the deterioration of

the ecological and geomorphological conditions of the region. As a result, the ecosystem balance has been disrupted. The Azerbaijani government has developed a master plan for the restoration of Karabakh and Eastern Zangezur territories, including Aghdam, Fuzuli, Khojaly, Khojavend, Shusha, Tartar, Jabrayil, Kalbajar, Gubadli, Lachin, Zangilan districts, and the city of Khankendi, for the next 20 years. The list of tasks includes road construction, communication works, commissioning of international airports, power plants, construction of “smart villages”, etc.

It is an undeniable fact that the involvement of territories in economic activity, especially in areas where potentially hazardous objects are located, leads to inevitable changes in the environment, accompanied by disruptions to the natural course of processes and intensification of anthropogenic impacts.

Among the most destructive exogenous processes are avalanches, landslides, and upheavals, as well as floods [13].

Failure to take appropriate environmental and engineering measures for economic activity and development of territories leads to the intensification and spread of landslides, which pose a threat to the lives of the population living in settlements, the stability of infrastructure, and the territory as a whole. Preventing dangerous processes is less expensive than eliminating their consequences. The number of accidents and disasters at construction sites is increasing as a result of the failure to calculate the degree of danger and the insufficient development of methods for calculating the strength of anti-gravity structures, and the failure to always comply with the requirements of anti-gravity construction standards. This determines the relevance of work on improving methods for calculating hazards associated with exogenous processes and the effectiveness of protecting structures in the areas. One of the main tasks of the emergency management methodology is the task of managing emergency monitoring projects [8].

Thus, the challenges regarding preventing dangerous processes and ensuring the stability of areas exposed to active soil displacement are concerning the safety of the population and household facilities. The cases of the numerous hazardous process activities are accompanied by the construction and operation of highways and railways, pipelines, power line supports, residential and other buildings.

Assessing threats at different stages of development in a territory and selecting measures to prevent them requires identifying and taking into account many factors and considering various scenarios for the development of events. These measures include analysis of reserve materials and current observation results, study of physical and mechanical properties of soils, development of models of hazardous processes, selection of calculation schemes, assessment of the probability and frequency of displacement development, possible damage, and analysis of consequences [7].

Depending on the available data, a qualitative and quantitative assessment of the hazard of exogenous processes is carried out. The main difficulty is the presence of uncertainty: spatial variability of soil properties, the subjective nature of the interpretation of the results, and the intensity of the temporal influence of the factor that causes the activation of their displacement [9].

The study of the dynamics of exogenous processes is inextricably linked to the analysis of the stresses in the rocks composing slopes. The nature of the stress distribution in rock masses must also

be taken into account when characterizing their strength and deformation properties. In recent research, it was revealed that the relationship between stress and displacement depends on the geological properties of the rocks [14]. The works of numerous foreign researchers [1; 2; 4; 15; 16; 17] in this field are of great interest.

The aim of the work is to study the development of exogenous processes in the area where the “Zafaryolu” highway passes, and to assess their danger.

2. Methods

The processes that cause the activation of gravitational processes can be determined by various methods (soil properties, terrain exploration, inspection of sections of highways, or underground mining). Geomorphological changes are detected based on soil survey data, geological maps, aerial photography data interpretation, or remote sensing. Physical changes are recorded through seismographs, displacement devices, and temperature sensors [18].

The initial stage of determining gravitational processes on highways involves reconnaissance of the area. Topographic maps describe the boundaries of the soil in detail. Significant changes in soil conditions can be determined based on the analysis of topographic maps. Geological-geomorphological maps of various scales are widely distributed, which enable us to determine the geological characteristics of the subsoil. Climatic data and historical observations of hazardous exogenous processes in the region can provide relevant information about the damage during torrential rainfall events. The main purpose of field studies is to update previously obtained data, establish criteria for subsequent observations, and record the size or other manifestations of processes.

When studying hazardous exogenous processes, special attention is paid to the rocks composing the slope, the properties of which are the most important factor in their formation. The study of the geological properties of rocks is of great interest for assessing slope stability and predicting hazardous processes. The stress-strain state of rocks involved in the gravitational process changes when exposed to stress for a long time. The main indicators of the mechanical properties of rocks include deformation and strength properties.

When analyzing hazardous exogenous processes on road surfaces, high-resolution satellite images (HR) and digital terrain models (DRTM) from CNES/Airbus, Maxar Technologies (Geo-

Eye-1), and medium-resolution Sentinel-2A and 2B were mainly used. Moreover, visual and semi-automatic decoding (classification with training) was performed in the ArcGIS environment.

To assess the danger of gravitational processes on the highways passing through the Karabakh and Eastern Zangezur regions, we propose a cartographic modeling method using GIS technologies. During the study, the ArcGIS software package (Hydrology, Spatial Analyst, 3D Analyst, etc.) was applied, and digital morphometric maps (slope inclination, slope steepness, vertical and horizontal fragmentation, etc.) at a scale of 1:100,000 were compiled. A morphometric stress map was compiled based on the data from the morphometric maps. Based on their analysis, areas of gravitational processes with potential geomorphological hazards were identified in the area where the "Zafar" highway passes.

3. Analysis and discussion

Ongoing construction work in the territories of Karabakh and Eastern Zangezur, which returned to the control of the Republic of Azerbaijan during the Second Karabakh War, represents the restoration of territories recently liberated from occupation by Azerbaijan. For this purpose, the Azerbaijani government has prepared the "Great Return" state program.

The construction of 19 highways with a length of 2,241 km is ongoing.

In Karabakh and Eastern Zangezur regions, most roads are limited to watersheds or flattened sections of slopes, where it is particularly easy to disrupt the balance of slope processes. Dangerous factors in the development of gravitational processes are the shearing of the slope above the road, the instability of the slope along which the road passes, the increase in dynamic loads on the ground, and the irregular flow of precipitation on most roads [12].

Predicting the development of landslides, avalanches, and debris flows is one of the key points when choosing a location for a transport artery. According to the observations, during the design and construction of roads, little attention is paid to protecting them from gravitational processes developed on the slope above the road. Slope processes develop both on the slope above and below the road line. Therefore, it is necessary, first of all, to develop and implement protective measures against hazards for road facilities in areas with high gravity hazards and gravity risks.

In this research work, the "Zafaryolu" in terms of the development of dangerous gravitational processes was considered.

The "Zafaryolu" takes its beginning from the Hajigabul-Minjivan-Zangezur corridor highway and extends to the city of Shusha. This road was built through the territories of the liberated Fuzuli, Khojavend, Khojaly and Shusha districts. The highway will cover more than 20 settlements in the districts, including the cities of Fuzuli and Shusha (Fig. 1). This road was named "Zafaryolu" by the President of Azerbaijan in order to perpetuate the memory of the road used during the liberation of the city of Shusha from occupation. The 103 km long road belongs to the second technical category and has two lanes. In order to obtain the width of the road specified in the project, rocks were blasted and moved aside during the construction of the road in areas with difficult terrain. In order to ensure drainage along the road, circular pipes, rectangular drainage systems and 3 automobile bridges with lengths of 33, 99, 75 m were constructed at sections of 0.6, 26 and 57 km (Fig. 2).



Figure 1. "Zafaryolu" before construction



Figure 2. "Zafaryolu" after construction

The area through which "Zafaryolu" passes tectonically corresponds to the Goycha-Karabakh and Miskhana-Gafan tectonic zones, which consist of Jurassic, Cretaceous, Paleogene, Neogene, and Quaternary rocks. Morphostructures composed of denudation-resistant rocks are widespread due to their origin. Such morphostructures include numerous monoclinical ridges on the southwestern slope of the Karabakh Range within the Zamzur anticlinorium. The structures expressed in the relief include the development zone of the northeastern wing of the Gafan anticlinorium. From the southeast, the Goycha-Karabakh and Miskhana-Gafan zones are limited by the Lower Aras transverse tectonic fault.

The Karabakh anticlinorium corresponds to the watershed of the ridge in the area between the Mount Alagaya and Mount Uchtugh and in the area of the Big Kirs Mount. As a result, in the watershed of the Karabakh range, horst uplift occurred in the last tectonic stage, the maximum value of which coincides with the Kirkhgyz and Boyuk Kirs mountain ranges. In the watershed zone, the slopes of the Karabakh Range above 1800-2000 m are complicated by gravitational (avalanche, landslide, etc.) relief forms. This structure of the slope is due to the presence of a deep fault and generally coincides with the emergence of Middle and Upper Jurassic rocks to the surface. Regional bending can be observed in the slope structure along the fault line [10]. Below the fold line of this slope, a wide strip of planation surfaces (probably Miocene) with heights varying between 1600-2200 m due to the differentiation of recent tectonic movements can be observed [10]. The relief surfaces reveal elements of the ancient river network in the form of valleys on ancient alluvium and are inclined both to the northeast, in accordance with the flow direction of the modern river network, and to the southeast, in accordance with the direction of ancient (Miocene) river systems. Hypsometrically, at the same level as these alignment surfaces is the structural surface of the synclinal plateau - the Shusha plateau, formed of Upper Jurassic lime-stones, deeply cut by the valleys of the Gargar-chay tributaries. The highest point of the Shusha Plateau is 1600 m, and the lowest point is 1300 m. This high mountain plateau is surrounded by deep faults that descend to the Khalfalichay and Dashaltychay rivers.

The lithology of the rocks composing the modern relief plays a major role in its plasticity. High-density chalk limestones form monoclinical ridges. Intrusive rocks play an important role in

the plasticity of the relief. Because they are resistant to denudation, they form positive relief forms. The relief is also characterized by the presence of intermountain depressions. For example, the Sirik depression is located on the southern slope of the southeastern end of the Karabakh ridge, south of the Ziyarat peak. The surface of the depression is smoothed, inclined in direction, and dissected by a network of ravines and gullies.

The area through which "Zafaryolu" passes is characterized by the development of avalanches of gravitational-tectonic origin that occur during seismic activity. The low mountain belt of the Karabakh range is characterized by the weakest manifestation of the mentioned processes. Avalanches correspond to monoclinical ranges and ridges. The surface of these monoclinical ridges and ranges is covered with layers of sedimentary and volcanogenic-sedimentary rocks. Avalanches occur relatively frequently in the mid-mountain and high mountain belts of the Karabakh range, which is due to the monoclinical structure of the orographic relief elements. They are located mainly on the southwestern steep slopes of the ranges, which are complicated by tectonic faults. However, in some places they are also observed in the bare areas of the northern and northeastern slopes of the range, as well as in the Khalfalichay valley. Large rock avalanches occur along the edges of lava flows and covers - in mountainous areas such as Kirkhgyz, Boyuk Gyzlar, etc.

The aggregate materials are also characteristic of the study area. The aggregate materials are divided into creamy and gravel aggregates according to their granulometry. Creamy aggregate materials are located in the high mountain belt - on the slopes of the Khachinchay valley, while gravel aggregate materials are mainly located in the middle and low mountain belts, in the direction of the river's flow.

In this place, landslide processes are weaker manifested. This is primarily explained by favorable climatic and geological conditions, i.e. relatively low amounts of atmospheric precipitation, low volumes of clayey sediments, flat-lying mountain rocks in large areas, etc. The lowland belt of the Karabakh range is characterized by very weak manifestations of landslides. In this place, landslides developed mainly in thick, overlying clayey sediments. Landslides in the middle mountain belt of the Karabakh range also developed mainly on the slopes of river valleys that cut through clayey sediments that fill and cover intermountain depressions. Landslides are observed

in the bedrock of the Khalfalichay, Kha-chinchay, and other rivers' basins.

The occurrence of landslides in the central part of the Karabakh range is related to the ophiolite belt. The widespread serpentinites and serpentinized rocks in this area are characterized by strong cleavage, intensive fracturing, and very poor denudation resistance [5]. When favorable conditions arise, individual layers and masses of these rocks are subject to displacement along fault planes and tectonic slip planes.

The morphometric characteristics of the relief are of great importance for numerous natural phenomena and processes [3; 6; 11]. Morphometric indicators of relief, which are important characteristics in ecological and geomorphological studies, include the following:

- 1) absolute height,
- 2) slope inclination,
- 3) exposition of slopes,
- 4) vertical and horizontal fragmentation of the relief.

For example, the amount of precipitation and solar radiation and atmospheric pressure depend on the absolute altitude of the area. The incli-

nation and orientation of slopes determine the direction of surface runoff volume. Therefore, morphometric indicators determine the development trend of exogenous processes. Linear objects (roads) are most affected by the angles of inclination and the length of slopes. Relief affects the operation of various facilities; unfavorable relief worsens the ecological condition of the area and increases the risk of industrial accidents.

All this suggests that morphometric maps serve as the main basis for ecological and geomorphological studies.

Morphometric analyses are conducted based on geoinformation technologies. For example, after analyzing the distribution of elevations using a digital elevation model (DEM), a hypsometric map is created that visually depicts elevation gradients.

To study the impact of morphometric indicators on the formation of dangerous exogenous processes, the hypsometric, slope, elevation, and vertical fragmentation indicators of the relief of the area through which the "Zafaryolu" highway passes were analyzed (Fig. 3, 4, 5, 6).

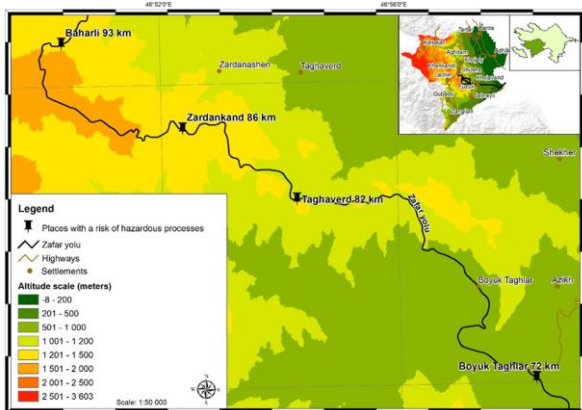


Figure 3. Hypsometric map of "Zafaryolu"

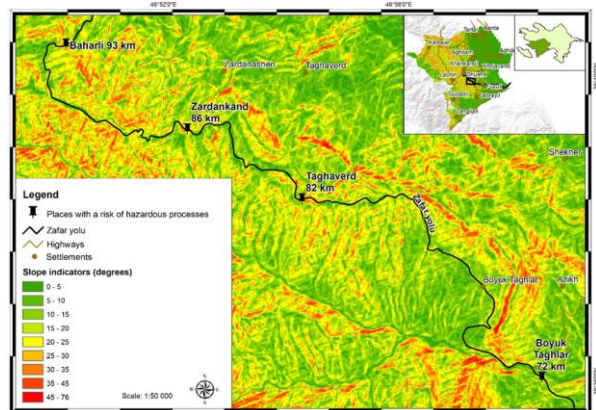


Figure 4. Slope inclination map of the "Zafaryolu"

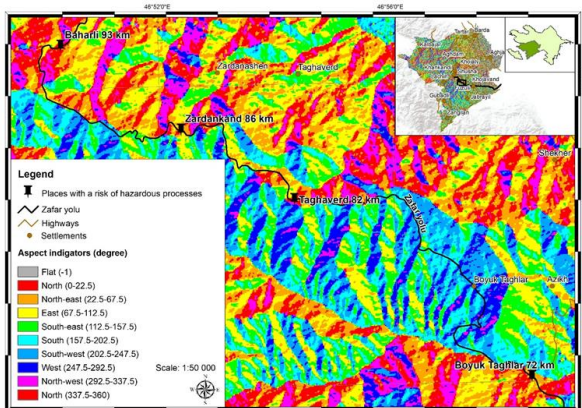


Figure 5. Exposition map of the "Zafaryolu"

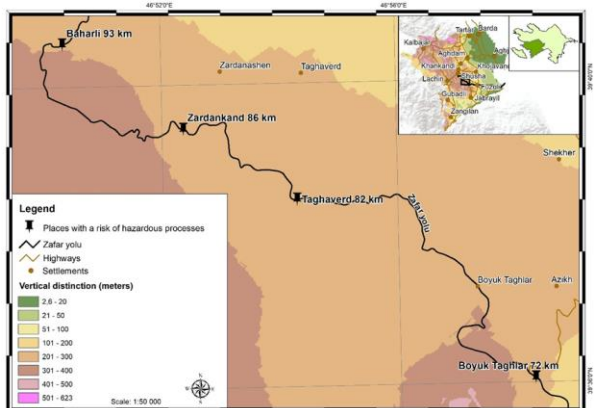


Figure 6. Vertical fragmentation map of "Zafaryolu"

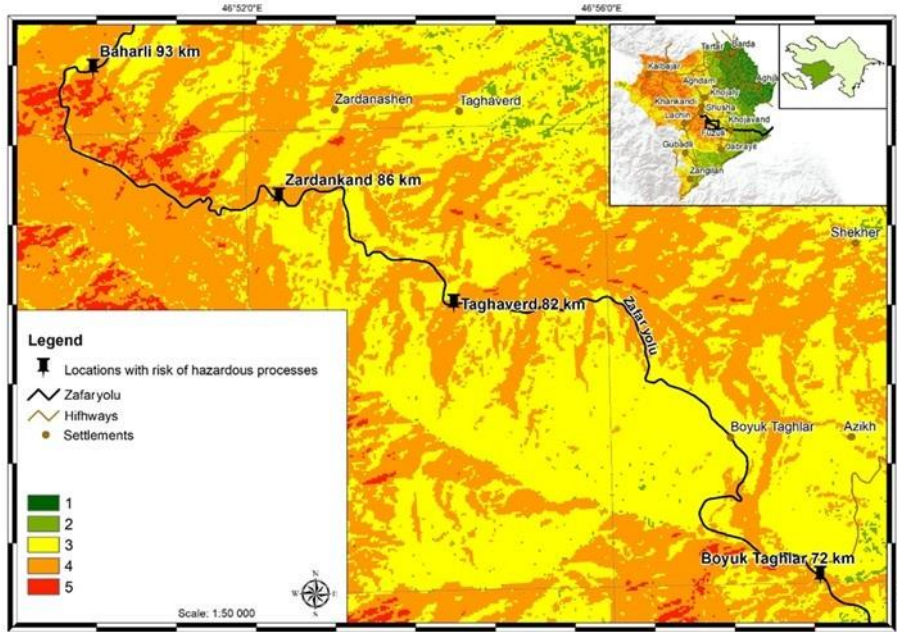


Figure 7. Morphometric stress map of "Zafaryolu"

Table 1

Morphometric stress rating scale

Vertical fragmentation (m)	Slope inclination (°)	Rating (points)
>1000	>40°	V
500-1000	30°-40°	IV
200-500	20°-30°	III
100-200	10°-20°	II
0-100	<10°	I

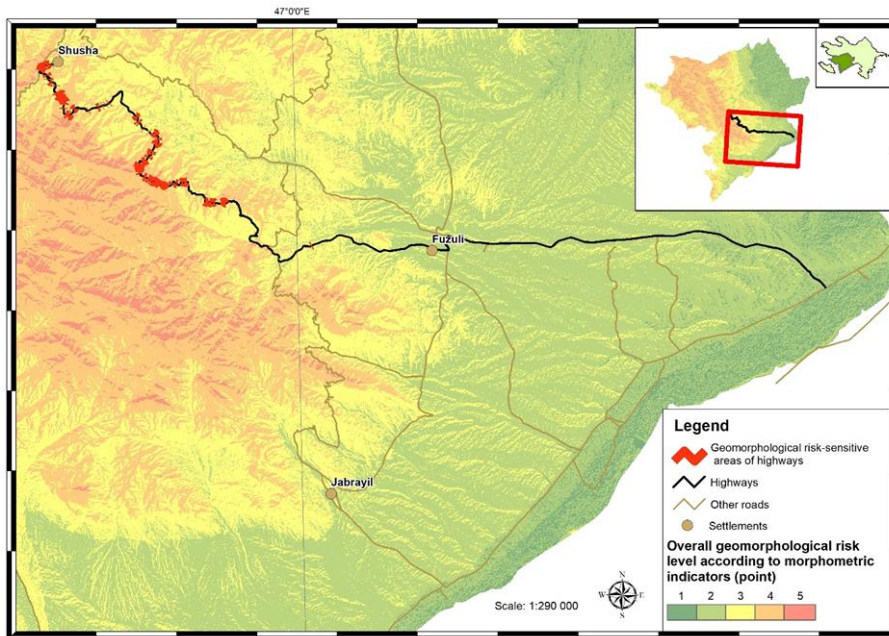


Figure 8. Parts of the "Zafaryolu" which are sensitive to geomorphological risks and hazards

A 5-point scale (degree of vertical fragmentation of the territory, slope inclination, etc.) was developed and adopted to determine the general background of the fragmentation of the modern relief and to assess the morphometric stress in the

area where the "Zafaryolu" highway passes through (Fig. 7), (Table 1).

According to the analyses conducted, 13 areas with high geomorphological risks and hazards

were identified along the “Zafaryolu” route (Fig. 8).

Thus, the analysis of various quantitative indicators of the relief and the compiled synthetic map of morphometric stress make it possible to determine the dependence of the intensity and direction of development of dangerous gravitational processes on the scale of relief fragmentation and the nature of morphometric indicators.

4. Conclusion

Based on the morphometric indicators of the relief (horizontal and vertical fragmentation, hypsometry, inclination and exposition), a geomorphological risk assessment was conducted in the Karabakh and Eastern Zangezur territories, and areas where dangerous geomorphological processes (seismic dislocation, avalanche, aggregation, landslide, flood, etc.) affect the road and transport infrastructure were identified, and a corresponding map was compiled. According to calculations, a total of 10.6 km (9.73%) of the "Zafaryolu" (103 km) are areas with high geomorphological risks and hazards.

The operation of such a complex and important facility as a highway requires the development of projects for engineering protection against dangerous geological and geomorphological processes. These projects should be based on the study and assessment of the modern engineering-geological and geomorphological conditions of the studied area, the characteristics of the history of slope development and the possibility of the development of dangerous processes in them, factors related to modern geodynamics (composition, thickness, conditions of formation of rocks, their dislocation and fracture, hydrogeological properties, etc.), the development of forecasts for changes in the stability of the geological environment during the operation of facilities based on calculations and modeling, and the development of appropriate protective measures.

It is essential to develop site-specific, detailed engineering projects to ensure comprehensive geotechnical protection of individual structures within areas undergoing highway construction. These engineering interventions may encompass slope grading and terracing; the design and implementation of surface drainage networks, including both open-channel and subsurface systems; as well as the construction of substantial retaining structures and stabilization measures for mountainous slopes susceptible to landslides and avalanches.

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**QARABAĞ VƏ ŞƏRQİ ZƏNGƏZUR
İQTİSADI RAYONLARININ YOLLARINDA
TƏHLÜKƏLİ EKZOGEN PROSESLƏRİN
İNKİŞAFININ QIYMƏTLƏNDİRİLMƏSİ
("Zəfəryolu" timsalında)**

S.Ə. Tarixazər, C.Y. Qasımov, S.A. Məmiyeva

Xülasə. Mövcud elmi problemlərdən biri yol səthlərində təhlükəli ekzogen proseslərdən görünən risk və ziyanın qiymətləndirilməsi metodologiyasının işlənilməsi və ekoloji risk xəritələrinin tərtib edilmə-

sidir. Məqalədə geomorfoloji tədqiqatlarının materiallarına, eləcə də istinad ədəbiyyatına əsaslanaraq təhlükəli proseslərin geomorfoloji xüsusiyyətləri araşdırılır, "Zəfəryolu"nun keçdiyi ərazinin geomorfoloji təsviri verilir.

"Zəfəryolu" avtomobil yolunun salındığı relyefin müasir parçalanmasının ümumi fonunu müəyyən etmək üçün ərazinin üfüqi və şaquli parçalanma dərəcəsini, yamacın meyilliyini və s. özündə əks etdirən morfometrik gərginliyin qiymətləndirilməsi üçün 5 ballıq şkala hazırlanmış və qəbul edilmişdir. Relyefin müxtəlif kəmiyyət göstəricilərinin təhlili və morfometrik gərginliyin tərtib olunmuş sintetik xəritəsi təhlükəli ekzogen proseslərin intensivliyi və inkişaf istiqamətinin həm də relyefin parçalanmasının miqyasından və xarakterindən asılılığını, yüksək göstəricisini müəyyən etməyə imkan verir.

Açar sözlər: ekoloji böhran, təhlükə, dağıdıcı ekzogen proseslər, davamlı inkişaf, avtomobil yolu, qiymətləndirmə, CİS texnologiyası.

CLIMATE

STUDY OF THE AIR TEMPERATURE REGIME OF THE EASTERN ZANGEZUR ECONOMIC REGION**S.H.Safarov, A.H.Majidzada***Institute of Geography named after academician H.A. Aliyev, Ministry of Science and Education
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Abstract

The article studies the general trends in the temperature regime of the Kalbajar, Lachin, Gubadli, Jabrayil and Zangilan regions, which are currently included in the Eastern Zangezur economic region, based on the MERRA-2 (Modern-Era Retrospective analysis for Research and Applications, Version 2) reanalysis data for the period 1980-2022. During the study, an increasing trend in average annual and seasonal temperatures was detected for the area during the period under review. The temperature increase by seasons and by annual period is statistically significant at the 5% level of confidence. The calculations showed that the average annual air temperature in Kalbajar and Lachin regions increased by 0.9°C in the period 2001-2022 compared to the period 1980-2000. This increase was recorded in Gubadli, Jabrayil and Zangilan regions by 1.1°C. These results are consistent with the results obtained in other regions of the republic. When looking at the temperature changes by months for both periods in the regions, the largest average temperature increases by months in Kalbajar and Lachin regions were recorded in February (1.7 °C), March (1.8 °C) and October (1.3 °C). In Gubadli, Jabrayil and Zangilan regions, the temperature increased by 2°C in February, by 2.6 °C in March, and no changes were recorded in April.

Keywords:Eastern Zangezur,
reanalysis,
air temperature,
climate change,
temperature anomaly**1. Introduction**

The territory of the Kelbajar and Lachin districts, which are part of the Eastern Zangezur Economic Region, is primarily mountainous, while Gubadli, Zangilan, and Jabrayil include both mountainous and flatland area [3].

According to data obtained from the Istisu Hydrometeorological Station in the Kelbajar district, located at an elevation of 2257 meters above sea level, for the period 1961-1990, the average annual temperature was 4.0°C. Based on the data from the Lachin Hydrometeorological Station, located at an elevation of 1099 meters above sea level, for the same period, the average annual temperature was 10.0°C. The coldest month was January (Kelbajar -5.3°C, Lachin 0°C), and the hottest month was July (Kelbajar 13.5°C, Lachin 21.0°C) [2].

In the Jabrayil district, according to data from the Jabrayil Hydrometeorological Station, the average annual temperature for the 1961-1990 period was 13.0°C. In the Zangilan district, based on data from the Mincivan settlement Hydrometeoro-

logical Station, the average annual temperature for the same period was 14.4°C. The coldest month was January (Jabrayil 2°C, Zangilan 3.6°C), and the hottest month was July (Jabrayil 24.9°C, Zangilan 26.1°C).

Due to the occupation of the area by Armenian armed forces between 1993-2020, no observational data is available for these years. Therefore, to determine the impact of recent climate changes on the temperature regime of the area, it is advisable to use alternative data sources and re-search methods, including satellite and reanalysis data.

The main goal of the study is to identify the changes in the temperature regime of the Eastern Zangezur Economic Region, particularly in the Kelbajar-Lachin and Gubadli-Jabrayil-Zangilan districts, during the recent years (1991-2022).

2. Materials and research methodology

In the study, monthly reanalysis data from MERRA-2 (Modern-Era Retrospective Analysis for Research and Applications, Version 2) for the

period 1980-2022, with a resolution of 0.5°, was used (<https://giovanni.gsfc.nasa.gov>). Since the resolution indicator is relatively low, temperature data was not obtained for the individual areas of each district. Instead, the areas of Kelbajar-Lachin and Gubadli-Jabrayil-Zangilan were selected, and average values were calculated. Therefore, these areas were marked on the map located on the Giovanni electronic portal, and with the help of specific calculations, the averaged temperature values for each month of the year were obtained. Based on the acquired data, temperature change trends for the years and seasons were determined according to the respective trend lines. The statistical significance of these trends was calculated based on the following inequality:

$$R/sR \geq s, \quad (1)$$

Here, the R-correlation coefficient, and sR, which represents the random mean square error [8]. The random mean square error is calculated based on the following formula:

$$\sigma_R = (1 - R^2)/\sqrt{(n - 1)} \quad (2)$$

n is the number of time series limits. For a 5% significance level and n = 40, s = 2.02.

3. Analysis and discussion

Table 1 presents the main statistical indicators of air temperature by month and annually for the Kelbajar-Lachin districts.

When examining temperature changes in the Kelbajar-Lachin region, as shown in Table 1, a 0.9°C increase in the average annual temperature

was recorded in the period 2001-2022 compared to the 1980-2000 period. An increase in average temperature was observed in all months except April. Significant temperature increases were recorded in February, March, June, August, September, and October. No changes in temperature were observed in April, and no significant increase was recorded in July, November, and December.

The greatest increase in the average maximum temperature was recorded, with the largest temperature increases observed in March and December, while the smallest increases occurred in February, April, and May.

In terms of minimum average temperature, a decrease was observed in January and April, while a sharp increase was recorded in October (3.5°C).

The annual average temperature increase trend in the Kelbajar-Lachin regions during the studied period is also visible in Figure 1. As shown in the figure, the linear trend indicating the increase is statistically significant according to formulas (1) and (2), and it amounts to 0.4°C per decade. The lowest temperature was recorded in 1992, and the highest temperature was recorded in 2010, which is consistent with the trends observed in other regions of Azerbaijan [7].

Table 2 shows the main statistical temperature indicators of air temperature by month and annually for the Gubadli, Jabrayil, and Zangilan regions.

Table 1

Main Statistical Indicators of Air Temperature by Month for the Periods 1980-2000 and 2001-2022 in the Kelbajar-Lachin Region, °C

Temperature, °C	Months												Annually
	1	2	3	4	5	6	7	8	9	10	11	12	
1980-2000													
Average	-5,7	-5,2	-1,0	5,8	10,0	14,6	17,7	17,0	13,2	6,9	1,0	-3,4	5,9
Max	-2,6	-1,7	2,0	8,6	12,5	17,0	20,2	19,8	15,3	9,0	3,6	-0,3	7,1
Min	-8,8	-8,7	-4,2	3,2	7,3	12,1	16,1	14,9	11,1	2,5	-4,2	-7,1	4,2
2001-2022													
Average	-5,0	-3,4	0,8	5,8	10,7	15,5	17,9	17,9	14,2	8,2	1,6	-3,1	6,8
Max	-2,0	-1,3	4,8	9,0	12,9	18,0	20,7	20,9	16,4	10,1	4,7	1,6	8,2
Min	-9,5	-7,9	-3,9	3,0	8,2	13,3	16,6	15,0	11,3	6,0	-3,8	-7,1	5,4
Temperature anomalies													
Average	0,7	1,7	1,8	0,0	0,7	1,0	0,2	0,9	1,0	1,3	0,5	0,4	0,9
Max	0,6	0,4	2,7	0,4	0,4	1,0	0,5	1,0	1,1	1,1	1,1	1,9	1,0
Min	-0,6	0,8	0,2	-0,2	0,9	1,2	0,5	0,1	0,3	3,5	0,4	0,0	1,2

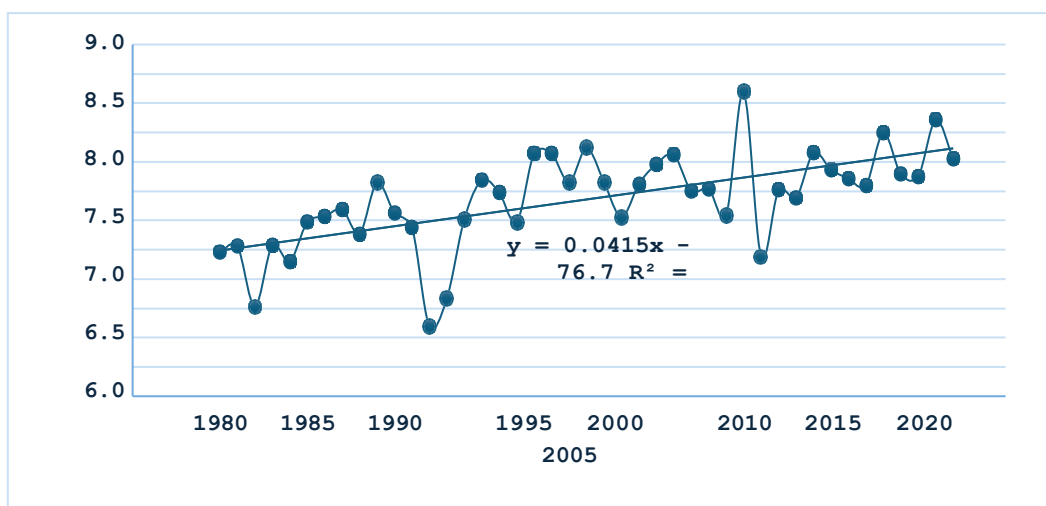


Figure 1: The time series of the average annual temperature of the Kelbajar-Lachin Region from 1980 to 2022

Table 2

Main statistical indicators of air temperature by month and annually for the Gubadli-Jabrayil-Zangilan regions

Temperature, °C	Months												Annually
	1	2	3	4	5	6	7	8	9	10	11	12	
1980-2000													
Average	-0.2	0.4	4.1	11.6	16.0	20.6	23.1	22.2	18.2	12.0	6.1	1.6	11.3
Max	2.7	4.6	6.8	15.6	18.8	22.9	25.5	25.8	20.3	15.4	9.2	5.0	12.8
Min	-3.0	-3.9	1.2	8.3	12.6	17.8	21.1	20.0	16.3	6.4	-0.2	-3.2	9.7
2001-2022													
Average	0.6	2.4	6.6	11.6	17.0	21.8	23.6	23.2	19.3	13.6	6.7	2.0	12.4
Max	3.7	4.9	11.1	15.9	19.5	24.2	26.6	26.2	21.5	16.5	9.8	6.6	13.7
Min	-4.1	-1.6	2.8	8.4	14.0	18.8	22.0	20.3	17.1	10.4	1.4	-3.0	10.9
Temperature anomalies													
Average	0.8	2.0	2.5	0.0	1.0	1.1	0.4	1.1	1.1	1.5	0.6	0.4	1.1
Max	1.0	0.4	4.3	0.3	0.6	1.3	1.1	0.4	1.2	1.1	0.6	1.6	1.0
Min	-1.1	2.4	1.6	0.1	1.5	1.0	0.9	0.3	0.8	4.0	1.7	0.2	1.2

Let's look at the temperature changes recorded for the Gubadli-Jabrayil-Zangilan regions. As shown in Table 2, compared to the temperature indicators of the 1980-2000 period, the average annual temperature increased by 1.1°C during the 2001-2022 period. An increase in the average temperature was observed in all months except for April. The highest temperature increase occurred in March (2.5°C), while the smallest increases were recorded in July, November, and December. Temperature increases were also observed in the maximum average temperature indicators. The highest temperature increase occurred in March (4.3°C), while the smallest increases

were recorded in February, April, and August. In January, the minimum average temperature decreased by 1.1°C. The greatest increase was recorded in October, while the smallest increases were observed in April, August, and December. The annual average temperature increase trend for the area during the mentioned period is shown in Figure 2. As seen in the figure, the linear trend indicating the increase is statistically significant according to formulas (1) and (2), and it amounts to 0.4°C per decade. The lowest temperature was recorded in 1992, and the highest temperature was recorded in 2010, which is consistent with the trends observed in other regions of Azerbaijan [7].

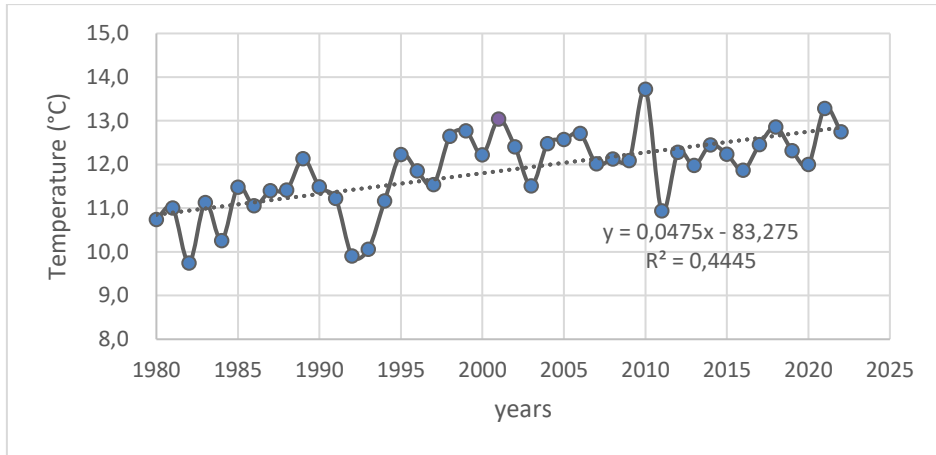


Figure 2. The time series of the average annual temperature in the Gubadli, Zangilan, and Jabrayil districts from 1980 to 2022

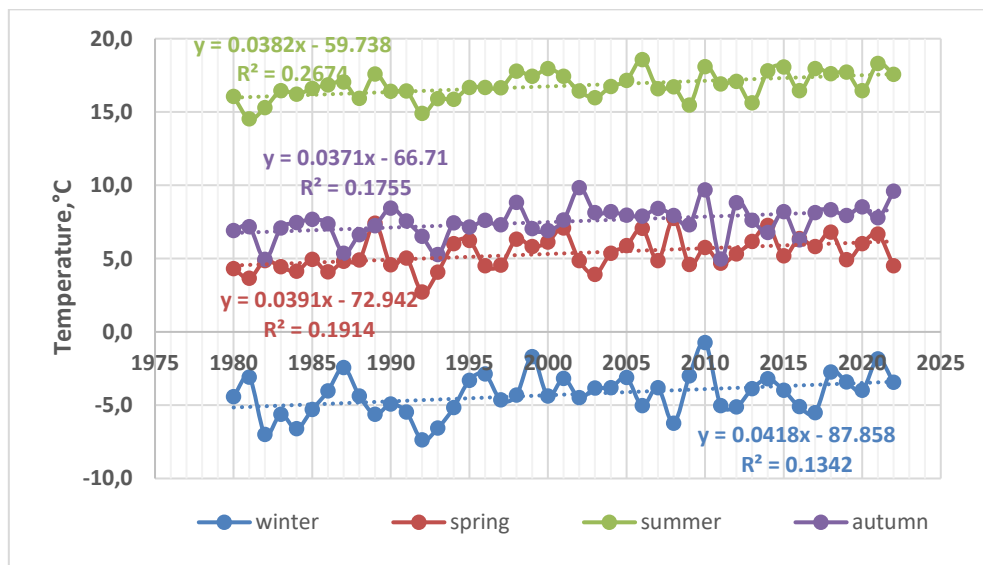


Figure 3. the time series of the average temperature by season in the Kelbajar-Lachin Region from 1980 to 2022

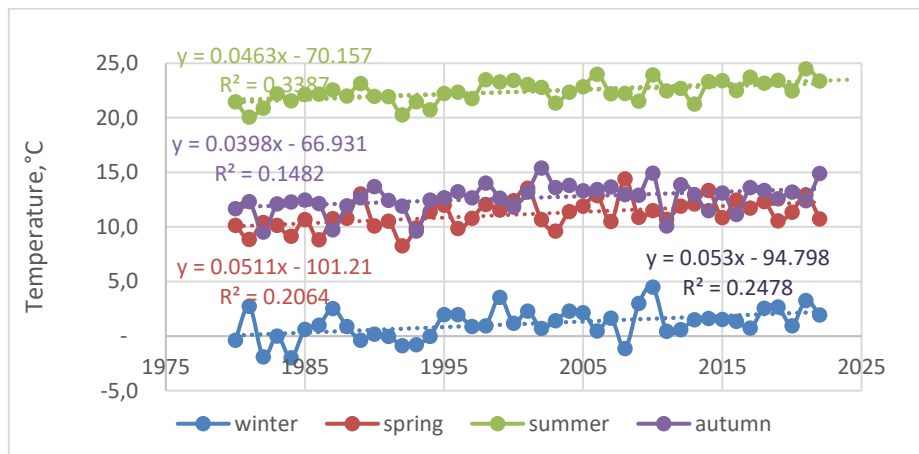


Figure 4. The time series of the average temperature by season in the Gubadli-Jabrayil-Zangilan region from 1980 to 2022.

Based on Figure 1 and Figure 2, and using formula (1), we can calculate the σ_R (random mean square error) as follows:

$$\sigma_R = (1 - 0.44)/\sqrt{(40 - 1)} \approx 0.0897, \quad (3)$$

Then, by substituting the obtained result into formula (1), we can determine that the trend in Figure 1 and Figure 2 is statistically significant.

Table 3

The difference in average temperatures by season for the periods 2001-2022 and 1980-2000 in the Kelbajar-Lachin and Gubadli-Jabrayil-Zangilan districts, °C.

Kelbajar-Lachin					Gubadli-Jabrayil-Zangilan			
Seasons	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn
Average	0.9	0.8	0.7	1.0	1.1	1.2	0.9	1.1
Max	1.0	0.3	0.6	1.0	0.9	1.4	1.0	1.4
Min	1.2	1.2	0.9	0.0	0.9	1.3	1.2	0.6

The study of changes in the temperature regime by season is also of great interest. In Figures 3 and 4, the time series of the average temperatures for different seasons in the Kelbajar-Lachin and Gubadli-Jabrayil-Zangilan regions are presented separately. As shown, temperature changes in all seasons exhibit an increasing trend, and according to the respective linear trends based on formulas (1) and (2), they are statistically significant at a 5% confidence level.

Table 3 presents the differences in average, maximum, and minimum temperatures by season for the periods 2001-2022 and 1980-2000 in the Kelbajar-Lachin and Gubadli-Jabrayil-Zangilan regions. As shown in the table, the highest temperature anomalies in the Kelbajar-Lachin regions were recorded in the winter and summer seasons (with a minimum average temperature of 1.2°C), while in the Gubadli-Jabrayil-Zangilan regions, the highest anomalies were observed in the summer and autumn seasons (with a maximum average temperature of 1.4°C).

Conclusion

An increasing trend in the temperature regime of the Eastern Zangezur Economic Region has been observed from 1980 to 2020. According to the calculations, the average annual temperature increased by 0.9°C in the Kelbajar-Lachin districts and by 1.1°C in the Gubadli-Jabrayil-Zangilan districts. The largest temperature increase in the economic region was observed in February, March, and October. When looking at seasonal changes, the most significant temperature changes were recorded in the winter and summer months. The temperature changes observed in the Eastern Zangezur region are consistent with the trends observed in other regions of Azerbaijan.

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ŞƏRQİ ZƏNGƏZUR İQTİSADİ RAYONUNDA HAVANIN TEMPERATUR REJİMİNİN TƏDQIQI

S.H.Səfərov, A.H.Məcizadə

Xülasə. Məqalədə 1980-2022-ci illər dövrü üzrə MERRA-2 (Modern-Era Retrospective analysis for Research and Applications, Version 2) reanaliz məlumatlarına əsasən hazırkı Şərqi Zəngəzur iqtisadi rayonuna daxil olan Kəlbəcər, Laçın, Qubadlı, Cəbrayıl və Zəngilan rayonları ərazisinin temperatur rejimində baş vermiş ümumi tendensiyalar tədqiq edilmişdir. Tədqiqat zamanı ərazi üzrə baxılan dövrdə orta illik və fəsilər üzrə temperaturlarda artım trendi aşkarlanmışdır. Fəsilər və illik dövr üzrə temperatur artımı 5%-lik təminat səviyyəsində statistik əhəmiyyətlidir.

Aparılan hesablamalar göstərmişdir ki, Kəlbəcər və Laçın rayonu üzrə 1980-2000-ci illər dövrünə nisbətən 2001-2022 dövründə havanın orta illik temperaturu 0,9 °C artmışdır. Qubadlı, Cəbrayıl və Zəngilan ra-yonları üzrə bu artım 1,1 °C qeydə alınmışdır. Bu nəti-cələr respublikanın digər regionlarında alınan nəticə-lərə uyğundur. Rayonlar üzrə hər iki dövrə görə aylar üzrə temperatur dəyişmələrinə nəzər yetirdikdə Kəl-bəcər və Laçın rayonları üzrə aylara görə ən böyük orta temperatur artımları fevral (1,7 °C), mart (1,8 °C) və

oktyabr (1,3 °C) aylarında qeydə alınmışdır. Qubadlı, Cəbrayıl və Zəngilan rayonlarında isə temperatur fevral ayında 2°C, mart 2,6 °C artmışdır, aprel ayında isə heç bir dəyişiklik qeydə alınmamışdır.

Açar sözlər: Şərqi Zəngəzur, reanaliz, havanın temperaturu, iqlim dəyişmələri, temperatur anomaliyası.

ANALYSIS OF TEMPERATURE, SNOW, AND PRECIPITATION REGIMES IN THE REPUBLIC OF AZERBAIJAN (for the multi-year period 2017-2023)

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Abstract

The analysis of multi-year observations shows that the average annual temperatures in the Republic of Azerbaijan, as well as the Greater and Lesser Caucasus regions are increasing both compared to the norm and to previous years. The average annual temperature increased the most in the Greater and Lesser Caucasus in 2021. A decrease in snow and rain is observed across the Republic over the years. Multi-year observations show that in years when snow decreases, rain increases, and in years when rain decreases, more snow falls in that same area. In the Republic of Azerbaijan, snow started falling in October 2021. In 2021, precipitation (rainfall) in the country was 134 mm below the norm. Compared to the 2020-2023 period, the most snow fell in 2022, primarily in January. In 2022, precipitation was 144.3 mm below the norm. In the years 2022-2023, snow fell even in May and April. In May 2023, more snow fell than in November of the same year. Although snow fell in the Republic in April and May of 2023, it decreased compared to the January, February, March, and December months of previous years. Conversely, rainfall increased and was approximately equal to the norm. The average annual temperature was 2.0°C above the norm in 2022 and 2.2°C above the norm in 2023.

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rain,
observation data

1. Introduction

According to the 1961-1991 norm, the global average annual temperature has increased by 0.5°C. Overall, since 1993, the Earth's climate has warmed by close to +1.0°C compared to the multi-year average. In some regions, the temperature increase is even higher. These occurrences have begun to manifest clearly in recent decades through the frequent repetition of events such as landslides, floods, flash floods, powerful hurricanes, droughts in various countries, the expansion of forest fire areas, and so on. The results of numerous studies show that 65% of the damage to the global economy resulting from adverse weather conditions falls to the share of agriculture [1; 4; 5; 6].

All of this proves that climate change is a real threat to humanity and compels the world community, scientists, and politicians to approach this issue seriously. It is no coincidence that today there is no high-level assembly of world states where issues related to climate change and the

natural disasters it causes are not included on the agenda [10].

In 2024, under the slogan "Let's unite for a Green World," the 29th session of the Conference of the Parties (COP29) to the UN Framework Convention on Climate Change was held in Azerbaijan. During this conference, decisions and commitments were adopted to keep the Earth's temperature increase within 1.5°C [1; 2; 11].

The climate of Azerbaijan's territory is also an integral part of the global climate system. The processes occurring within this system impact the country's climatic conditions with varying intensity and over different time periods. Therefore, the study of climate change, the investigation of its impact on various sectors of the economy, and the research into the adaptation capabilities of the economic system have become crucial issues for Azerbaijan's territory and its economy [5; 6].

In the presented work, temperature, precipitation, and snow observation data for the Republic of Azerbaijan and its regions were analyzed com-

paratively, and the impact of climate change on these meteorological parameters was studied.

2. Research Methodology

The presented work utilized observation data from automatic and traditional meteorological stations operating under the National Hydrometeorological Service (MHX), mathematical statistical methods, and the temperature and precipitation norm from the 1961-1990 period [7].

3. Analysis and discussion

Dynamics of changes in the meteorological conditions of the Greater Caucasus region of Azerbaijan for the 2017-2023 period. The snow cover, average, maximum, and minimum temperatures, and precipitation regime of the Saribash (1680m), Altiaghaj (1099m), and Khaltan (1063m) regions in the Greater Caucasus were analyzed.

In Saribash (1680 m), a decrease in snow cover height is observed over the years for the months of January, February, and November, with the exception of December 2020 (335 cm), while an increase is observed in March and April. Overall, more snow fell in February (1618 cm) and March (165 cm) compared to January. A gradual decrease in snow cover over the years is observed in November, while an increase is observed in April. More snow fell in April compared to November. The first snow in Saribash began to fall in October 2018.

It can be seen from Figure 1 that the most snow in Saribaş over the seven-year period fell in March 2022.

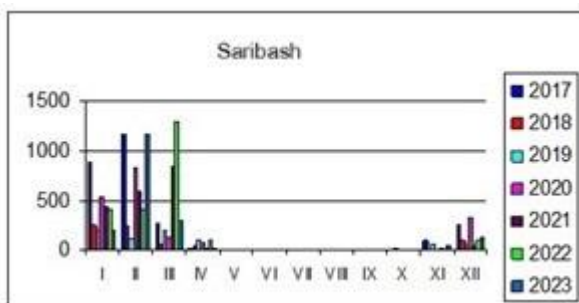


Figure 1. Dynamics of changes in total snow by month for 2017-2023

In Saribash, the average monthly temperatures increased more significantly in all months except June, July, and August, with a particularly notable increase in November. A gradual increase in the maximum daily temperatures over the years is observed, especially during the winter and autumn seasons. The minimum daily temperatures decreased, particularly in the winter season. With the exception of December 2021 (-12.7°C), they decreased by approximately 2.1°C in January and by 1.2°C in December. In the autumn season, the

minimum daily temperatures also decreased in September and November. In October, they remained almost constant, with the exception of the year 2021. Precipitation during the month decreased in January, February, and October, but increased during the spring and summer seasons.

In Altiaghaj (1099 m), the total snow cover gradually increased in January and March, with the exception of January 2019. It even reached 540 cm in March 2022, which is 44 cm more than the snow that fell in December 2020 (496 cm) during the multi-year period. However, it began to gradually decrease in February. Snow also fell in Altiaghaj in April. The highest snow cover here was recorded in 2018 and increased in the following years compared to 2017. As a result of the year-over-year increase in snow in March during the multi-year period, the total snow that fell in this month became approximately equal to the total snow that fell in January.

The average annual temperatures decreased in January, May, and September of 2020 and 2023, but increased in other months, particularly in October and November. The maximum daily temperatures increased in November, December, and January. The minimum daily temperatures, however, decreased in all months, especially in April and November. Precipitation was higher than the norm in 2020 but decreased in other years. On March 21st, 52 cm of snow fell.

In Khaltan (1063 m), during the multi-year period, starting from 2018, less snow gradually began to fall in the cold months, with the exception of March 2017 (1393 cm) and December 2017 (113 cm). This decrease was more pronounced in 2018 and 2019. More snow fell in April compared to November. On March 19, 2022, the maximum snow depth was 47 cm.

In Khaltan, the average annual temperatures decreased in January, May, and June but increased in other months. The maximum daily temperatures increased. The minimum daily temperatures increased in January 2023 (-22.9°C) and October 2021, but a decrease over the years was observed in other months. Precipitation increased in February, April, May, July, August, and November, but decreased more significantly in January and December.

The total snow that fell over the last seven years in the Saribash, Altiaghaj, and Khaltan regions of the Greater Caucasus is shown in Figure 2.

It can be seen from Figure 2 that more snow fell in Saribash compared to the other regions. Furthermore, as the altitude decreases, more snow

fell in March in Khaltan compared to Altiaghaj (Figure 3).

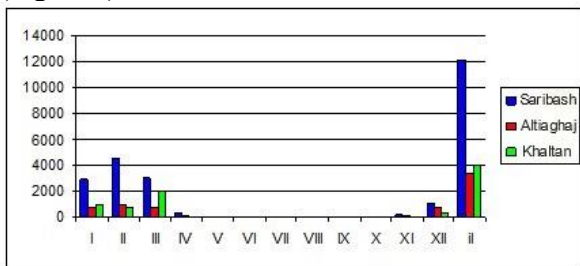


Figure 2. Dynamics of changes in total snow by month over seven years (2017-2023) in the Greater Caucasus

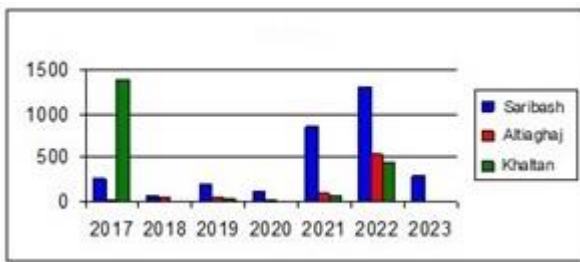


Figure 3. Dynamics of changes in snowfall in March in the Greater Caucasus over the years

Figure 3 shows that the increased snowfall in March over the last three years in Saribash, which is located at a higher altitude than Altiaghaj and Khaltan, compared to previous years, can be considered a result of rising temperatures across altitudes and seasonal changes.

Dynamics of changes in the meteorological conditions of the Lesser Caucasus for the 2017-2023 period. The snow cover, average, maximum, and minimum temperatures, and precipitation regime of the Dashkasan (1637m), Gadabay (1414m), and Goygol (1584m) regions in the Lesser Caucasus were analyzed.

In Dashkasan (1637 m), a decrease in snow over the years is observed, with the exception of February 2017 and the January-February months of 2021. An increase is observed in the months of March and December. The most snow within a year fell in March 2021 and March 2022, with 266 cm and 253 cm, respectively. Over the last seven years, more snow fell in Dashkasan in December, February, and March compared to January.

The average monthly temperature increased in all months, with the exception of January 2023 and the September and October months of 2021. The increase was particularly notable in November and December. The maximum temperatures during the month increased most significantly in November and December. The minimum temperature decreased the most in January and November.

An increase in precipitation over the years is observed during the months of December, April, and May. A decrease is observed in other months, particularly in January.

In Goygol (1584 m), a decrease in snow over the years is observed in January and February (with the exception of 2021), while an increase is observed in March and December. During this multi-year period, more snow fell in March 2019 and March 2022 compared to the January, February, and December months of those years. An increase in snowfall in April compared to previous years is also observed. Over the multi-year period, 158 cm more snow fell in March than in January, and 206 cm more than in December.

In Goygol, the average monthly temperatures increased primarily in November and December, but decreased in January. An increase in maximum daily temperatures was most observed in September, October, November, December, January, February, and March. The average monthly precipitation increased in June and December but decreased in other months.

In Gadabay (1414 m), snow in January decreased over the years during the multi-year period, with the exception of 2021 (105 cm). The least snow in February during this period fell in 2022 (14 cm). Snow in February decreased from 2017 to 2020, increased in 2021 (186 cm), sharply decreased in 2022, and increased again in 2023 (122 cm). In 2022, less snow fell in February, while more fell in March (194 cm). Snowfall in December has increased over the years. Overall, during this period, more snow fell in February and March than in January.

The average monthly temperature increased in all months, particularly in November. The maximum daily temperatures increased more during the winter and autumn seasons, while the minimum temperatures decreased, with the exception of December. The average monthly precipitation increased in October and November but decreased in other months.

The total snow that fell over the last seven years in the Dashkasan, Goygol, and Gadabay regions of the Lesser Caucasus is shown in Figure 4.

It can be seen from Figure 4 that snow fell in approximately equal amounts in all three regions in January. More snow fell in Dashkasan in February, March, and December. In Gadabay, which is located at a lower altitude than Goygol, more snow fell in March compared to January. In the analyzed regions of the Lesser Caucasus, a gradual decrease in snow over the last 7 years is

observed in January and December, while an increase is observed in February and March (Figure 5).

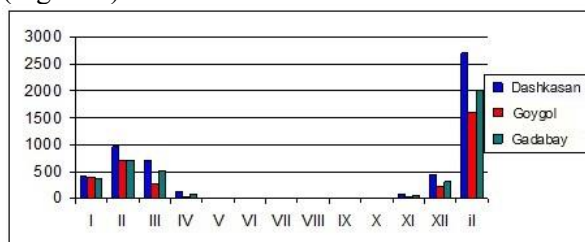


Figure 4. Dynamics of changes in total snow by month (2017-2023) across the Lesser Caucasus

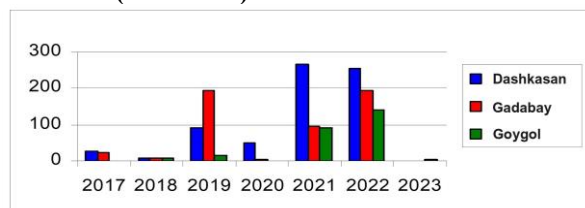


Figure 5. Dynamics of year-to-year changes in total snow fallen during the month of March in the Lesser Caucasus.

Figure 5 also shows that snow fell in all three regions in March every year. Less snow fell in Dashkasan and Gadabay in March of 2017 and 2018. In 2019, it increased significantly in Gadabay. In 2020, less snow fell in Gadabay, while more fell in Dashkasan. In 2021 and 2022, a lot of snow fell in all three regions, particularly in Dashkasan. An increase in snow in March over this multi-year period is observed in Dashkasan, as well as in Gadabay and Goygol. In 2023, snow decreased; conversely, precipitation (rain) was higher.

4. Conclusion

1. It was observed that in March, a large amount of snow fell in Khaltan in 2017, which decreased in subsequent years. Conversely, in Altiaghaj, an increase over the years was observed.

2. In Saribash, which is located at a higher altitude than Altiaghaj and Khaltan, more snow fell in March during the last three years compared to previous years.

3. In Saribash, Altiaghaj, and Khaltan, the average monthly temperatures increased primarily in October and November, while precipitation decreased more significantly in January and December.

4. In Dashkasan, a decrease in snow over the years is observed, with the exception of February 2017 and the January-February months of 2021. An increase is observed in March and December.

5. In Dashkasan, the average monthly temperature increased in all months, particularly in November and December. A gradual increase in

precipitation was observed in December, while a decrease was observed in February and other months, especially January.

6. In Goygol, more snow fell in February and March compared to January and December. An increase in snow in April compared to previous years was also observed.

7. In Goygol, the average monthly temperatures increased primarily in November and December but decreased in January. The average monthly precipitation increased in June and December but decreased in other months.

8. In Gadabay, more snow fell in February and March than in January. The average monthly temperature increased in all months, particularly in November. The average monthly precipitation increased in October and November but decreased in other months.

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**AZƏRBAYCAN RESPUBLİKASINDA
TEMPERATUR, QAR, YAĞINTI REJİMİNİN
(2017-2023 çoxillik dövrü üzrə) TƏHLİLİ**

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Xülasə. Çoxillik müşahidələrin təhlili göstərir ki, Azərbaycan Respublikası daxilində, Böyük Qafqaz və Kiçik Qafqazda orta illik temperaturlar həm norma ilə, həm də özündən əvvəlki illərlə müqayisədə artır. Orta illik temperatur Böyük və Kiçik Qafqazda 2021-ci ildə daha çox artmışdır. Respublika üzrə qar və yağışın illər üzrə azalması müşahidə edilir. Çoxillik müşahidələr göstərir ki, qarın azaldığı illərdə yağış artır, yağışın azaldığı illərdə həməən əraziyə qar çox düşür. 2021-ci ildə respublikaya qar oktyabr ayından yağmışdır. 2021-ci ildə respublikaya yağış normadan -134 mm az düşmüşdür. 2020-2023-cü illərlə müqayisədə ən çox qar 2022-ci ildə yağmış, və əsasən yanvar ayına daha çox düşmüşdür. 2022-ci ildə yağış normadan -144.3

mm az olmuşdur. 2022-2023-cü illərdə qar may, hətta aprel ayında da yağmışdır. 2023-cü ilin may ayına noyabr ayından daha çox qar yağmışdır. 2023-cü ildə qar respublikaya may, aprel aylarında da yağsada əvvəlki illərin yanvar, fevral, mart, dekabr ayları ilə müqayisədə azalmış, əksinə yağış artmış və təxminən normaya bərabər olmuşdur. Orta illik temperatur normadan 2022-ci ildə 2⁰C, 2023-cü ildə isə 2.2 ⁰C çox olmuşdur.

Açar sözlər: Böyük Qafqaz, Kiçik Qafqaz, orta illik temperatur, meteoroloji elementlər, qar, yağış, müşahidə məlumatları.

HIDROLOGY

MITIGATION MEASURES AGAINST FLOOD FLOWS IN AZERBAIJAN

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Abstract

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This article is dedicated to the implementation of protective measures against floods and the methods for determining appropriate locations for embankments. The primary objective of the study is to identify scientifically grounded flood mitigation strategies. Methodologically, the study focuses on categorizing embankments based on the runoff velocity of floodwaters and the resulting hydraulic impact. The proposed measures include: The artificial dispersion of cumulonimbus rainclouds over river basins using artillery fire; The construction of a hydraulic structure at the alluvial fan of the river to divert flood flows into three separate directions; The establishment of soil embankments to resist floodwaters.

The second measure is distinguished from previously used approaches by its categorized design and enhanced structural resistance. Specifically, for debris-laden and water-stone floods, the study recommends constructing reinforced concrete embankments from the beginning to the midpoint of the alluvial fan, followed by earth embankments downstream. The rationale behind extending reinforced concrete structures up to the midpoint lies in their ability to withstand the hydraulic impact along the dynamic axis of the flood flow.

1. Introduction

Water bodies, while being an invaluable and essential part of human life, can also cause significant damage to various sectors of the economy. In particular, the destruction caused by floods is often far greater than that of regular river overflows. As is well known, with the advancement of society's productive forces, human impact on nature intensifies. One consequence of this is that erosion materials accumulated on the surface of river basins are washed into riverbeds by the season's first intense rainfalls-typically occurring in summer-ultimately forming floods that inflict widespread damage on all economic activities located in the alluvial fan. In recent years, the increasing frequency and intensity of floods have been driven by two key factors: global climate change and escalating human interference with natural systems. This growing threat underscores the urgent need for effective and scientifically sound flood control measures.

It is important to note that, despite the destructive nature of floods, they can also play a beneficial role. Floods may act as a "natural factory," contributing essential raw materials for the production of construction materials and mineral fertilizers.

Flood control measures have attracted considerable attention in various regions around the world, including the Caucasus, Central Asia, Crimea, Yalta, the Far East, the Carpathians, the Altai Mountains, the Cordilleras, and the Andes. Among these, the strategies implemented in the Caucasus and Central Asia stand out due to their relatively higher effectiveness and practical success [3, 8, 10]. In the Republic of Azerbaijan, the most severe and destructive floods are observed in the Greater Caucasus region. This reality underscores the urgent necessity of developing and applying scientifically grounded flood control measures in the country. In the modern era, comprehensive analysis of flood flows allows for the design and implementation of more effective

mitigation strategies. An evaluation of accumulated experiences in flood management reveals that, despite the application of certain preventive measures, the intensification of exogenous processes—largely driven by global warming—has increased both the frequency and severity of floods. Consequently, the demand for more advanced and robust flood control strategies has significantly grown in recent years [1, 4, 5, 6].

In earlier periods, flood protection measures—regardless of their intended purpose—primarily consisted of check dams and earthen embankments, and only occasionally of protective fences [7, 9]. In particular, the construction of check dams often required the mass cutting of forest trees, which significantly reduced vegetation cover and led to the degradation of the ecological environment.

In recent years, the increasing threat of floods caused by the transport of eroded materials during intense downpours in the mountainous regions of arid subtropical zones has underscored the growing necessity for the use of scientifically grounded engineering structures. Effective flood risk reduction in these areas increasingly depends on the implementation of well-designed, evidence-based protective infrastructure.

The objective of this study is to identify and develop scientifically substantiated flood mitigation measures. The research aims to enhance the effectiveness of protective strategies through a systematic and evidence-based approach tailored to regional hydrological and geomorphological conditions.

2. Research Methodology

The methodology involves calculating the runoff velocity of flood flows and determining appropriate new protective measures. Special attention is given to hydraulic impact assessment in order to categorize and optimize the design of flood control structures.

3. Analysis and Discussion

It is well known that floods in mountain rivers are not only turbulent but, in some cases, possess large-scale catastrophic characteristics. While flood deposits cause significant damage to agricultural lands, they also serve as good mineral fertilizers for plants; however, these deposits disrupt the respiratory system of roots. This effect is particularly noticeable in hazelnut orchards and tobacco plantations. Such floods are observed predominantly in the Greater Caucasus region of Azerbaijan, with relatively weaker floods occurring in the Lesser Caucasus and the Nakhchivan

Autonomous Republic, except for the Jeyranchol and Lankaran natural regions. There is no river in which only one type of flood occurs. Floods in rivers vary not only across different years but also along the longitudinal profile of the river during the transport phase. Typically, muddy floods occur in the upper reaches, transitioning to debris-laden mudflows and water-stone flows in the middle reaches, and again transforming into muddy floods, especially after the alluvial fan. This pattern is explained by the slope of the terrain and the corresponding erosion law, as expressed by (Equation 1).

$$W = Av^6 \text{ or } d^3\gamma = Av^6 \quad (1)$$

In the equation W or $d^3\gamma$ —The weight of the sediment particle rolling along the bottom; the natural velocity of the flow (v); and A —the coefficient of proportionality—manifest themselves in this manner. Based on this law, rivers possess varying capacities to erode their channels.

It can be seen from the equation that the weight of the particle rolling along the bottom depends on the sixth power of the speed. That is, it is more clearly seen in the conditional ratio of plain and mountain rivers 1:5 (in catastrophic floods this ratio can be even greater). That is, the speed of the transported flood in a mountain river is equal to $1:5^6$ or $1:15625$. Therefore, mountain rivers differ from plain rivers in their great destructive properties. From this it is clear that plain rivers have the ability to transport sand, clay and silt, while mountain rivers have the ability to transport the flow of sediments rolling along the bottom. The reported rate depends more on the fall and slope of the river (table 1).

The analysis of Table 1 shows that while the average slope of the rivers varies between 40-190 ‰, the average slope of the river basin varies between 310-822 ‰. In contrast, in Balakenchay and Talachay, Damarjig, Damiraparanchay, Goychay and Agsu and Ayrichay basins, although the forest area is 29%-87%, the active effect of the forest against erosion is not felt. Since the basins of the mentioned rivers contain easily washed clay shales and the forests are weak, the slopes of the rivers in the Nakhchivan Autonomous Republic and the wide distribution of easily washed rocks cause them to become the most flood-prone rivers. In addition to the above, the large and sharp fall of the rivers, the height of the floodplains above sea level and the density of the river, ravine and goby network are also one of the main conditions.

Table 1

Morphometric characteristics of rivers

River - area	The river				Forest area in the basin, %	Density of hydrographic network, km/km ²
	length, in km	fall, in m	average slope, ‰	with the average slope of the basin ‰		
Gudiyalchay-Kupchal	47	2350	50	303	6	1
Velvelachai-Tengialti	43	2666	62	231	10	1.1
Balakenchay-Balaken	20	3031	101	492	82	0.56
Talachay-Zagatala	21	2100	100	210	87	1.25
Kurmukchay-Sarybash	12	1260	105	620	-	1.86
Kurmukchay-Ilisu	19	2280	120	590	5	1.20
Bulanigsu-Sarybash	9.4	2378	121	822	5	1.80
Kunakhaysu-Sarybash	6.1	811	133	740	5	1.53
Hamamchay-Ilisi	11	1961	126	650	17	0.90
Eyrichay-Bashdashakhil	12	1615	160	590	40	1.42
Damarciq-near the mouth	8.5	1615	190	430	31	1.42
Chukhadurmaz-near the mouth	12	1615	170	580	45	1.99
Gaynar-near the mouth	5.5	2731	184	-	67	0.92
Demiraparanchay-Gabala	23	2323	101	512	29	1.05
Goychay-Goychay	62	2356	38	-	44	0.72
Aghsu-Aghsu	37	1768	52	246	44	0.46
Levchay-Qamishli	29	1914	63	404	16	1.22
Tutxun-near the mouth	34	2142	56	377	18	1.22
Gargarchay-Aghakorpu	24	936	52	295	6	1.15
Ganjachay-Zurnabad	36	2052	43	389	21	1.1
Goshgarchay-Dashkan	15	870	58	190	5	1.13
Ordubadchay-Nusnus	12	1824	152	500	-	0.53
Gilanchay-Bist	23	1288	150	376	2	0.56
Gilanchay-Bashdize	45	1980	44	310	1	0.51
Alinjachay-Arafsa	16	1248	78	386	1	0.31
Nakhchivanchay-Garababa	36	1980	40	267	4	0.48
Jahrichay-Payiz	30	1940	48	278	2	0.41

Floodplains in the rivers of our republic are mainly located at altitudes above 1800 m above sea level and have an area of up to 75 km² [9].

The average effect of a complex of factors determines the formation and strength of the hydraulic shock of a flood. Thus, the magnitude of the hydraulic shock of a flood depends, among other factors, on the fall of the river and the height of the stream. It is known that a particle in the form of a plume located at the bottom of the river bed or its front (front) part P_l is subjected to a hydrodynamic pressure force. The force of the flow is proportional to the speed of friction with the bottom. It is expressed by the following equation (formula 2).

$$P_l = a \frac{\gamma}{g} v_{dib\ bas} \cdot \Omega \quad (2)$$

a -proportionality coefficient; γ -specific gravity of water; g -gravity acceleration; v bottom-initial velocity of bottom sediments; Ω -indicates the

cross-sectional area of the particle perpendicular to the flow direction.

It should be noted that, depending on the length of the rivers and the absolute height of the floodplains, floods have different speeds in the upper, middle and lower reaches [2, 11]. Thus, if we take the conditional runoff speeds of the flood, taking into account the lower, middle and upper reaches of the river, as 3 m/s, 4 m/s and 5 m/s, respectively, then the duration of the flood transport corresponding to its dynamic strength will also be different (table 2).

Analysis of table 2 indicates that the flood velocity in the upper course of the Valvalachay river, over a distance of 6 km, reaches 5 m/s with a runoff of 20', while in the middle course, over 30 km, the velocity is 4 m/s with a runoff of 125'. In the lower course, covering 7 km, the velocity decreases to 3 m/s with a runoff of 39%, requiring a total time of 3 hours and 4 minutes.

Table 2

The duration of the flood transport

River - area	length, in km	upstream			midstream			downstream			total duration, hours, minutes.
		length, in km	speed, m/sec	duration, hours, minutes	length, in km	speed, m/sec	duration, hours, minutes	length, in km	speed, m/sec	duration, hours, minutes	
Gudiyalchay-Kupchal	47	1-7	5	23'	8-40	4	138'	41-47	3	39'	200'
Velvelichay-Tengialti	43	1-6	5	20'	7-36	4	125'	37-43	3	39'	184'
Balakenchay-Balaken	20	1-3	5	11'	3-10	4	29'	11-20	3	56'	96'
Talachay-Zagatala	21	1-3	5	10'	3-10	4	29'	11-21	3	61'	100'
Kurmukchay-Sarybash	12	1-3	5	10'	3-10	4.5	26'	11-12	4	50'	86'
Kurmukchay-Ilisu	19	1-3	5	10'	4-9	4.5	22'	10-19	3	56'	88'
Bulanigsu-Sarybash	9.4	1-2	5	7'	3-7	4.5	19'	7-9.4	4	10'	36'
Kunakhaysu-Sarybash	6.1	0-1	5	3'	2-4	4.5	11'	5-6.1	4	9'	23'
Hamamchay-Ilisu	11	1-2	5	7'	3-5	4.5	11'	6-11	3	33'	51'
Eyrichay-Bashdashaqil	12	1-3	5	10'	4-7	4.5	15'	8-12	3	28'	53'
Damarchig-near the mouth	8.5	1-2	5	7'	3-6	4.5	15'	7-8.5	4	10'	32'
Chukhadurmaz-near the mouth	12	1-2	5	7'	3-8	4.5	22'	9-12	4	17'	46'
Gaynar-near the mouth	5.5	0-1	5	3'	2-3	4.5	7'	4-5.5	4	10'	20'
Demiraparanchay-Gabala	23	1-6	5	20'	7-15	4	146'	16-23	3	44'	210'
Goychay-Goychay	62	1-15	5	50'	16-50	4	46'	51-62	3	67'	163'
Aghsu-Aghsu	34	1-10	5	33'	11-21	4	41'	22-34	3	72'	146'
Levchay-Qamishli	29	1-10	5	33'	11-21	4.5	59'	22-29	4	33'	125'
Tutxun-near the mouth	37	1-12	5	40'	13-28	4.5	29'	28-37	4	39'	108'
Gargarchay-Aghakorpu	24	1-10	5	33'	11-17	4	62'	18-24	3	29'	124'
Ganjachay-Zurnabad	36	1-12	5	40'	13-27	4	11'	28-36	3	50'	101'
Goshgarchay-Dashkan	15	1-6	5	20'	7-9	4.5	15'	10-15	3	33'	68'
Ordubadshay-Nusnus	12	1-5	5	17'	6-9	4.5	26'	10-12	3	17'	60'
Gilanchay-Bist	23	1-12	5	40'	13-19	4.5	12'	20-23	3	12'	64'
Alinjachay-Arafsa	16	1-6	5	20'	7-11	4.5	19'	12-16	3	28'	67'
Nakhchivanchay-Qarababa	36	1-10	5	33'	11-25	4.5	56'	26-36	3	61'	150'

Corresponding to the velocity distributions of the floods, in Talachay, runoff values of 10', 10', 61' and a time of 1 hour 21 minutes are recorded; in Kurmukchay, runoff values of 6', 22', 56' and 1 hour 14 minutes; in Damardzichay, 7', 15', 10', and 32 minutes; and in Gaynar, 3', 7', 10' and 20 minutes are observed. Similar patterns have been noted in other flood-prone rivers. Comparable studies were also conducted in the 1970s [7, 9]. However, global climate changes during those years were not as pronounced as in recent times.

The amount of water collected in different intensities in the upper, middle and lower reaches of the river basins is also different according to

the relative velocity distribution of the flood. Thus, during intense downpours of 1, 2, and 3 mm/min. in the 172.3 km² elementary basin area of the upper reaches of the Gudyalchay River, 1 mm/min. 172 thousand m³, 2 mm/min. 345 thousand m³ and 3 mm/min. 517 thousand m³ of water are collected, while in the corresponding intensive downpours of 344.6 km² of the middle reaches, 345 thousand m³, 689 thousand m³ and 1084 million m³ of water can be collected, and in the total flow of 517 km² up to the Kupchal settlement, 517 thousand m³, 1034 million m³ and 1551 million m³ of water can be collected [5]. A similar situation is observed in Talachay and other

ivers. Thus, in the 45.3 km² elementary area of the upper reaches of the Talachay, 45 thousand m³, 91 thousand m³ and 136 thousand m³ are collected at the corresponding intensities of heavy rains, in the 90 km² elementary basin area of the middle reaches 90 thousand m³, 181 thousand m³ and 273 thousand m³, and in the 136 km² elementary areas of the total flow up to the Zagatala water gauging station downstream 136 thousand m³, 272 thousand m³ and 408 thousand m³ of water are collected. The above-mentioned require the implementation of appropriate flood control measures.

Unfortunately, until recent years, flood control measures were taken after the occurrence of floods. The assessment of the cause of the flood is also of great importance in terms of the effectiveness of the dam to be built. Thus, it is natural that there is a difference between the measures taken to combat them, as compared to mud floods, due to the diversity of water-stone and mud-stone floods. While earth dams and narrow concrete dams are sufficient on the banks of rivers where mud floods pass, other floods require the construction of large hydrotechnical structures. Taking into account the above, some of the measures that will be effective in minimizing the impact of floods include the following: Although the measures taken to combat floods require large financial resources, they are required to control floods and reduce the damage caused as much as possible. As of modern times, the state of flood studies does not respond to the solution of water management issues. Therefore, there is a great need to take effective control measures.

One of the measures is to organize the fragmentation of cumulonimbus clouds formed over the river basin with artillery fire in order to reduce the flood in mountain rivers. This measure consists in reducing the amount of precipitation falling on the river basin to a safe level. The proposed method can be cheaper than the construction of protective dams along the river and other anti-flood measures. There is a great need to clean the channels with bulldozers at the beginning of the spring and autumn seasons every year. The use of this method creates conditions for the passage of muddy floods from the rivers. This can also lead to a relative reduction in damage to farms. This method can be used for rivers flowing through the Greater and Lesser Caucasus.

Another measure to reduce the speed of the flood and the damage caused by it is to build a hydraulic structure at the head of the confluence that divides the flood flow into 3 parts. The main

part of the flood is discharged through the channel, and the remaining part is discharged through flood channels on the right and left sides. The purpose of using the method is to reduce the hydrodynamic impact of the flood in 3 directions. It is appropriate to use this method in rivers with muddy-stony and water-stony floods. The riverbeds should be cleaned before the flood at the beginning of the spring-autumn seasons. The cleaned flood materials should be transported to stone quarries and converted into efficient use in the form of construction materials. Such an approach allows for a comparative reduction in damage to agricultural areas. The use of the method plays a significant role in reducing the peak level of the flood. This method can be applied to flood rivers flowing through the southern slope of the Greater Caucasus, the Lesser Caucasus, and the territories of the Nakhchivan Autonomous Republic.

The next method is to organize regular cleaning of the riverbeds of rivers with muddy floods with bulldozers every year before the spring and autumn floods and floods. This method can be used in rivers flowing from the Lankaran Natural Region, Jeyranchol and Gobustan.

The mentioned control measures can be divided into groups of low, medium and high effectiveness.

1. Low-efficiency control measures include (annually) cleaning of the riverbed, especially the area of the flood cone, and maintaining a stable channel system.

2. Medium-efficiency control measures include the protection of natural forest cover along the river, the construction of artificial embankments, and regular cleaning of blockages in the channel caused by floodwaters.

3. High-efficiency control measures include the construction of dams and forest reclamation works by category.

The above-mentioned group of control measures should be divided into current and prospective periods and differ in the degree of flood hazard depending on the physical and geographical characteristics of the area.

4. Conclusion

1. Studies show that the need for new methods is explained by the simplicity of the previous ones, their temporary practical significance, their failure to fully meet the requirements of the modern era, and the intensive erosion of river basin surfaces due to global climate change.

2. It has been established that the fact that flood flows mainly pass through rivers at night

leads to their not being observed in the camera. This requires that new methods applied for flood protection be based on hydrological calculations and empirical equations.

3. Calculations show that the construction of flood protection dams also depends largely on the fall of the river. Thus, the fall of the river determines the hydraulic impact of the flood. It is important to build dams with a flat trapezoidal reinforced concrete structure that will sit along the confluence of rivers with a large fall.

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AZƏRBAYCANDA SEL AXINLARINA QARŞI MÜBARİZƏ TƏDBİRLƏRİ

C.H.Məmmədov

Xülasə. Məqalə seldən mühafizə üçün qoruyucu tədbirlərinin görülməsi və ona müvafiq bənd yerlərinin müəyyən edilməsi üsullarına həsr olunmuşdur. Tədqiqatın məqsədini elmi cəhətdən əsaslandırılmış mübarizə tədbirlərinin müəyyən edilməsi, metodiki həlli isə sel axınlarının qaçış sürətini və hidravliki zərbəni nəzərə almaqla, bəndlərin kateqoriyalarının müəyyən edilməsi təşkil edir. Tədbirlərdən birincisi çay hövzəsi üzərindəki topa yağışlı buludların top atəşi ilə parçalanması, ikincisi çayın gətirmə konusunda sel axımını 3 istiqamətə ayıran hidrotexniki qurğunun tikilməsi, üçüncüsü isə selə qarşı torpaq bəndlərin salınmasından ibarətdir. İkinci üsul kateqoriyalarla tikilməsi və möhkəm müqaviməti ilə əvvəllər tətbiq edilən üsullardan fərqlənir. Belə ki, bu üsulda palçıqlı-daşlı və sulu-daşlı sellərdə mühafizə bəndlərinin gətirmə konusun əvvəlindən ortasına kimi dəmir-beton konstruksiyalı, ondan sonra isə torpaq bəndlərdən ibarət olması təklif edilir. Dəmir-beton bəndlərin gətirmə konusun orta məsafəsinə kimi uzadılmasında məqsəd, bu bəndlərin selin dinamik oxunun hidravliki zərbəsinə müqavimət göstərmə qabiliyyəti ilə izah edilir.

Açar sözlər: sel, palçıqlı sel, palçıqlı-daşlı sel, sulu-daşlı sel, gətirmə konusu, sel gətirmələri

LANDSCAPE SCIENCES

ECOGEOCHEMICAL PROPERTIES OF THE LANDSCAPES OF KARABAKH AND EASTERN ZANGEZUR REGION

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Abstract

Soil and plant samples taken from the territory of East Zangezur during field studies were analyzed using an X-ray fluorescence spectrometer of the Elvax-CEP 01 brand. The results of the analyses showed that only chlorine (Cl) in the area is at the level of Clarke in the Earth's crust, and all other elements are many times (even 10 and a hundred times) more than Clarke. It was determined that sulfate macrocompounds in the region are typomorphic, and sodium, calcium, and magnesium salts predominate in the area. The presence of chemical elements, especially solid metals, in excess of the norm increases the likelihood of the formation of geochemical anomaly foci in the area. Therefore, it is very important to conduct ecogeochemical studies to ensure the ecological safety of the population and biota in the territories liberated from occupation in connection with the "Great Return". The article analyzes the geochemical structure of the landscapes of Eastern Zangezur.

1. Introduction

The formation of the landscape-geochemical system depends on natural and anthropogenic factors. As a result of Armenia's military aggression and occupation policy, which lasted for 30 years until 2020, anthropogenic factors had a greater impact on the change in the geochemical conditions of the landscapes in Karabakh and Eastern Zangezur. The deployment of military forces, the movement of heavy equipment, the construction of engineering and fortification facilities, the use of numerous explosive equipment and means, prohibited weapons, fires, etc. have resulted in a violation of the geochemical balance of the region [8]. In some areas contaminated with chemical weapons, radioactive substances, and heavy metals, the likelihood of the emergence of geochemical anomalies of anthropogenic origin has increased [1]. Therefore, in connection with the "Great Return", it is very important to conduct ecogeochemical studies to ensure the ecological safety of the population and biota in the territories liberated from occupation. The study of the geochemical characteristics of landscapes creates

a basis for research in the field of geomedicine, assesses more specific natural geochemical variations and human-caused disturbances, identifies geochemical areas of interest for the exploration of mineral resources [6]. And creates a basis for the detection of potentially dangerous areas from a geochemical perspective.

The main purpose of the study is to analyze the geochemical structure of the landscapes of Eastern Zangezur.

2. Material and method

In the study, soil, water and plant samples were taken by employees of the "Landscape and Landscape Planning" department from various points of Zangilan, Gubadli and Lachin districts (Zangilan airport, mined areas of Zangilan, Khanlig gorge of Gubadli, Hakari reservoir area, Hal village road, etc.) (table 1). Field studies were conducted between 500-1500 m altitudes of the area. During the field studies, the method of laying out sections was used in accordance with the specific landscape conditions of the studied area, samples were taken from the genetic layers of the soil, plants and natural waters in the places where

the sections were laid, and chemical and spectral analysis of the collected samples was carried out in laboratory conditions. The samples were analyzed using an “Elvax-CEP 01” X-ray fluorescent spectrometer, and tables were compiled on the obtained geochemical indicators.

The analysis of the landscape structure and diseases characteristic of landscape complexes used the indicators of the “Ecogeochemical landscape map of Azerbaijan” [3] and the “Medical ecogeochemical landscape map” [2].

Research area. The relief of the research area consists of plains, plateaus, low, medium and high mountains and ridges. The mountainous part of the Eastern Zangezur region is composed of Mesozoic limestones, schists, sandstones, and the plains and foothills are composed of Cenozoic sediments. The largest morphostructural unit of the area, the Karabakh volcanic plateau, is composed of volcanic eruption materials of the Pliocene-Quaternary period. The climate types prevailing in the area are mildly warm with dry winters, mildly warm with dry summers, cold with dry winters, and mountain-tundra. The region is distinguished by its rich landscape diversity, from partly subnival, alpine and subalpine meadows of the highlands to wormwood-dry steppes of the plains. Information on the geographical location

of the samples taken from the area is given in detail in table 1.

3. Analysis and discussion

The geochemical landscape is a paragenetic combination of elementary landscapes associated with the flow of matter and energy, and each geochemical landscape is characterized by the migration of certain chemical elements and compounds [11]. In the classification based on the migration properties of chemical elements by A.T. Perelman, biogenic migration is preferred over water migration, large taxonomic units such as group, type and subtype are distinguished according to the characteristics of the biological cycle, and relatively small taxonomic units such as classes, genera and species are distinguished according to the nature of water migration [11, 12]. According to the migration characteristics of chemical elements and compounds, alluvial (Al), supraquatic (SA), transaccumulative (TAK) and accumulative (Ak) geochemical landscape types are distinguished in the study area. Sulfate-hydrocarbonate-sodium ($\text{SO}_4\text{-HCO}_3\text{-Na}$), sulfate-calcium-sodium ($\text{SO}_4\text{-Ca-Na}$), sulfate-sodium-magnesium ($\text{SO}_4\text{-Na-Mg}$) and hydrocarbonate-calcium-sodium ($\text{HCO}_3\text{-Ca-Na}$) macrocompounds dominate in the region (table 4).

Table 1

Geographical coordinates of sampling sites

№	Station	Latitude	Longitude
1	Zangilan	39°04'56.2//	46°39'24.8//
2	Malakeshin	39°06'49//	46°41'18.2//
3	Malakeshin	39°06'52.3//	46°41'24.4//
4	Khanlig Valley	39°50'3//	46°43'31//
5	Khanlig Valley	39°15'50//	46°43'31.0//
6	Khanlig Valley	39°15'50.3//	46°43'30.8//
7	Khanlig Valley	39°16'34.5//	46°43'14.5//
8	Khanlig Valley	39°16'26.7//	46°42'51.8//
9	Khanlig Valley	39°16'16.0//	46°42'04.2//
10	Khanlig Valley	39°16'16.0//	46°43'30.2//
11	Khanlig Valley	39°15'55.2//	46°42'30.5//
12	Hal village	39°16'50.0//	46°41'31.9//
13	Hal village	39°16'13.2//	46°41'31.9//
14	Hal village	39°16'52.4//	46°40'54.1//
15	Lachin	39°39'01.7//	46°32'27.5//
16	Lachin	39°38'06.6//	46°32'59.2//
17	Lachin	39°35'23.3//	46°33'07.7//
18	Malkhalaf	39°32'50.8//	46°35'07.3//
19	Gulabird	39°30'14.3//	46°36'26.4//
20	Khandagh	39°24'41.1//	46°39'18.7//
21	Ishigli	39°23'24.4//	46°39'57.2//
22	Mirzanagili	39°24'27.0//	47°16'524.4//
23	The Third Aghali	39°11'14.3//	46°53'40.9//
24	The First Alibeyli	39°07'19.2//	46°44'28.2//

In geochemical classification, landscape types are distinguished according to the ratio of biological productivity to biomass, and each geochemical landscape differs from each other in its structure. The landscapes of Eastern Zangezur are divided into 8 geochemical landscape types according to the volume of biological mass (figure). A brief description of the ecogeochemical conditions of these types is as follows.

Alluvial (Al), supraquatic (SA), accumulative (Ak) migration is typical in the subnival shale landscape. In these landscapes, sulfate-magnesium-sodium ($\text{SO}_4\text{-Mg-Na}$) macrocompounds prevail. In the area, As, Pb, B are in excess, Ba, J, F are in deficit (figure, table 4).

Transalluvial (TA) and transaccumulative (TAK) migration is typical for alpine and subalpine meadows and meadow-steppe landscapes. In these landscapes, sulfate-magnesium-sodium ($\text{SO}_4\text{-Mg-Na}$) macrocompounds prevail. In the area, Zn, Cu, Pb are in excess, Mn, Ba, Sr are in deficit (figure, table 4). Alluvial (Al), supraquatic (SA) and accumulative (Ak) migration is typical in the beech-alder and oak-alder forest landscapes of the middle and partly high mountains. In these landscapes, sulfate-calcium-sodium ($\text{SO}_4\text{-Ca-Na}$) macrocompounds dominate. Zn, Sn, Ag are in excess in the area, while Mn, Ba, Sr are in deficit (figure, table 4).

Table 2

Microelement composition of soil samples taken from the landscapes of the Eastern Zangezur region

Elements		Average amount, in %		Intensity	Concentration clarke, CC
Atomic N	Chemical symbol	Clarke in the Earth's crust, ECC	Clarke's distribution (CD)		
1	2	3	4	5	6
Opposite Zangilan Airport, 5 cm					
26	Fe	4.65	8,22±3720	29679	0,122±0,0003
37	Rb	0.015	10,71±214,28	1591	0,093±0,005
38	Sr	0.034	4,26±188,88	10579	0,23±0,005
39	Y	0.0029	4,46±72,5	1033	0,224±0,014
40	Zr	0.017	4,05±154,54	7201	0,247±0,0064
50	Rh			679	
65	Tb			306	
Opposite Zangilan Airport 10 cm					
17	Cl	0.017	0,017±0,30	196	58,45±3,33
26	Fe	4.65	7,48±86,7	32318	0,13±0,012
37	Rb	0.015	1,134±11,43	1569	0,88±0,087
38	Sr	0.034	4,97±55,74	8885	0,201±0,018
39	Y	0.0029	4,46±41,43	1025	0,224±0,024
40	Zr	0.017	4,23±47,22	6750	0,236±0,021
50	Sn	0.00025	0,178±1,66	1109	5,6±0,6
65	Tb			603	
Opposite Zangilan Airport 20 cm					
26	Fe	4.65	7,58±3369,56	31792	0,132±0,00029
37	Rb	0.015	9,26±187,5	1798	0,108±0,005
38	Sr	0.034	4,48±200	9828	0,229±0,005
39	Y	0.0029	40,27±725	1124	0,248±0,014
40	Zr	0.017	3,75±154,54	7593	0,266±0,006
65	Tb			369	
Zangilan, mined area 5 cm					
17	Cl	0.017	0,0081±0,312	429	124,027±3,202
25	Mn	0,10	16,077±104,16	216	0,062±0,0096
26	Fe	4,65	6,473±90,396	37661	0,154±0,0110
37	Rb	0,015	5,703±71,43	2935	0,175±0,014
38	Sr	0,034	5,81±77,27	7613	0,172±0,013
39	Y	0,0029	3,26±36,29	1396	0,307±0,027
40	Zr	0,017	3,307±44,74	8638	0,32±0,022
47	Ag	0,000007	0,0125±0,116	771	80±8,57
50	Sn			770	

1	2	3	4	5	6
65	Tb			565	
Zangilan, mined area 10 cm					
17	Cl	0,017	0,0083±0,3439	420	119,89±2,91
26	Fe	4,65	7,42±99,97	33363	0,135±0,010
37	Rb	0,015	6,07±71,42	2814	0,165±0,014
38	Sr	0,034	5,88±75,55	7682	0,17±0,013
39	Y	0,0029	3,58±41,42	1292	0,27±0,024
40	Zr	0,017	3,57±45,94	8179	0,28±
65	Tb			718	
Zangilan, mined area 20 cm					
17	Cl	0,017	0,007±0,341	477	142,72±2,93
26	Fe	4,65	6,96±96,53	33672	0,143±0,0103
37	Rb	0,015	6,75±83,3	2387	0,148±0,012
38	Sr	0,034	5,66±75,55	7545	0,176±0,013
39	Y	0,0029	3,72±41,43	1181	0,27±0,024
40	Zr	0,017	3,53±47,22	7835	0,28±0,021
65	Tb			225	
Gubadli, Khanlig Gorge 5 cm					
17	Cl	0,017	0,0121±0,2828	276	82,36±35,35
26	Fe	4,65	6,94±86,49	34540	0,1441±0,0115
37	Rb	0,015	12,5±125	1315	0,08±0,008
38	Sr	0,034	2,104±2,59	20733	0,475±0,038
39	Y	0,0029	5,68±58	792	0,0175±0,0172
40	Zr	0,017	4,08±48,57	6896	0,244±0,020
41	Nb	0,0021	9,13±70	427	0,109±0,014
42	Mo	0,00011	0,92±5,5	222	1,09±0,18
47	Ag	0,000007	0,012±0,116	756	78,57±8,57
50	Sn	0,00025	0,27±2,5	701	3,6±1,66
65	Tb			510	
Gubadli, Khanlig Gorge 10 cm					
26	Fe	4,65	7,11±2943,03	32912	0,14±0,0016
37	Rb	0,015	12,60±214,28	1283	0,08±0,005
38	Sr	0,034	2,18±125,92	19515	0,457±0,008
39	Y	0,0029	5,47±72,5	807	0,183±0,014
40	Zr	0,017	4,31±154,54	6385	0,232±0,006
65	Tb			457	
Gubadli, Khanlig Gorge 20 cm					
17	Cl	0,017	0,0128±0,324	266	78,09±3,08
26	Fe	4,65	7,81±93,22	31219	0,128±0,0107
37	Rb	0,015	15±150	1126	0,066±0,006
38	Sr	0,034	2,713±31,77	16449	0,368±0,0314
39	Y	0,0029	6,59±58	702	0,152±0,017
40	Zr	0,017	4485±5,151	6436	0,223±0,019
65	Tb			393	
Hakari Reservoir					
17	Cl	0,017	0,0146±0,198	215	68,40±5,04
22	Ti	0,45	11,78±85,227	262	0,084±0,0117
25	Mn	0,10	7,342±64,102	433	0,1362±0,0156
26	Fe	4,65	3,69±58,58	60301	0,27±0,017
37	Rb	0,015	50±375	298	0,02±0,003
38	Sr	0,034	4,141±97,14	9467	0,241±0,016
39	Y	0,0029	3,536±41,43	1141	0,282±0,024
40	Zr	0,017	2,59±38,63	9748	0,384±0,0258
41	Nb	0,0021	9,13±70	383	0,109±0,014
65	Tb			869	

Table 3

Micronutrient composition of plant samples taken from the landscapes of the Eastern Zangezur region

Elements		Average amount, in %		Intensity	Concentration clarke, CC
Atomic N	Chemical symbol	Clarke in the Earth's crust, ECC	Clarke's distribution (CD)		
1	2	3	4	5	6
Opposite Zangilan airport, various plants					
17	Cl	0.017	0,012±0,64	271	81,98±1,56
26	Fe	4.65	19,82±190,73	12018	0,050±0,005
35	Br	0,00021	0,034±0,323	5165	29,143±3,09
37	Rb	0.015	7,89±71,43	2131	0,126±0,14
38	Sr	0.034	3,201±30,91	13904	0,312±0,032
39	Y	0.0029	18,125±96,66	256	0,055±0,0103
40	Zr	0.017	15,17±13,07	1900	0,06±0,007
50	Sn	0.00025	0,155±1,315	1280	6,44±0,76
Zangilan, (mined area), various grass plants					
26	Fe	4.65	169,46±7881,35	1414	0,006±0,0001
30	Zn	0,0083	3,502±39,52	508	0,285±0,025
35	Br	0,00021	0,283±3,5	637	3,523±0,285
37	Rb	0.015	48,38±500	354	0,0206±0,002
38	Sr	0.034	2,54±73,91	17891	0,394±0,0135
47	Ag	0,000007	0,175±0,0162	613	61,43±5,714
Khanlig Gorge, various herbaceous plants					
26	Fe	4.65	60,319±4843,75	3864	0,016±0,00021
30	Zn	0,0083	2,98±36,08	580	0,0334±0,277
35	Br	0,00021	0,0067±0,3	25985	148,47±3,33
37	Rb	0.015	5,41±136,36	3074	0,184±0,007
38	Sr	0.034	5,059±170	8671	0,157±0,06
40	Zr	0,017	154,54±850	190	0,006±0,0012
47	Ag	0,000007	0,009±0,14	1031	107,14±7,142
Khanlig Valley, various plants 2					
26	Fe	4,65	59,83±12916,6	4018	0,016±0,00007
35	Br	0,00021	0,089±1,75	2018	11,14±0,571
37	Rb	0,015	5,45±125	3152	0,183±0,008
38	Sr	0,034	5,41±154,54	8413	0,185±0,0064
40	Zr	0,017	130,7±850	219	0,007±0,012
Khanlig Valley, various plants plant 1					
26	Fe	4,65	78,51±9300	3146	0,013±0,00010
30	Zn	0,0083	0,47±46,11	388	2,12±0,022
35	Br	0,00021	0,15±2,33	1200	0,64±0,43
37	Rb	0,015	20,27±300	876	0,049±0,003
38	Sr	0,034	2,87±91,89	16290	0,35±0,010
40	Zr	0,017	73,91±850	404	0,013±0,0011
Hal village road 1					
17	Cl	0,017	0,0112±1,035	295	88,60±0,965
26	Fe	4,65	36,59±337,44	6546	0,027±0,0029
30	Zn	0,0083	2,95±21,84	600	0,338±0,046
35	Br	0,00021	0,043±0,396	4128	23±2,52
37	Rb	0,015	5,35±48,38	3176	0,186±0,0206
38	Sr	0,034	2,535±23,77	17771	0,39±0,04
40	Zr	0,017	36,17±283,33	798	0,027±0,0035
Hal village road 2					
26	Fe	4,65	34,85±8773,58	6896	0,0286±0,00011
30	Zn	0,0083	3,62±3,95	490	0,276±0,025

1	2	3	4	5	6
37	Rb	0,015	3,401±100	5027	0,294±0,01
38	Sr	0,034	2,43±100	18591	0,410±0,01
40	Zr	0,017	21,25±340	1379	0,047±0,0029
47	Ag	0,000007	0,011±0,175	901	90±5,71
Hakari reservoir, mountain meadow flowers					
26	Fe	4,65	16,34±22,14	15341	0,061±0,00004
37	Rb	0,015	13,27±250	1332	0,075±0,004
38	Sr	0,034	6,46±226,66	7249	0,155±0,0044
40	Zr	0,017	10,625±283,33	2849	0,09±0,0035
48	Cd	0,000013	0,0156±0,26	1170	63,84±3,85
Khanlig village, various herbaceous plants					
17	Cl	0,017	0,007±0,972	427	131,69±1,03
26	Fe	4,65	28,09±305,32	8189	0,035±0,0033
30	Zn	0,0083	6,241±41,5	271	0,160±0,0241
37	Rb	0,015	3,88±40,54	4196	0,26±0,025
38	Sr	0,034	2,38±26,35	18081	0,42±0,038
40	Zr	0,017	23,28±212,5	1200	0,043±0,0047
49	In	0,000025	0,028±0,25	940	35,6±4

Transalluvial (TA), supraquatic (SA) and accumulative (Ac) migration are typical in semi-arid forest landscapes of the low and middle highlands. Hydrocarbonate-calcium-sodium ($\text{HCO}_3\text{-Ca-Na}$) macrocompounds prevail in these landscapes. Pb, V, Cu are in excess in the area, Ti, Sr are in deficit (table 4).

Alluvial (Al) and supraquatic (SA) migration are typical for arid forest, forest-shrub and shrub-steppe landscapes of the low highlands. Sulphate-hydrocarbonate-sodium ($\text{SO}_4\text{-HCO}_3\text{-Na}$) macrocompounds prevail in these landscapes. Ag, B, Cu, Hg are in excess in the area, Co, Ti, Zr are in deficit (table 2, 3).

Transalluvial (TA), transaccumulative (TAc) and accumulative (Ac) migration are typical in the forest-steppe and steppe landscapes of the low and middle highlands. For these landscapes, sulfate-calcium-sodium ($\text{SO}_4\text{-Ca-Na}$) macrocompounds prevail. Cu, V, B, Sr are in excess in the area, and Ba, Ni, Zr are in deficit (table 2, 3).

Alluvial (Al) and supraquatic (SA) migration are typical for the dry steppe, steppe and arid-denudation landscapes of the low highlands and depressions. Sulphate-calcium-sodium ($\text{SO}_4\text{-Ca-Na}$) macrocompounds prevail in these landscapes. Cu, Mo, Ni, Pb are in excess in the area, and Mn, Ti, Ba, Sr are in deficit (table 2, 3).

Transaccumulative (TAk) and accumulative (Ac) migration is typical for the post-forest steppe and intrazonal landscapes of the denudation-accumulative plains. In these landscapes, sulfate-calcium-sodium ($\text{SO}_4\text{-Ca-Na}$) macrocompounds prevail. In the area, B, V, Pb, Co are in excess, Sr, Zr, Rb, Fr are in deficit (table 2, 3).

According to the results of the analysis of geochemical landscape types, sulfate macrocompounds in the area are typomorphic. Hydrocarbonate compounds are found only in semi-arid forests of the low and middle highlands ($\text{HCO}_3\text{-Ca-Na}$) and in arid-forest, forest-shrub and shrub-steppe landscapes of the low highlands ($\text{SO}_4\text{-HCO}_3\text{-Na}$). The elements copper (Cu), rubidium (Rb), zirconium (Zr), vanadium (V), boron (B), silver (Ag) are more typical for the region. Deficiencies of manganese (Mn), zirconium (Zr), titanium (Ti), fluorine (F), nickel (Ni), cobalt (Co), barium (Ba), zinc (Zn), mercury (Hg) were observed in the area (table 2, 3).

It should be noted that the structural analysis of the ecogeochemical conditions of the East Zangezour region is based on existing maps, scientific literature and field research materials conducted in 2023-2024. However, relatively different results were obtained in the analysis of samples taken from the areas where field research was conducted. According to the results of spectral analyses, chlorine (Cl) is a deficit element only in a 10 cm cross-section sample opposite the Zangilan airport in the area and is at the Clarke level in the Earth's crust. According to the results of spectral analyses, all the remaining elements are many times (even 10 and a hundred times) more abundant than in the Clarke. The most common microelements in the area are iron (Fe), rubidium (Rb), iodine (Y) in the area opposite the Zangilan airport, iron (Fe), rubidium (Rb), manganese (Mn) in the mined areas of Zangilan, iron (Fe), rubidium (Rb), niobium (Nb) and strontium (Sr) in the Khanlig gorge, titanium (Ti) and manganese (Mn) in the Hakari reservoir area (table 2, 3). These

data play a valuable indicator role in studying the mineral and raw material reserves of the area, as well as in conducting geological exploration work.

3.1. The effect of biochemically active microelements on living organisms. Human health is mainly determined by the amount of chemical elements in the environment (soil, plants, rocks, water, atmosphere, etc.) [10]. The presence of certain macroelements and microelements in the landscape in excess or less than the norm poses a threat to the life and health of living organisms, especially humans, whose permanent habitat is in geochemical anomalies [7]. According to studies, up to 20 of the 118 elements in the periodic table (silver (As), beryllium (Be), cobalt (Co), chromium (Cr), cadmium (Cd), mercury (Hg), lead (Pb) and molybdenum (Mo), etc.) are dangerous for humans and their surrounding natural environment. Also, along with microelements, the very high concentration of metals such as copper (Cu), zinc (Zn) and aluminum (Al) in the environment is also a source of danger to the health of living organisms [4, 5, 11].

Microelements such as copper (Cu), zinc (Zn), lead (Pb), molybdenum (Mo), iron (Fe) are most common in the study area. These elements are included in the group of biogenic microelements. Biogenic elements are chemical elements that are constantly included in the composition of organisms and are necessary for their life [4, 10]. Biogenic microelements increase the activity of various enzymes, create conditions for the synthesis of sugar, starch, proteins, nucleic acids, vitamins, enzymes. The effect of these elements, which are more common in the area, on the human body has been sufficiently described in the scientific literature.

Copper (Cu) is found in the human body mainly in the form of complex organic compounds in an amount of 70-120 mg, and approximately 30% of this is accumulated in the liver and brain, and the rest in the muscles, bones, blood and kidneys. Excess copper in the body for one reason or another causes depigmentation of the skin, the development of a skin disease called vitiligo. Copper deficiency causes fatigue, constant and causeless headaches, bad mood, and irritability [4, 11].

The main natural compounds of zinc (Zn) are the mineral galme ($ZnCO_3$) and the zinc sulfide (ZnS) compound, from which it is possible to obtain free zinc. This element is involved in the formation of hormones of the pituitary gland, adrenal glands and pancreas. It is necessary for the

normal development and functioning of the sensory organs (taste, vision, smell) [4, 5, 11].

Excess zinc in the human body creates conditions for the division and growth of cancer cells. Zinc deficiency slows down the normal growth of plants and animals, leading to the existence of dwarf plants and animals [10].

Lead (Pb) accumulation in the human body causes various clinical symptoms. The ionic mechanism of lead toxicity causes significant changes in various biological processes such as cell adhesion, intracellular and intercellular signaling, protein folding, maturation, apoptosis, ion transport, enzyme regulation, and neurotransmitter release [9].

The initial manifestation of poisoning with this element is anemia. In later stages, abdominal pain and encephalopathy syndrome occur. Excess lead in the body also prevents hemoglobin synthesis and the absorption of calcium, which is necessary for the development of bone tissue.

Molybdenum (Mo) enters the body through plant foods and is more toxic than molybdenum in inorganic compounds. The main part of this element is concentrated in bone tissue, liver, kidneys, brain, pancreas and thyroid glands [4].

Molybdenum activates a number of enzymes necessary for the metabolism of proteins, fats and carbohydrates in the body, promotes body development and growth, strengthens dental tissue, protects teeth from destruction and helps prevent caries. Molybdenosis is observed in humans and animals in geographical regions where there is an excess of molybdenum in the soil. Molybdenosis resembles a kind of gout, arthrosis, polyarthralgia are observed [4, 5, 9, 13].

Hypertension, blood pressure instability, functional disorders of the nervous system, metabolic disorders are observed in workers in molybdenum production. Diseases such as atrophic rhinitis, gastritis, cardiovascular dystonia are observed in those who work in such conditions for a long time [4, 9, 13].

Iron (Fe) is an essential element for almost all living systems [9]. The organs in the body where iron accumulates the most are the liver and spleen. "Iron fasting" has a severe impact on the body. First of all, the synthesis of hemoglobin, an iron-containing protein in red blood cells, is disrupted, as a result of which less oxygen reaches organs and tissues, and the heart, brain and kidneys are primarily affected [13]. Iron toxicity in cells causes iron-mediated tissue damage, which includes cellular oxidative and reduction mechanisms and their toxicity to intracellular organelles such as

mitochondria and lysosomes [9]. In nature, various iron medicines (iron-lactate, iron-glycero-phosphate, iron 2 sulfate, feramide, hemistimulin, etc.) are used in the treatment of diseases associated with iron deficiency, as well as to strengthen the body [9].

As a result of long-term research in Azerbaijan, correlative relationships between a number of diseases typical for individual landscape complexes and the concentration of various macroelements and microelements have been identified, and a corresponding “Medical-ecogeochemical landscape map” has been compiled [2]. Accordingly, based on the compiled landscape map of the Eastern Zangezur region, it was possible to group diseases typical for landscape types as follows:

- In alpine and subalpine meadows and meadow-steppe landscapes, there is a risk of a very wide spread of oncological and endemic goiter diseases, and a wide spread of nervous diseases and fluorosis diseases.

- In the beech-alder and oak-alder forest landscapes of the middle and partly high mountains, a very wide spread of endemic goiter, dental caries, a wide spread of oncology, and a weak spread of nervous diseases are expected.

- In the semi-arid forest landscapes of the low and middle highlands, there are opportunities for endemic goiter, dental caries, fluorosis, and low prevalence of oncological diseases.

- In the forest-steppe and steppe landscapes of the low and middle highlands, there is a danger of widespread brucellosis, widespread endemic goiter, hypertension, and nervous diseases.

- In the arid forest, forest-shrub and shrub-steppe landscapes of the low highlands, there is a danger of widespread oncology, cardiovascular diseases, and respiratory diseases, widespread hypertension, dysentery, digestive system diseases, brucellosis, and low prevalence of conjunctivitis diseases are characteristic.

- In the dry steppe, steppe, and arid-denudation landscapes of the low highlands and depressions, there are geochemical conditions for widespread respiratory diseases, widespread dental caries, dysentery, brucellosis, hypertension, and low prevalence of conjunctivitis diseases.

- In the post-forest steppe and intrazonal landscapes of denudation-accumulative plains, dental caries, digestive system diseases, cardiovascular and respiratory diseases are widespread, dysentery, nervous diseases, brucellosis, hypertension, conjunctivitis diseases are low.

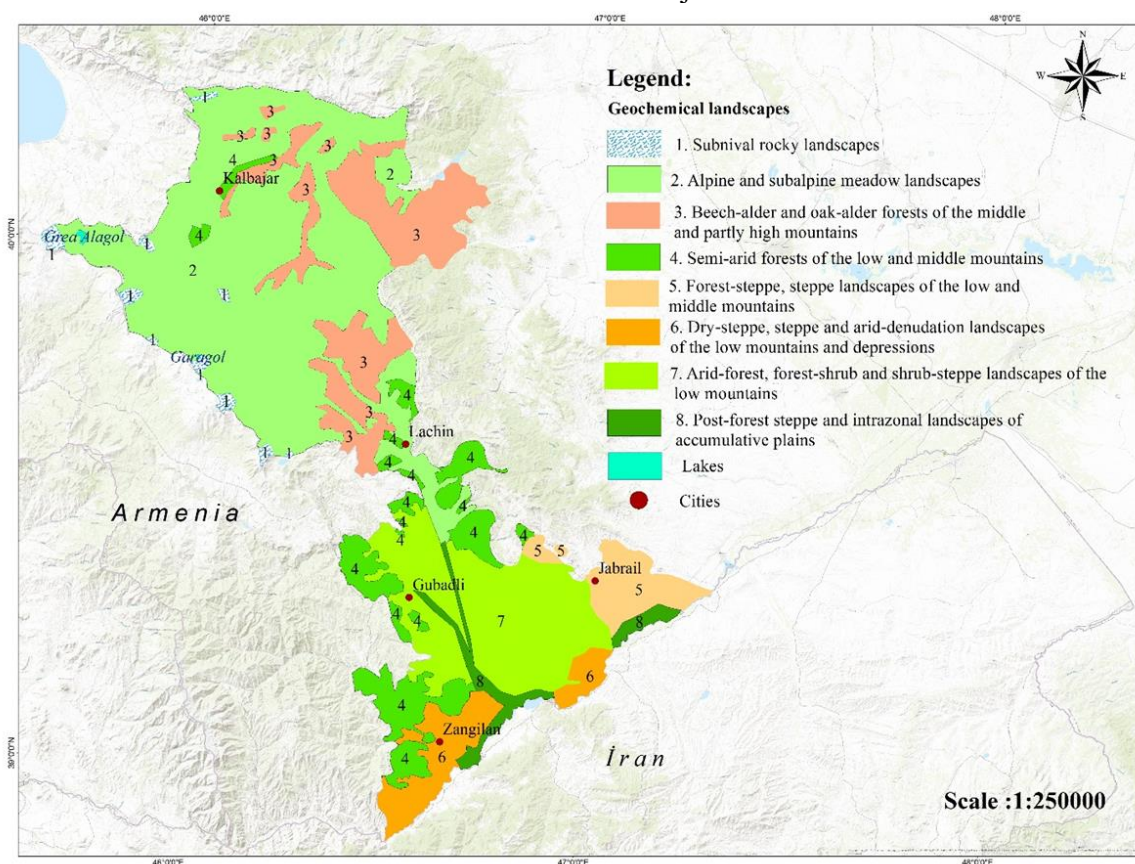


Fig. Ecogeochemical landscapes of the Eastern Zangezur region (map legend is given in table 4)

Table 4

Ecogeochemical landscapes

Groups	Types	Sorts				Macro-compounds	Excess elements in the numerator, deficit elements in the denominator
By volume of biological mass	According to the ratio of biological productivity to biomass	Due to the migration characteristics of chemical elements					
High mountain landscape	1. Subnival rocky landscapes	Al		A		Ac	So ₄ -Mg-Na <u>As_{3,7} Pb_{2,3} B_{2,0}</u> Ba _{0,4} J _{0,03} F _{0,02}
Mountain-meadow landscape	2. Alpine and subalpine meadow landscapes		T A			TAc	So ₄ -Na-Mg <u>Pb_{5,8} Cu_{4,8} Zn_{3,5}</u> Mn _{0,4} Sr _{0,1} F _{0,03}
Mountain-mountain landscape	3. Beech-alder and oak-alder forests of the middle and partly high mountains	Al		A		Ac	So ₄ -Ca-Na <u>Zn_{1,0,5} Sn_{3,9} Ag_{3,3}</u> Mn _{0,5} Ba _{0,4} Sr _{0,3}
	4. Semi-arid forests of the low and middle mountains-		A	A		Ac	HCO ₃ -Ca-Na <u>Pb_{12,3} V_{8,5} Cu_{6,1}</u> Sr _{0,4} Ti _{0,3} Sr _{0,2}
Landscape of semi-arid mid- and lowland mountains	5. Forest-steppe, steppe landscapes of the low and middle mountains		T A			TAc Ac	So ₄ -Ca-Na <u>Cu_{9,6} V_{7,9} B_{5,8} Sr_{4,2}</u> Ba _{0,6} Ni _{0,3} Ba _{0,2} Zr _{0,1}
Arid and semiarid landscapes of the lowlands	6. Dry-steppe, steppe and arid-denudation landscapes of the low mountains and depressions	Al		A			So ₄ -Ca-Na <u>Mo_{10,2} B_{8,9} V_{6,3} Cu_{8,9}</u> Zn _{0,4} Ba _{0,3} Zr _{0,1}
	7. Arid-forest, forest-shrub and shrub-steppe landscapes of the low mountains	Al		A			SO ₄ -HCO ₃ - Na <u>Ag_{7,3} B_{6,3} Cu_{5,6} Hg_{3,4}</u> CO _{0,6} Ti _{0,4} Zr _{0,1}
	8. Post-forest steppe and intrazonal landscapes of accumulative plains					TAc Ac	So ₄ -Ca-Na <u>B_{10,0} V_{2,4} Pb_{2,3} Co_{2,4}</u> Se Z _{0,1} Rb _{0,07} Fr _{0,04}

Analysis of the “Medical-ecogeochemical landscape map” shows that the number of diseases increases from high mountains to lowland landscapes in accordance with geochemical conditions in the region. There is a threat of a very wide spread of oncological, endemic goiter, dental caries, cardiovascular diseases, respiratory diseases, and brucellosis diseases in the area. The absence of widespread diseases is characteristic of the arid forest and forest-shrub landscape of the low and middle highlands, the dry steppe, steppe, arid-denudation landscape of the low highlands and depressions, and the post-forest steppe landscape of the denudation-accumulative plains. It was determined that dysentery and conjunctival diseases are the least common in the area.

4. Conclusion

1. The conducted analyses made it possible to relatively accurately determine the general ecogeochemical background of the landscape of the study area. 2. The geochemical analysis of landscape types determined that sulfate macrocompounds in the study area are typomorphic, and hydrocarbonate compounds are found in the semi-arid forests of the low and middle highlands (HCO₃-Ca-Na) and in the arid-forest, forest-shrub and shrub-steppe landscape of the low highlands (SO₄-HCO₃-Na). The elements copper (Cu), rubidium (Rb), zirconium (Zr), vanadium (V), boron

(B), silver (Ag) are more typical for the region. 3. A comparative analysis of the available literature materials and the results of field studies showed that while previous studies in the study area showed a deficiency of many elements (manganese (Mn), zirconium (Zr), titanium (Ti), fluorine (F), nickel (Ni), cobalt (Co), barium (Ba), zinc (Zn), mercury (Hg)), currently these elements are many times higher than normal. The excess of chemical elements, especially heavy metals, increases the likelihood of geochemical anomalies in the area. This is a potential long-term source of danger for all living things. 4. In order to better understand and assess the impact of war on nature and reduce negative ecological impacts, it is important to conduct continuous geochemical studies in the area.

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QARABAĞ VƏ ŞƏRQİ ZƏNGƏZUR REGIONU LANDŞAFTLARININ EKOGEOKİMYƏVİ XÜSUSİYYƏTLƏRİ

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Xülasə. Çöl tədqiqatlarında Şərqi Zəngəzur ərazisindən götürülmüş torpaq və bitki nümunələrinin "Elvax-CEP 01" markalı rentgen-fluorescent spektrometri vasitəsilə analizi aparılmışdır. Analizlərin nəticələri göstərdi ki, ərazidə yalnız xlor (Cl) Yer qabığındakı klark səviyyəsindədir və digər bütün elementlər klarka nisbətən dəfələrlə (hətta 10 və yüz dəfələrlə) çoxdur. Müəyyən olundu ki, regionda sulfatlı makrobirləşmələr tipomorfdur və ərazidə natriumlu, kalsiumlu, maqneziumlu duzlar üstünlük təşkil edir. Kimyəvi elementlərin, xüsusilə ağır metalaların normadan çox olması ərazidə geokimyəvi anomaliya ocaqlarının yaranma ehtimalını artırır. Buna görə də "Böyük qayıdış"la əlaqədar olaraq işğaldan azad olunmuş ərazilərdə əhalinin və biotanın ekoloji təhlükəsizliyinin təmin olunması üçün ekogeokimyəvi tədqiqatların aparılması çox vacibdir. Məqalədə Şərqi Zəngəzur landşaftlarının geokimyəvi strukturu təhlil edilmişdir.

Açar sözlər: Şərqi Zəngəzur, landşaft, kimyəvi elementlər, miqrasiya, geokimyəvi birləşmələr, xəstəliklər

LANDSCAPE ZONING OF THE GUBA DISTRICT: A CLUSTER-BASED APPROACH TO TOURISM POTENTIAL

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Abstract

This article examines the landscape zoning of the Guba district of Azerbaijan with a focus on its tourism and recreational potential. Considering the abundance of natural and cultural resources in the region, the study aims to identify promising zones for the development of tourism infrastructure through the use of cluster analysis and geographic information systems (GIS). The main objective is to classify the natural landscapes of the Guba district and optimize their utilization for various types of tourism. The research results show that effective territorial planning and management can contribute to the sustainable development of the tourism sector and improve the quality of life for local residents.

1. Introduction

In recent decades, tourism has become an important factor in the socio-economic development of many regions around the world [4, 6]. However, the growing number of tourists necessitates the adoption of a special approach to planning and the rational use of natural resources in order to minimize negative environmental impacts and ensure sustainable development. One of the key tools for achieving these goals is landscape zoning, which makes it possible to identify geographically homogeneous areas for the optimal utilization of their tourism and recreational potential [2]. This study focuses on the Guba district of Azerbaijan, rich in natural and cultural resources that can serve as a basis for tourism development.

The main objective of the study is to carry out landscape zoning of the Guba district using cluster analysis in order to identify the most promising areas for the development of tourism infrastructure and the provision of tourism services. The work relies on modern methods of geographic information systems (GIS) and spatial analysis, which makes it possible to obtain more accurate and well-substantiated results.

The Guba administrative district (area 2,610 km²), located in the north of the Republic of

Azerbaijan, represents a unique combination of natural and cultural resources. With its picturesque landscapes, diverse flora and fauna, and rich cultural heritage, the district possesses significant tourism and recreational potential. Effective landscape planning is a key factor in developing the tourism sector, which can contribute to regional economic growth, improve the quality of life for local residents, and preserve the environment. However, to fully realize this potential, it is necessary to implement innovative approaches to landscape planning that integrate modern technologies, sustainable development principles, and active involvement of the local community [10].

Landscape zoning is one of the key methods of spatial planning and is used to classify natural areas based on their physical and geographical characteristics [1]. The purpose of this process is to identify and describe landscapes on the basis of their internal unity and specific features, in order to enable more effective planning and use of territories for various purposes, including tourism. Zoning makes it possible to manage territories efficiently and determine their most appropriate use depending on the intended objectives [9]. In the context of tourism, zoning helps identify areas most suitable for different types of recreation,

ranging from active tourism to ecotourism [11]. For this reason, it is necessary to define and classify the natural landscapes of the Guba district in order to determine the most promising zones for tourism activities and to optimize tourist routes and recreational areas.

For the landscape zoning of the Guba district, we consider it advisable to use a cluster-based approach, which makes it possible to identify homogeneous areas with similar natural conditions and recreational opportunities. Creating clusters for zoning landscapes according to their tourism and recreational potential offers significant advantages and is theoretically well-founded. Clustering enables more effective organization and management of territorial units, taking into account their specific characteristics and potential, which is particularly relevant in the field of tourism and recreation.

The cluster approach to zoning applied in this study involves grouping landscapes based on the similarity of their natural characteristics (for example, relief, climate, vegetation). Geographic information analysis methods play an important role in this process, allowing for the creation of accurate maps and spatial models [15]. In addition, anthropogenic factors - such as the impact of tourism on the environment - are taken into account, enabling more precise planning of infrastructure development in harmony with natural conditions.

2. Methods

To conduct the landscape zoning, cluster analysis methods and geographic information systems were used. The K-means clustering algorithm was selected to classify the natural areas of the Guba district [5] based on similarities in climatic and relief conditions. The analysis considered parameters such as elevation above sea level, average annual temperature, precipitation, and vegetation cover. For visualizing the clustering results and creating maps, the ArcGIS platform was employed, which made it possible to present the data as thematic maps with clearly delineated landscape zones.

An important element of the study was the examination of both anthropogenic and natural factors influencing the tourism and recreational potential of the areas. Resource assessment included an analysis of the accessibility of zones for tourists as well as potential environmental threats associated with increased tourist flows. The obtained results were divided into several clusters, each characterized by a specific potential for tourism development.

3. Analysis and Discussion.

Stages of Landscape Zoning. Given the relevance and objectives of the study, as well as the rich diversity of natural conditions in the Guba district and the need for their rational use, the implementation of landscape zoning becomes a central element of this work. This process is aimed at identifying territorial features, grouping them according to natural and anthropogenic characteristics, and developing approaches for their optimal utilization in tourism and recreational activities.

1) *Analysis of landscape complexes:* Using collected data (geological and climatic conditions — temperature, precipitation, relief, soil and vegetation types, anthropogenic factors, and existing recreational zones) to divide the territory into clusters, each characterized by a specific landscape type (e.g., nival zones, alpine zones, mountain-forest zones). Identification of the unique features of each cluster (for example, snow cover in nivation zones, rich biodiversity in mountain-forest zones).

2) *Application of cluster analysis:* Using methods such as K-means or hierarchical clustering to identify clusters. Determining the number of clusters based on natural characteristics and tourism-recreational potential. It is possible to distinguish 4–5 clusters for the Guba district.

3) *Creation of cartographic models:* Mapping the clusters using GIS technologies to visualize the zoning and identify areas suitable for tourism activities.

4) *Analysis of the tourism and recreational potential of clusters:* Evaluation of each cluster in terms of suitability for various types of tourism (ecotourism, active recreation, cultural tourism). Identification of priority zones for the development of infrastructure and tourist routes.

The Guba administrative district, with an absolute elevation range from 100 m to 4,191 m, is characterized by a diversity of natural landscapes, including nival, subnival, alpine and subalpine meadow zones, oak-hornbeam and beech-hornbeam forest zones, as well as post-forest meadow-steppe, steppe, and arid sparse forest landscape complexes (Figure 1).

- Nival landscape complexes occupy the peaks and near-peak parts of mountain ridges within the Guba administrative district and are located above 3,800 meters in elevation. They are characterized by the climate of alpine tundra, where snow cover persists year-round. The annual sunshine duration is approximately 2,200 hours, with total solar radiation and radiation balance values of about 140–145 and 20 kcal/cm²,

respectively. The average annual temperature ranges from -5 to -10°C , and summer temperatures rarely exceed 5°C . The total average annual precipitation reaches 600–900 mm, mostly in the form of snow [13, 14].

Vegetation is primarily composed of mosses and lichens, as well as rare high-altitude species adapted to harsh conditions. Soil-vegetation cover is absent due to intense weathering processes occurring here, especially frost weathering [8]. This landscape type is mostly represented by bare rocks, stone accumulations, and in some places, modern snowfields and glaciers.

- Subnival landscape complexes: Located below the nival zone within an elevation range of 3,200 to 3,800 meters, they are characterized by a reduced snow cover compared to the nival areas. The average summer temperature is about 10°C , while winter temperatures drop to -8°C . Humidity is high, around 80%, as the snow melts slowly and remains for 6 to 8 months. Vegetation is often sparse and fragmented; some alpine meadow species - flowering plants - may be present. The soil cover consists of fine earth formations that fill rock cracks and depressions [3].

- Alpine meadow high-mountain landscape complexes develop between absolute elevations of 2,800 to 3,100 (3,200) meters. These unstable and highly differentiated subtypes of high-mountain landscapes form fragmented areas of varying widths and lengths, depending on the amplitude of the current relief, slope gradient, and slope exposure. The relief of the alpine mountain-meadow belt, especially in the Gudyalchay river basin, is characterized by rockfalls, scree slopes, talus deposits, landslides, and, in places, solifluction [12]. The climate is cold, with a relatively high average annual precipitation of 800–1,000 mm, falling as rain and snow; snow cover lasts for 4–5 months. The total solar radiation is about 140 kcal/cm^2 , and the radiation balance is 35 kcal/cm^2 [16].

The alpine zone is distinguished by denser grassy vegetation because snow melts earlier here, creating favorable conditions for meadow plants to grow. These meadows are covered with a variety of grasses (such as meadow clary, fescue, and bluegrass) on weakly developed mountain-meadow peat soils, and occasionally sod soils.

- Subalpine meadow landscapes: The subalpine zone is located at elevations below the alpine zone (2,200–2,800 m) and is characterized by more favorable climatic conditions for the development of productive landscape complexes.

The climate in the subalpine zone is somewhat milder. The average annual air temperature ranges from 2 to 6°C , and precipitation falls predominantly in summer (600–800 mm per year). These conditions contribute to a longer growing season and denser vegetation. The vegetation is dominated by tall meadow plants, including grasses such as bluegrass and clover. Subalpine meadow landscapes are rich in biodiversity and serve as natural pastures for local livestock.

- Mountain-forest landscape complexes occupy a significant area within the elevation range of 600–700 m to 2,200–2,300 m. The total forest area comprises approximately 30% of the entire district. This type of landscape is characterized by climates such as cold with dry winters (at elevations of 1,700–2,200 m) and moderately warm with evenly distributed precipitation in the lower mountainous areas. The annual solar radiation ranges from 120 to 135 kcal/cm^2 . Depending on oroclimatic conditions, the forest belt exhibits considerable diversity. The most productive forest stands consist of oak-beech, hornbeam-beech, and oak forests. The mountain-forest complex of the Guba administrative district represents an important ecological and economic resource, supporting both the local population and the region's biodiversity.

- Mountain-forest-steppe and meadow-shrub landscapes develop at elevations ranging from 500–600 m to 900–1,100 m. The terrain in these landscapes is relatively gently sloping and slightly dissected. The average annual air temperature varies from 14°C at lower elevations to 6 – 10°C at higher elevations within this range. The average annual precipitation is 300–600 mm [14].

Within these landscapes, the soil-vegetation cover is well developed. Common soil types include residual mountain-brown post-forest soils and mountain-brown forest soils. The vegetation cover mainly consists of oak, hornbeam, ash, hawthorn, dogwood, blackberry, pear, and others, while the herbaceous layer includes feather grass, needle grass, several species of wormwood, and more.

1. Landscape zoning makes it possible to identify areas with uniform natural characteristics such as relief, climate, vegetation types, and soils. Clustering, in this context, groups such areas together to form specialized tourist zones, enabling development that takes their specific features into account. For example, mountain areas and coastal zones may attract different categories of tourists.

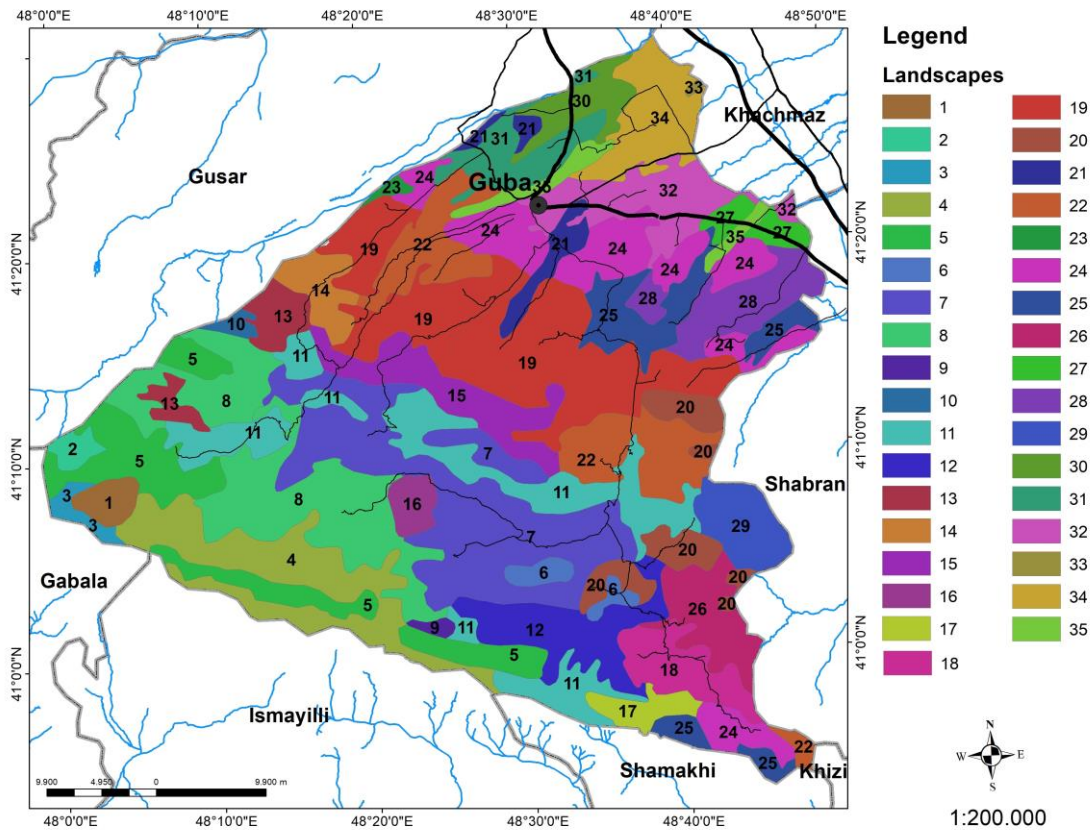


Figure 1. Landscape map of the Guba administrative district

Legend:

I. Nival landscapes

1. Moderately and partially weakly dissected steep slopes of the high mountains with rocky-nival landscapes, lacking soil and vegetation cover.

2. Intensively dissected high-mountain slopes with partial glacial cover, lacking soil and vegetation cover, with actively developing erosion-denudation processes.

II. Subnival landscapes

3. Moderately and weakly dissected, moderately inclined mountain slopes with exposed parent rocks and a disturbed soil and vegetation cover.

4. Strongly and moderately dissected rocky and talus-colluvial mountain slopes, lacking soil and vegetation cover, with patchy development of alpine meadows on rock ledges.

5. Intensively and moderately dissected steep, precipitous, rocky high-mountain slopes with subnival-rocky landscapes, lacking soil and vegetation cover.

III. Alpine meadows

6. Weakly dissected narrow watersheds and gentle mountain slopes with dense turf cover dominated by clover, chamomile, and mixed grasses.

7. Intensively dissected, very steep, sometimes precipitous mountain slopes with alfalfa and clover on eroded mountain-meadow soils.

8. Strongly dissected steep mountain slopes with alfalfa and mixed grasses on eroded mountain-meadow soils.

9. Undissected high synclinal plateaus with clover and mixed grasses on poorly developed eroded mountain-meadow soils located on rock ledges.

10. Strongly dissected rocky slopes with areas of alpine meadows on thin, severely eroded mountain-meadow soils.

11. Moderately dissected steep mountain slopes with alpine vegetation on eroded mountain-meadow soils.

IV. Subalpine meadows

13. Weakly dissected, gently sloping intramontane (basin) plains with alfalfa, savory, timothy grass, and buttercup on turf mountain-meadow soils.

14. Moderately dissected landslide slopes of mountains with alfalfa, savory, and mixed grasses on thin mountain-meadow soils.

15. Moderately dissected, moderately sloping mountain slopes with alfalfa, timothy grass, savory, and buttercup on turf-mountain-meadow soils.

16. Moderately dissected sloping, sometimes steep, stony-talus mountain slopes with subalpine meadows on mountain-meadow turf soils.

17. Moderately dissected, moderately sloping landslide-talus slopes with sparse alfalfa, savory, and grass-mixed herb vegetation on mountain-meadow turf soils.

V. Beech-hornbeam and oak-hornbeam forests of the mid-mountain zone

18. Moderately dissected, moderately sloping mountain slopes with beech-hornbeam and partially oak-hornbeam forests on brown mountain-forest soils.

19. Moderately and weakly dissected, gently sloping terraced slopes of the mid-mountain, partly low-mountain zone, with beech-hornbeam forests on brown mountain-forest and brown soils.

VI. Forests and forest-shrublands of the low-mountain zone

20. Moderately dissected, gently sloping mountain slopes with oak-hornbeam forests and forest-shrublands on mountain-brown soils

21. Weakly dissected landslide-prone river valleys with oak, hawthorn, cornelian cherry, blackberry, and sagebrush-forb vegetation on mountain-brown forest soils.

22. Moderately dissected, moderately sloping mountain slopes with sparse oak, hornbeam, and ash on brown mountain-forest soils.

VII. Forest-steppe, steppe, and meadow-steppe landscapes of the low- and mid-mountain zones.

23. Moderately dissected landslide-prone slopes of intermountain basins with post-forest steppes, barberry and wild rose shrubs, as well as forb vegetation (including sagebrush) on meadow-steppe soils.

24. Weakly dissected landslide-prone slopes with sparse oak-hornbeam forests, shrubs, and forbs on brown mountain-forest soils.

25. Intensively dissected steep slopes with oak-hornbeam forest-shrublands and shrubs of blackberry, wild rose, and thorn on eroded mountain-brown soils.

26. Weakly dissected gentle slopes with sagebrush-beardgrass forb vegetation, and in places oak-hornbeam forest-shrublands, on well-developed dark chestnut soils.

VIII. Arid-denudation landscapes of the low-mountain zone and intermountain basins.

27. Moderately dissected, moderately inclined slopes of the arid-denudation low-mountain zone with forest-shrublands and shrubs of oak, pear, thorn, wild rose, blackberry, and cotoneaster on dark chestnut soils.

IX. Plain arid-forest, forest-shrub, and shrub-steppe landscapes

28. Slightly dissected, gently sloping convex plains with shrubs and wormwood-feather grass steppes on post-forest brown and chestnut soils, heavily transformed into orchard-plantation agro-landscapes.

29. Slightly dissected, gently sloping alluvial-proluvial plains with wormwood-feather grass and forb-shrub dry steppes on steppe-modified brown soils, transformed into orchard-plantation agro-landscapes.

X. Post-forest steppe landscapes of denudation-accumulation plains

30. Strongly dissected elevated plains with wormwood-grass steppes and shrub thickets of blackberry and wild rose on mountain-brown soils.

31. Slightly dissected elevated plains with oak, wild rose, blackberry, and shrub thickets on mountain-brown soils.

32. Slightly dissected, gently sloping accumulative plains occupied by shrub steppes on alluvial-meadow and meadow-forest soils.

33. Slightly dissected, gently sloping accumulative plains with post-forest steppes and shrubs on alluvial-meadow and meadow-forest soils.

34. Undissected flat plains and alluvial fan surfaces with shrub and meadow-steppe vegetation on alluvial-meadow soils.

XI. Intrazonal landscapes of accumulative plains.

35. Moderately dissected river terraces with meadow-swamp vegetation on alluvial-meadow soils.

2. Defining functional zones and their intended use. Landscape zoning using a cluster-based approach simplifies the process of identifying functional zones (recreational areas, resort zones, nature parks, etc.). This is important for developing tourism products that are integrated into the natural environment without causing significant disturbance. Each cluster can be specifically adapted for a certain type of tourism, ranging from ecological to active recreation [7]. This approach enables functional zoning that takes into account both ecological and cultural features.

3. Considering resilience and load capacity of landscape complexes. The cluster-based approach in landscape zoning helps assess the ecological capacity of different areas and establish limits of use, thereby minimizing the impact of tourism on landscapes. Using clusters allows for a more accurate determination of which territories can withstand intensive use and which should be protected from mass tourism.

4. Promoting the development of landscape tourism and recreation. Landscape zoning using clusters facilitates the creation of recreational areas that incorporate diverse natural and cultural elements, providing tourists with unique experiences. For example, routes can be designed to connect different clusters, offering visitors immersion in various types of landscapes within a single trip. This approach makes it possible to provide diversity while reducing the load on any particular site.

5. Conservation and management of natural heritage. Clusters make it possible to identify and designate areas of high natural value that require a special approach to management and preservation. This is particularly relevant in regions where landscapes contain rare or unique ecosystems, landscape monuments, or important natural sites. The use of environmentally friendly technologies in the construction of hotels and tourist infrastructure can minimize environmental impact. The application of solar panels, waste recycling systems, and water-saving technologies will con-

tribute to the sustainable development of the region.

The cluster diagram represents a scheme reflecting the interrelationships between the main directions of landscape zoning for tourism purposes (Figure 2). Each cluster denotes a distinct thematic area, which integrates with others through shared tasks, goals, and methods aimed at the sustainable development of the region.

Criteria and methods form the foundation for both scientific and practical analysis, defining approaches to zoning territories based on their geographic, ecological, and resource characteristics. These methods are closely linked to the fundamental principles of landscape zoning, which include the objectives and theoretical basis for analyzing the natural and cultural features of areas. The theory, in turn, is supported by practical examples, enhancing its applied significance.

Mass tourism, with its impact on natural and cultural sites, creates challenges such as conflicts and climate change. Overcoming these issues requires legal regulation to ensure the sustainability of the industry. The local population plays a crucial role in this process, as their involvement in management and planning allows for more

An important aspect is anthropogenic landscapes, which demonstrate the impact of human activity on nature. These correspond with the

typology of tourist landscapes, including natural, mixed, and human-altered zones, thus opening opportunities for their use in tourism.

Historical and cultural heritage holds significant value for tourism, as sites of historical and cultural importance become key attractions. This direction is closely linked to ecotourism, which promotes the conservation of natural resources and is especially relevant for areas with high biodiversity.

The successful development of tourism is impossible without high-quality infrastructure, including roads, recreational areas, and hotels. Infrastructure ensures the accessibility of territories and their comfortable use, which is an important condition for the successful implementation of tourism initiatives.

The Guba administrative district, endowed with unique natural and cultural resources, encompasses all the aforementioned aspects. This region has the potential to develop as a tourism hub, including mass, cultural, and ecological types, which underscores the importance of a comprehensive approach to its development.

Thus, all clusters are interconnected through a common goal - the creation of a sustainable tourism system that takes into account natural, cultural, and social factors, ensuring the harmonious development of the region.

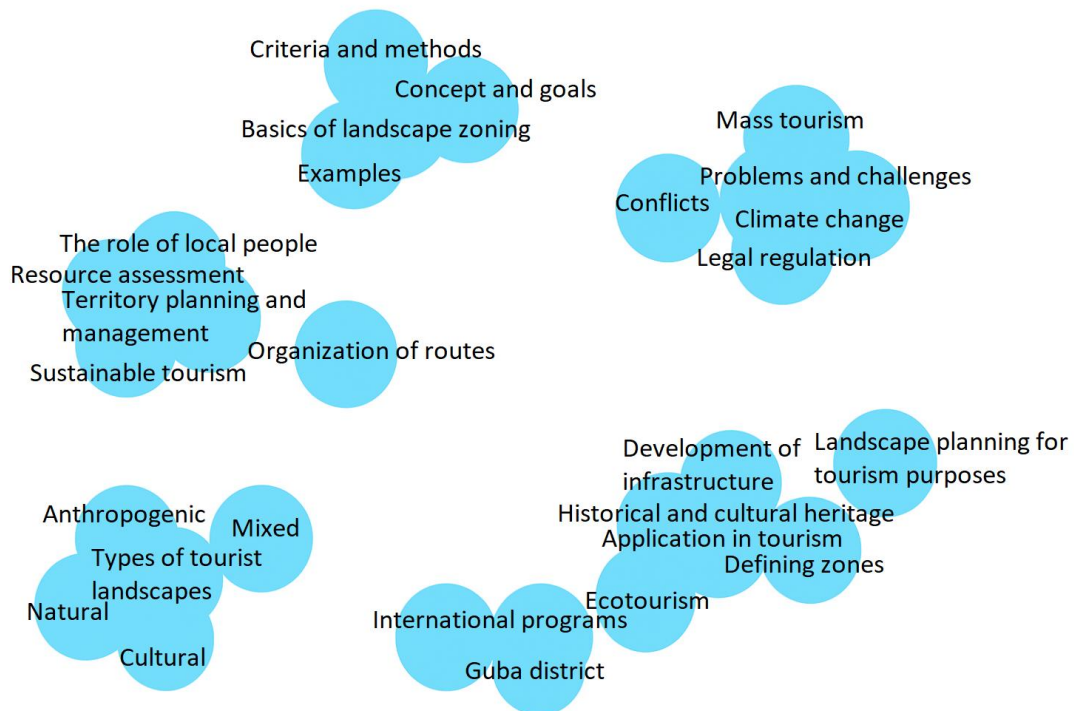


Figure 2. Cluster-based landscape zoning for tourism purposes

Table 1

Classification of zones of the Guba district by tourism potential

Cluster	Altitude above sea level (m)	Average annual temperature (°C)	Precipitation (mm)	Vegetation type	Tourism and recreational potential
1	200-500	10-15	300-400	Floodplain meadow-steppe	Water tourism, hiking
2	500-1000	10-15	400-600	Forest-steppe	Ecotourism, cycling routes
3	600 (800)-1800 (2200)	2-10	600-800	Forests and shrubs	Active tourism (trekking)
4	1800-3000	-5-0	600-1000	Subalpine and alpine meadows	Ecotourism, mountaineering, skiing
5	3000+	-10-5	600-900	Subnival-nival zones	Extreme tourism (ski touring)

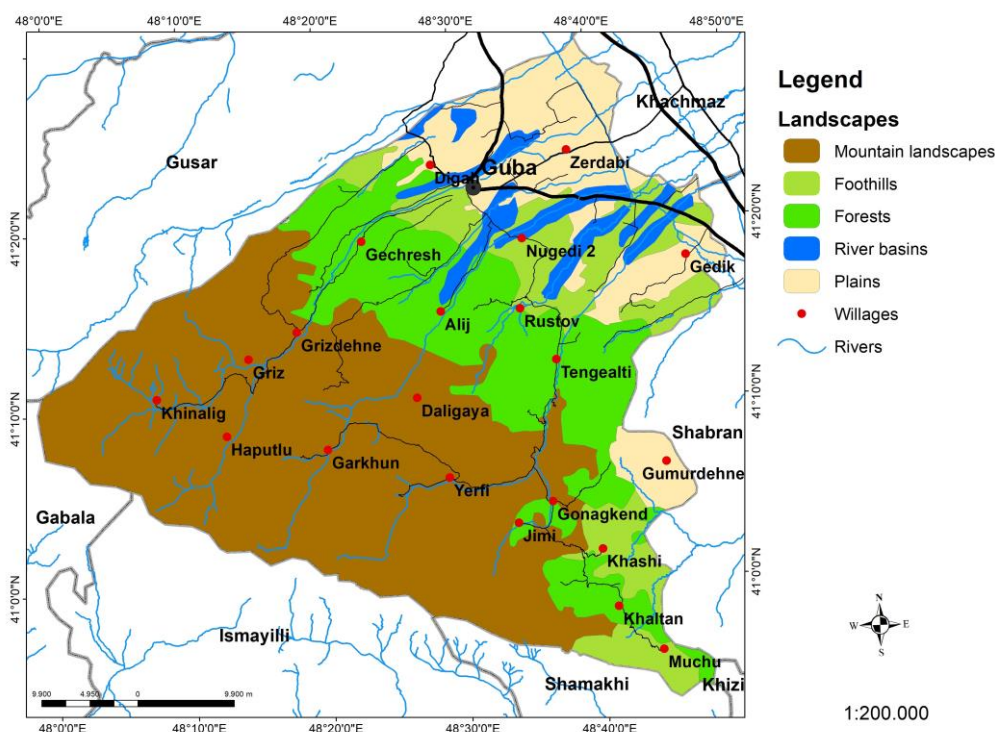


Figure 3. Map-scheme of landscape and tourism zoning

Landscape zoning is a key tool for identifying the potential of territories and ensuring the sustainable development of tourism. This approach makes it possible not only to determine the most promising directions for tourism but also to minimize possible negative impacts on ecosystems. It contributes to the effective planning of natural resource use and the development of infrastructure that fits harmoniously into the natural environment while meeting the needs of tourists. Based on landscape zoning, a map of the Guba district was created, assessing the tourism potential of various areas. This map (Figure 3) clearly illustrates zones with diverse tourism

opportunities and the necessary measures for their sustainable development.

1. Mountain landscapes with ecotourism potential

High-mountain areas featuring alpine and subalpine meadows, rocky peaks, and steep gorges. Suitable for ecotourism, hiking, rock climbing, mountain ascents, and wildlife observation.

Infrastructure: Accessibility may be limited; development of trails, campsites, and informational signage is required.

2. Foothill zones with recreational opportunities

Mid-altitude landscapes combining forests, meadows, and hills, with gentler slopes and mod-

erate climatic conditions. Suitable for family recreation, picnics, camping, cycling tours, and photo tours.

Infrastructure: Requires camping areas, recreational zones, designated picnic sites, and cycling routes.

3. Forest zones for wellness and educational tourism

Dense deciduous forests of oak and beech-hornbeam trees, rich in flora and fauna, with a mild climate. Suitable for wellness retreats, ecological excursions, forest hikes, and berry and mushroom picking.

Infrastructure: Development of eco-trails, signage, small observation decks, and areas for meditation or yoga is needed.

4. Floodplain zones for water-based and rural tourism

Areas along rivers featuring floodplain meadows, lakes, and small water bodies, with fertile soils and marshy sections. Suitable for water recreation, fishing, rural tourism, and bird-watching.

Infrastructure: Requires camping facilities, boat rentals, birdwatching platforms, and farm zones for visitors.

5. Valley zones for agritourism and cultural recreation

Valleys between foothills and mountains featuring agricultural lands with orchards, vineyards, and fields. Suitable for agritourism (visiting farms), excursion tourism (harvest festivals), and ethnotourism.

Infrastructure: Requires the development of agritour routes, tasting areas, ethno-cultural centers, and signage.

This zoning allows for the identification of key areas for tourism development based on the natural and landscape features of the Guba district. However, to achieve sustainable development of tourism potential, it is essential to consider ecological and economic aspects of the tourism sector. Protecting ecosystems is necessary to maintain the natural balance and preserve biodiversity. The design of tourism infrastructure must take ecosystem sustainability into account. For example, in high-mountain areas, it is important to minimize the impact on soil and vegetation by using methods such as building trails with natural materials and creating restricted access zones to allow ecosystem recovery.

4. Conclusion

Landscape zoning of the Guba district using a cluster-based approach enables the identification of zones homogeneous in natural characteristics

and the creation of effective tourist routes based on them. This approach fosters a deeper understanding of the region's natural diversity and allows for the development of strategies aimed at sustainable tourism development, focused on minimizing ecological risks and preserving biological diversity.

The results of the conducted study confirm the high importance of landscape zoning for optimizing the tourism resources of the Guba administrative district. The identified landscape clusters provide opportunities for targeted development of tourism infrastructure, including ecotourism and active recreation, which can significantly enhance the region's attractiveness to tourists. However, realizing this potential requires the implementation of innovative approaches in planning and natural resource management, including the active involvement of the local population in the tourism development process. Sustainable use of natural resources, based on scientific methods and modern technologies, will ensure not only economic growth but also the preservation of the unique natural and cultural heritage of the Guba district.

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QUBA RAYONUNUN LANDŞAFT RAYONLAŞDIRILMASI: TURİZM POTENSİYALINA KLASTER ƏSASLI YANAŞMASI

S.T. Kazımova

Xülasə. Təqdim olunan məqalədə Azərbaycanın Quba rayonu ərazisində turizm-rekreasiya potensialının landşaft rayonlaşdırılması araşdırılır. Ərazinin təbii və mədəni sərvətlərinin zənginliyi nəzərə alınaraq, tədqiqat işində klaster yanaşması və Coğrafi İnformasiya Sistemlərindən (CİS) istifadə edilməklə turizm infrastrukturunun inkişafı üçün perspektivli sahələr müəyyən edilmişdir. Bu zaman, əsas məqsəd kimi Quba rayonunun təbii landşaftları təsnif edilərək onların müxtəlif turizm növlərinin inkişafı üçün istifadəsinin optimallaşdırılması yolları verilir. Tədqiqatın nəticəsi göstərir ki, ərazilərin səmərəli planlaşdırılması və idarə olunması turizmin davamlı inkişafına, eləcə də yerli sakinlərin həyat keyfiyyətinin yaxşılaşdırılmasına töhfə verə bilər.

Açar sözlər: landşaft rayonlaşdırılması, turizm-rekreasiya potensialı, ekoturizm, Coğrafi İnformasiya Sistemləri, klaster, aktiv istirahət.

THE EFFECT OF WIND EROSION ON THE DESERTIFICATION PROCESS IN THE ABSHERON PENINSULA

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Abstract

Climate change, land cover degradation, anthropogenic impacts, and the improper management of agricultural lands contribute to the intensification of wind erosion. This process is particularly dangerous for the Absheron Peninsula, which is located within the semi-arid dry steppe climate zone. Wind erosion leads to the loss of the fertile soil layer, degradation of vegetation cover, disruption of the water balance, and consequently, a decline in agricultural productivity, which in turn results in serious economic and ecological consequences. Therefore, the study of the causes, scale, and mitigation measures of wind erosion constitutes one of the main directions in combating desertification. For this purpose, the NDMI (Normalized Difference Moisture Index) map was generated using 2024 Landsat 8–9 OLI/TIRS C2 L2 multispectral imagery. Additionally, based on 2015 and 2023 Landsat 8–9 OLI/TIRS C2 L2 multispectral images, “Land Cover and Land Use” maps were created, along with a map of the average wind speed in the Absheron peninsula. As a result, the number of windy days, wind speed, soil granulometric composition, and soil moisture were determined; the areas with different land cover types were calculated; the regions with intense wind erosion were identified; and the development of the desertification process was assessed.

1. Introduction

The rapid increasing in temperature on the earth, including the increase in hurricanes, floods has drawn the attention of countries of the world to the investigation of the causes of global warming and the preparation and implementation of a plan of measures against it. It is noticeable that climate changes, especially the process of desertification, manifests itself sharply in the Absheron peninsula, characterized by a semi-desert dry-desert climate type, with hot-dry summers and mild winters, not bypassing the Republic of Azerbaijan. In this regard, it is no coincidence that the Conference of the Parties to the UN Framework Convention on Climate Change or Cop29 is held in Azerbaijan.

Determining the intensity of wind erosion, which is one of the most characteristic factors affecting the desertification process, for the Absheron Peninsula, as well as investigating the causes of wind erosion, is one of the objectives. The increase in wind erosion not only results in the blowing away of the upper fertile layer of the

soil, but also causes the spread of soil contaminated with salt and radioactive substances to the surrounding areas.

2. Material and method

Maps were drawn using ArcGis 10.8 software using various base data taken from the National Atlas of Azerbaijan Republic, and factors such as average wind speed, soil cover and texture, soil moisture, and land cover that affect wind erosion were investigated. Using Landsat 8-9 OLI/TIRS C2 L2 multispectral images for the first 5 days of April 2024, the NDMI map of the area was drawn up based on the ratio of NIR and SWIR values and calculated using the following formula.

$$\text{NDMI} = (\text{NIR} - \text{SWIR}) / (\text{NIR} + \text{SWIR}) \quad (1)$$

$$\text{NDMI} = (\text{B05} - \text{B06}) / (\text{B05} + \text{B06}) \quad (2)$$

Based on Landsat 8-9 OLI/TIRS C2 L2 multispectral images for the first 10 days of April for 2015 and 2023, “Land cover and land use” maps were compiled. Areas of territories with different land cover were calculated by controlled decoding of space images from 2015 and 2023.

By comparing these data, the development of wind erosion, including the desertification process, was determined. In addition, the basic materials of the Global Wind Atlas were vectorized in ArcGis 10.8 software, and the “Average wind speed in the Caspian coastal plains” map was drawn up.

3. Analysis and discussion

Wind erosion is a chain of events that causes soil particles to be entrained, transported, and finally deposited as a result of the interaction of wind with the soil surface. Erosion is considered when the wind speed reaches 6 m/s at a height of 0.3 m above the ground surface and 8 m/s at a height of 9 m above the ground surface. Wind causes deflation in light soils at a speed of 10 m/s and more [5].

The high wind speed in the area and the large number of windy days create conditions for the

occurrence of wind erosion. The number of days with strong winds reaching 15 m/sec in the Absheron Peninsula area has reached 139, as well as the average monthly wind speed at meteorological stations is higher in the summer months, which leads to further drying of the soil surface that has lost moisture and acceleration of the deflation process. (Table 1).

According to the map “Average wind speed in the Caspian coastal plains (Absheron Peninsula)” in the mountains of Baku ears (383.8 m), Deghdovlar (234.7 m), Khanedan (209.3), Nishanga (243 m), Ulugaya (178.6 m), Bozdag volcano (309 m) and from there to the mountain of Deveboynu (271.8 m), Osman Bozdag volcano (392.1 m) and in the areas northwest of this volcano the average wind speed reaches 9-12 m/s. The average wind speed decreases from 8-9 m/s to 6-7 m/s as we go east and west from these areas.

Table 1

Average monthly wind speed, m/s [10]

Meteorological station	Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Baku	1999	4,0	3,8	4,4	4,2	5,1	5,0	5,0	5,2	4,8	4,8	3,8	4,8	4,6
	2000	3,8	3,7	4,6	3,8	4,1	4,7	4,7	5,5	5,0	4,0	3,9	3,9	4,3
	2001	3,6	5,2	4,4	3,8	4,0	3,4	3,4	5,5	4,8	3,6	3,1	2,9	4,1
	2002	3,5	3,7	3,5	5,6	3,0	3,6	3,6	3,3	4,3	4,3	4,7	3,5	4,1
	2003	4,0	4,1	4,1	4,2	3,6	4,0	4,0	4,8	4,8	4,0	4,5	3,7	4,3
Sumgayit	1999	4,5	4,3	5,1	4,6	5,7	5,1	5,1	6,4	6,0	6,0	5,2	5,7	5,4
	2000	5,0	4,9	6,0	4,5	5,7	5,8	5,8	6,7	6,4	5,6	5,5	5,9	5,6
	2001	6,1	6,5	5,3	4,6	5,2	3,8	3,8	6,8	5,9	4,6	5,3	5,2	5,3
	2002	5,8	6,4	6,1	5,9	4,0	3,1	3,1	3,7	5,0	6,9	7,8	6,4	5,6
	2003	5,7	6,5	4,7	5,0	4,1	4,8	4,8	5,5	6,3	5,6	8,2	5,1	5,6
Mashtaga	1999	4,1	4,0	3,8	3,9	4,6	3,7	3,7	3,8	4,0	4,2	3,6	4,0	4,0
	2000	3,8	3,6	4,3	3,8	3,8	3,7	3,7	3,6	4,6	3,7	3,6	3,9	3,9
	2001	3,8	5,2	3,1	3,0	3,4	1,9	1,9	3,7	3,6	2,3	2,3	2,7	3,2
	2002	3,4	3,8	3,2	4,6	2,5	2,5	2,5	2,7	3,5	3,7	5,1	3,1	3,5
	2003	4,4	4,2	4,2	3,8	3,2	3,9	3,9	4,1	5,1	3,7	4,5	3,8	4,2

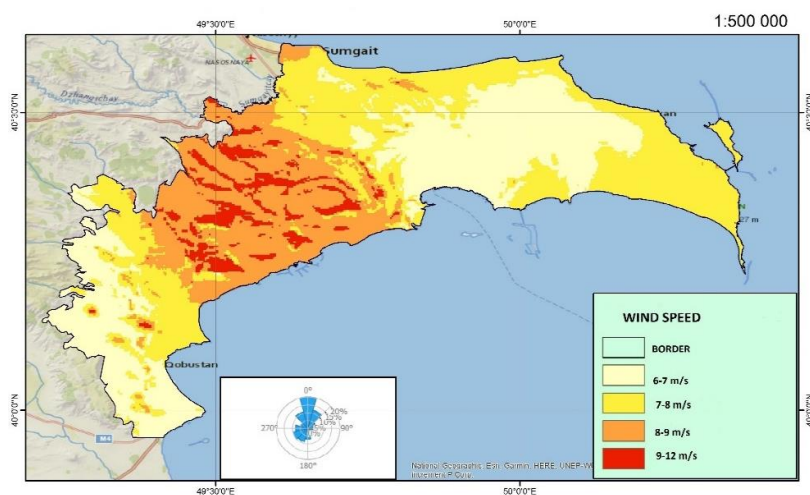


Figure 1. Wind speed in the Absheron peninsula [9]

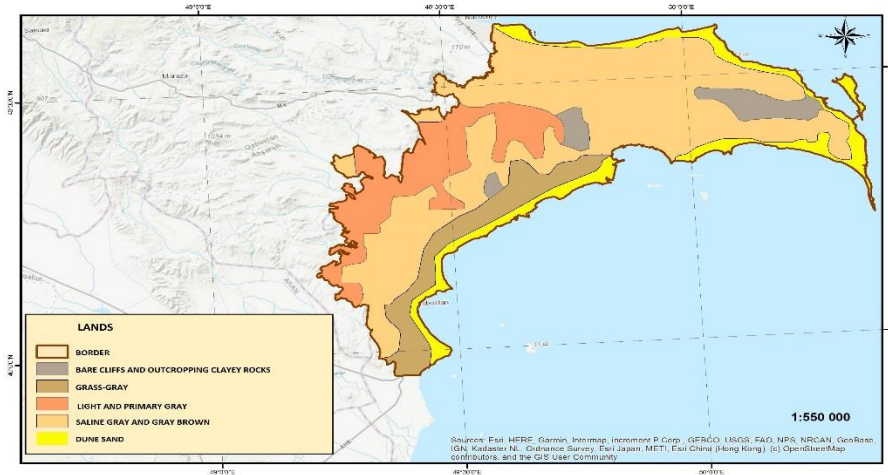


Figure 2. Lands of the Caspian coastal plains [7]

In the northwestern part of the Absheron peninsula, Haji Isa mountain (452 m) and around it, the wind speed from northwest to southeast reaches 9-12 m/s. At the same time, the wind speed reaches the highest level in Absheron in the direction of Bayanata (588 m), Sungurdag (673 m).

There are favorable conditions for the intensification of wind erosion in the areas listed above, where the wind speed reaches 9-12 m/s. The high wind speed not only results in the blowing away of the top fertile layer of the soil, but also causes the spread of soil contaminated with radioactive substances and heavy metals over large areas.

Soil surface conditions. Soil properties can change rapidly due to weather events, tillage and other management operations. This includes properties such as bulk density and dry aggregate size distribution. If the size of the soil aggregates is larger than 1mm, it is almost not subjected to deflation.

Soil texture is the most important soil property affecting the susceptibility of soil to wind erosion. In areas located in the eastern parts of Absheron, such as Kurdakhani, Buzovna, Corat and Mastaga the sand layer with a coarse texture and easier erodibility is 50 sm thick and is replaced by clayey soils in the lower layers[1].

In the area of Sumgayit and Haji Zeynalabdin settlements, sand-fish ear piles occupy a large area. In recent years, the retreat of the Caspian Sea has resulted in the expansion of the coastal sand dunes. The sand duneus running parallel to the coast from Corat to Gilazi are in some parts cut by piles of limestone that have come out from under the sea. Sand piles are in semi-solid and moving forms and are intensively exposed to wind erosion. Due to the lowering of the underground wa-

ter level, these sand piles become dry and more erodible [8].

The gray and gray-brown soils that cover a large area in the Boghaz plain, including the western and eastern parts of Absheron, are light and medium gritty, characterized by an abundance of CaCO₃, and are subject to foaming when acid is applied to them. The abundance of lime in these soils facilitates erosion. Gray-brown saline soils are clayey according to their mechanical composition, the amount of physical clay in their content reaches 70-75% [8]. Although the mechanical composition of the soils spread over the area is clayey, it weakens the intensive course of the erosion process, but the abundance of CaCO₃ in the soil creates conditions for the intensity of this process.

Soil moisture-sand-sized material with a gravimetric moisture content greater than 5% is resistant to erosion by most natural winds.

According to the NDMI map of the Caspian coastal plains along the shores of the Absheron Peninsula, the moisture supply index of the eastern parts of the area is -0.02-0.4, which is considered more satisfactory than the western parts.

In the western parts, this indicator varies between -0.5 and -0.06 and is characterized by a very low supply of moisture, and a sharp lack of moisture in these areas leads to the intensification of the erosion process due to the influence of the winds blowing in the summer months.

The roughness of the surface, rocks, plants on the surface, as well as microrelief are factors that cause wind erosion. The roughness created during plowing protects the soil surface from the impact of erosive particles by reducing the effect of the cross section of the wind [4].

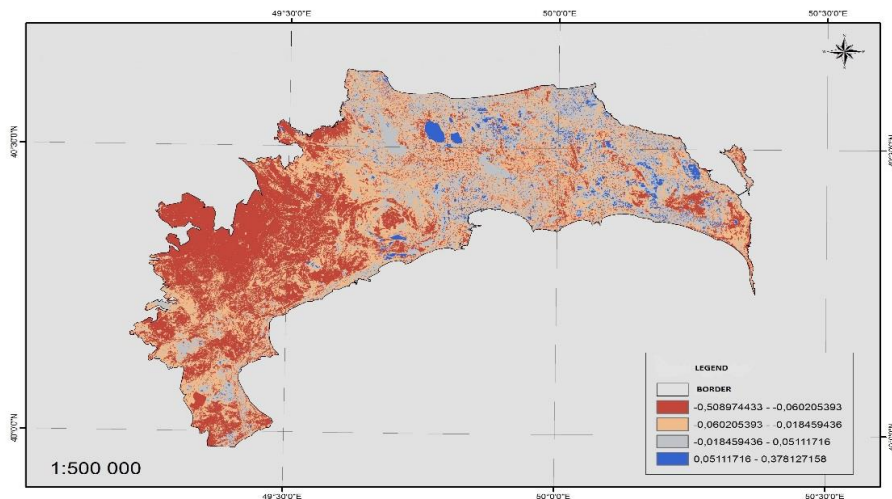


Figure 3. The NDMI map

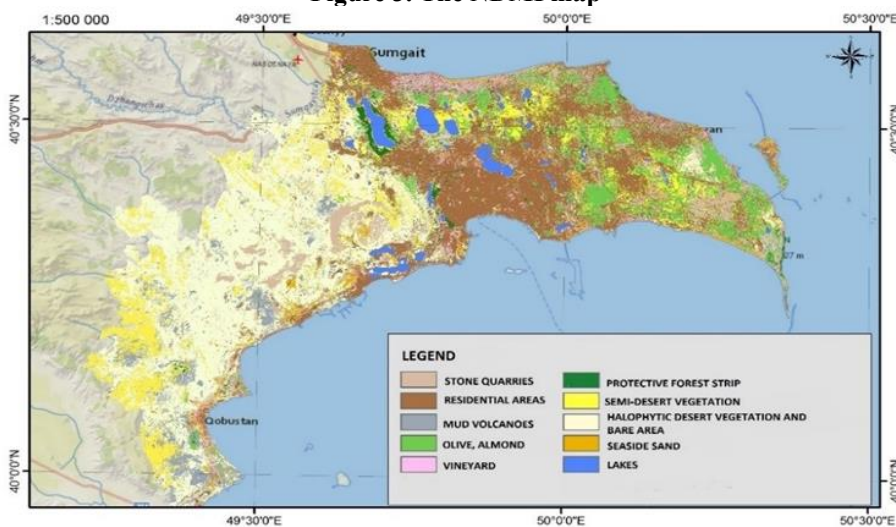


Figure 4. Land cover and land use map of the Caspian coastal plains-2015

Based on the maps prepared with reference to Landsat 8 images of April 2023 and Landsat 8 images of April 2015, it can be determined that there is a decrease in the area of naturally distributed vegetation in the coastal plains of the Absheron Peninsula of the Caspian Sea.

As a result of the analysis of these maps, it was determined that the area of desert vegetation with halophytes and bare areas decreased from 889.86 km² to 855.18 km² and the area of semi-desert vegetation with wormwood decreased from 294.37 km² to 258.91 km². The observed decrease in the area of halophytic desert vegetation and barren areas is due to the increase in the area of semi-desert vegetation with wormwood in the western part of the coastal plains of the Absheron Peninsula and stone quarries. The area of stone quarries has increased from 161.9 km² to 170 km² in the corresponding years, which naturally results in the bareness of the area. The largest deposits of stone quarries on the territory are located in Zigh,

Zira, Nardaran, Mashtaga, Garadag, Guzdek areas, which make up 37% of stone quarries in the country. The main deposits of construction sand are located in the Kirmaki valley near the villages of Duvanni and Balakhani. After the use of stone and sand quarries in the Caspian coastal areas, the pits created in those areas are flooded, resulting in the creation of lake-marsh hydromorphic landscapes [3].

In general, the reason for the decrease in the area of semi-desert vegetation here is due to the increase in the area of olive and almond gardens in the eastern parts of Absheron. This change in the distribution area of the natural vegetation of the area means that there are favorable conditions for wind erosion to go intensively in the western and central parts of Absheron region. At the same time, the area of the lakes in the area decreased from 68.83 km² to 67.66 km², which in turn is one of the indicators of the desertification process.

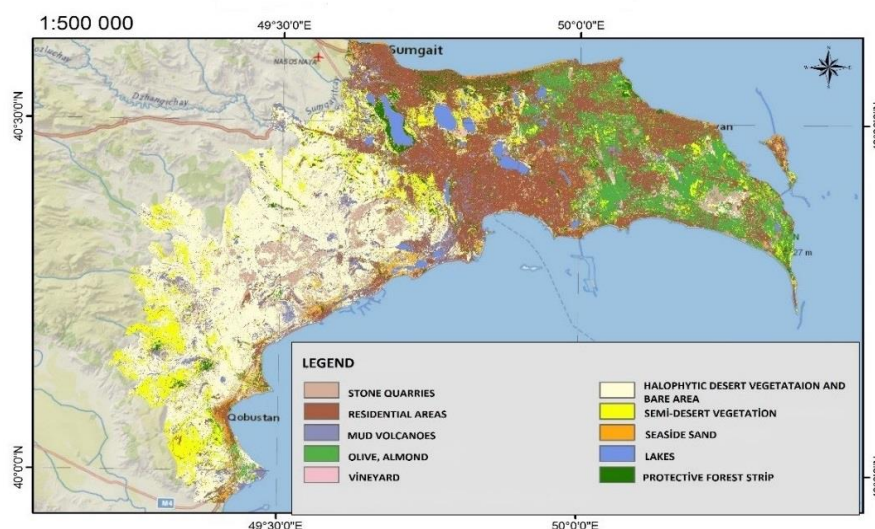


Figure 5. Land cover and land use map of the Caspian coastal plains-2023

Table 2

Land cover and land use

Land cover		Area (km ²)	
		2015	2023
1	Stone quarries	161,89	169,98
2	Residential areas	644,44	693,56
3	Mud volcanoes	139,59	133,45
4	Olive, almond	244,35	300,45
5	Vineyard	83,83	27,35
6	Halophytic desert vegetation and bare areas	889,86	855,18
7	Semi-desert vegetation with wormwood	294,37	258,91
8	Seaside sand dunes	74,83	60
9	Lakes	68,83	67,66
10	Protective forest strips	33,26	71,79

Strong winds characteristic of the area weaken their activity in the parts of the soil surface densely covered with vegetation, but in sparsely vegetated areas, pomegranate particles of the soil, including large pieces of sand, are blown away and carried to other surrounding areas. In areas with intensive wind erosion, the humus-rich upperwell-structured layer of the soil destroyed, so the amount of nutrients in the soil decreases and its fertility decreases [6].

Mud volcanoes are one of the natural factors that have a negative impact on the degree of vegetation cover in the Absheron region. As a result of periodic eruptions of mud volcanoes in the area, volcanic breccia takes a fan-shaped shape and spreads over several kilometers, and the thickness of volcanic breccia usually reaches 10-12 m. The high volume of solid volcanic material discharged by volcanoes to the surface is confirmed by the following indicators: Ayrantoken-2.4 billion.m³,

Otmanbozdag-1.2 billion.m³, Kenizdag-735 million m³ [2].

The presence of salt in mud volcano materials result in soil salinization. B. A. Klopotovskiy (1940) shows that the mud of old volcanoes is formed late in the deep layers due to the leaching process of salts.

According to V. V. Akimtsev (1957), rotting-sulphate soils are formed on such piles. From H. A. Aliyev's (1948) studies, it is known that mud volcano materials contain 2-10% water-soluble salt [8].

According to the "Land Cover and Land Use" maps of 2015 and 2023, when comparing the areas covered by mud volcano products, it can be observed that the area of these areas has decreased from 139.59 km² to 133.45 km². This is due to the replacement of those areas with bare ground cover and halophytic desert vegetation. In general, the eruption of mud volcanoes in the western parts of Absheron affects the devegetation, bareness of the

area, including salinization, and as a result, it affects the wind speed and the increase of wind erosion.

In arid and semi-arid regions, insufficient and irregular rainfall, excessive evaporation due to high temperatures, and low humidity due to strong winds. On the Absheron Peninsula, the summer is hot and dry, and the soil is not supplied with sufficient moisture. High temperature evaporates the moisture and results in drying of the soil from the top. High temperature evaporates the moisture and results in drying of the soil from the top. The top part of the fragile, exposed soil, devoid of vegetation, is dispersed by the action of strong winds and transported to other areas.

4. Conclusion

1. In the mountains of Baku ears (383.8 m), Degdovlar (234.7 m), Khanedan (209.3 m), Nishanga (243 m), Ulugaya (178.6 m), Bozdag volcano (309), where the average wind speed reaches 9-12 m/s and from there towards the mountain of Devaboyunu (271.8 m), Osman Bozdag volcano (392.1 m) and the areas northwest of this volcano have favorable conditions for strong wind erosion. At the same time, the number of days with strong winds reaching 15 m/sec on the peninsula indicates the intensity of this process.

2. The soils of the Caspian coastal plains (along the Absheron Peninsula) have a sandy and clayey texture, and while sandy soils are easily eroded, this process is accelerated by the presence of CaCO in the clayey soils.

3. As a result of the NDMI analysis, it is determined that the moisture supply of the eastern parts of the peninsula is more satisfactory than the western coastal plains. Indicators of moisture supply are -0.02-0.4, respectively it varies from -0.5 to -0.06.

Based on the "Land Cover and Land Use" maps compiled for 2023 and 2015, it can be determined that the area of naturally distributed vegetation is observed in the coastal plains of the Absheron Peninsula of the Caspian Sea. Thus, the area of halophyte desert vegetation and barren areas is from 889.86 km² to 855.18 km², and the area of semi-desert vegetation with wormwood is from 294.37 km² to 258.91 km², the area of lakes is 68.83 km² to 67.66 km², while the area of mud volcanoes it decreased from 139.59 km² to 133.45 km² and the area of stone quarries increased from 161.9 km² to 170 km². As a result of the analysis of these indicators, it is determined that the process of wind erosion and desertification is intensive in the area.

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ABŞERON YARIMADASINDA KÜLƏK EROZİYASININ SƏHRALAŞMA PROSESİNƏ TƏSİRİ

G.Ə. Həsənova

Xülasə. İqlim dəyişikliyi, torpaq örtüyünün deqradasiyası, antropogen təsirlər və əkinçilik sahələrinin düzgün idarə olunmaması külək eroziyasının güclənməsinə səbəb olur. Yarımsəhra quru çöl iqlim tipində yerləşən Abşeron yarımadası üçün xüsusilə təhlükəli olan bu proses torpağın münbit qatının itirilməsi, bitki örtüyünün zədələnməsi, su balansının pozulması və nəticədə kənd təsərrüfatı məhsuldarlığının azalması ilə nəticələnir ki, bu da həm iqtisadi, həm də ekoloji baxımdan ciddi nəticələr doğurur. Ona görə də külək eroziyasının səbəblərinin, miqyasının və qarşısının alınma yollarının araşdırılması səhralaşmaya qarşı mübarizənin əsas istiqamətlərindən biridir. Bu məqsədlə 2024- aid Landsat 8-9 OLI/TIRS C2 L2 multispektral görüntülərdən istifadə edərək NDMI xəritəsi, 2015 və 2023-cü illər üzrə Landsat8-9 OLI/TIRS C2 L2 multispektral görüntülərinə əsasən "Torpaq Örtüyü və Torpaq Örtüyündən İstifadə" xəritələri və "Abşeron yarımadasında küləyin orta sürəti" xəritəsi tərtib edilmişdir. Nəticədə ərazidə olan küləkli günlərin sayı, küləyin sürəti, torpağın qranulometrik tərkibi, torpağın nəmliyi müəyyən edilmiş, müxtəlif səth örtüklərinə malik ərazilərin sahələri hesablanmış, külək eroziyasının intensiv getdiyi ərazilər aşkar olunmuş və səhralaşma prosesinin inkişafı müəyyən edilmişdir.

Açar sözlər: külək eroziyası, səhralaşma prosesi, küləkli günlər, NDMI analizi, səth örtüyündən istifadə.

HUMAN GEOGRAPHY

APPLICATION OPPORTUNITIES OF THE CLUSTER MODEL IN THE CONSTRUCTION MATERIALS INDUSTRY: IN THE CONTEXT OF THE INDUSTRIAL GEOGRAPHY OF THE BAKU AND ABSHERON-KHIZI ECONOMIC REGIONS

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Abstract

The article provides a scientific analysis of the necessity of applying the cluster model in the spatial organization and development of the construction materials industry within the Baku and Absheron–Khizi economic regions, which are among the leading industrial centers of the Republic. The study focuses on identifying the formation and development opportunities of construction materials clusters in the Garadagh administrative district of the Baku economic region and the city of Sumgayit in the Absheron–Khizi economic region. The research results reveal that strengthening mutual integration and cooperation among industrial enterprises, research institutions, service sectors, and other related structures plays a crucial role in enhancing the efficiency of the construction materials industry. The analysis of international cluster practices in the construction materials sector indicates that the Garadagh district and the city of Sumgayit in the Absheron region possess the highest industrial potential for establishing such a cluster model.

1. Introduction

In the modern era, the sustainable development of the construction materials industry necessitates the strengthening of interrelations between industrial sectors, research institutions, and machinery manufacturing enterprises. The *State Program for the Development of the Construction Materials Industry for the Period up to 2020 and for the Future until 2030*, adopted in Russia in 2016, emphasized that the weakening of linkages among machine-building, production sectors, and research centers had significantly slowed down the pace of industrial growth [17]. Consequently, since 2016, the cluster-based approach has been introduced in Russia's construction materials industry to restore these interconnections.

A similar situation has been observed in the Republic of Azerbaijan, where during the Soviet period, the existing scientific and industrial cooperation played a crucial role in advancing the development of the construction materials industry. Therefore, the formation of clusters in this sector, along with the restoration of technological, eco-

nomical, and innovative linkages among production enterprises, machine-building plants, and service sectors, represents an important and timely priority for the country's industrial development.

The main aim of the research is to optimize the spatial structure of industrial enterprises by taking into account the economic potential of economic regions, as well as to enhance the efficiency of the sector through the restoration of linkages between research institutions and production facilities.

The objectives of the research are to analyze the current state of cooperation between manufacturing enterprises, service sectors, the machinery industry, and research institutions; to substantiate the advantages of the cluster approach; and to develop strategic recommendations aimed at promoting regional development.

2. Materials and methods

From a methodological perspective, the study employs a comparative-geographical approach, drawing on the experience of structural transformations and clustering processes carried out in Russia's industrial sector since 2016. In addition,

based on the analysis of various statistical and empirical data, general conclusions were derived. To present different conceptual approaches to clustering, several research methods were applied, including the analytical-synthetic method, descriptive statistical analysis, sectoral–structural analysis, and other complementary methodological tools.

3. Analysis and discussion

In recent years, the spatial organization of the construction materials industry in many developed countries has been shaped by new trends. Within this framework, the establishment of “Construction Materials Clusters” is considered one of the key innovations in the industrial sector.

There is no universally accepted definition of the term *cluster*. In 1990, Michael Porter introduced the concept of the “cluster” into economic science, defining it as “a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities” [4]. It should be noted that in some countries, clusters consist of enterprises representing the same industrial sector, while in others, they include enterprises with diverse functions and purposes [15].

An analysis of industrial clusters in modern countries such as Germany, Russia, Georgia, and Turkey reveals that clusters represent a set of interrelated enterprises and organizations located within a specific geographic area that cooperate closely and generate mutual economic benefits.

In the Republic of Azerbaijan, the issues of establishing and developing industrial clusters are extensively addressed in the *State Program on the Development of Industry for 2015–2020* and in the *Strategic Roadmaps for the National Economy and Key Sectors* [16]. The *Strategic Roadmap* emphasizes that industrial parks, estates, and technoparks cannot be considered fully-fledged clusters, as they do not possess all the fundamental characteristics of clustering. These areas are primarily limited to technological linkages covering different stages of production, while economic integration among participants remains weak [1].

However, in a genuine industrial cluster, at least ten enterprises should participate, including a final product manufacturer, and each of the other enterprises must consume at least 50% of the products or services produced by one or more of the cluster participants. Therefore, the main distinguishing feature of clusters lies in the simultaneous existence of both technological and economic interconnections.

It should be noted that since 2016, significant progress and clustering processes have been observed in the field of construction materials production in Russia. At present, there are more than 150 clusters across the country, encompassing over 2,000 enterprises. Among them, the Volgograd Construction Materials Production Cluster, which brings together 10 member enterprises, is considered one of the most successful examples of an industrial cluster in this sector.

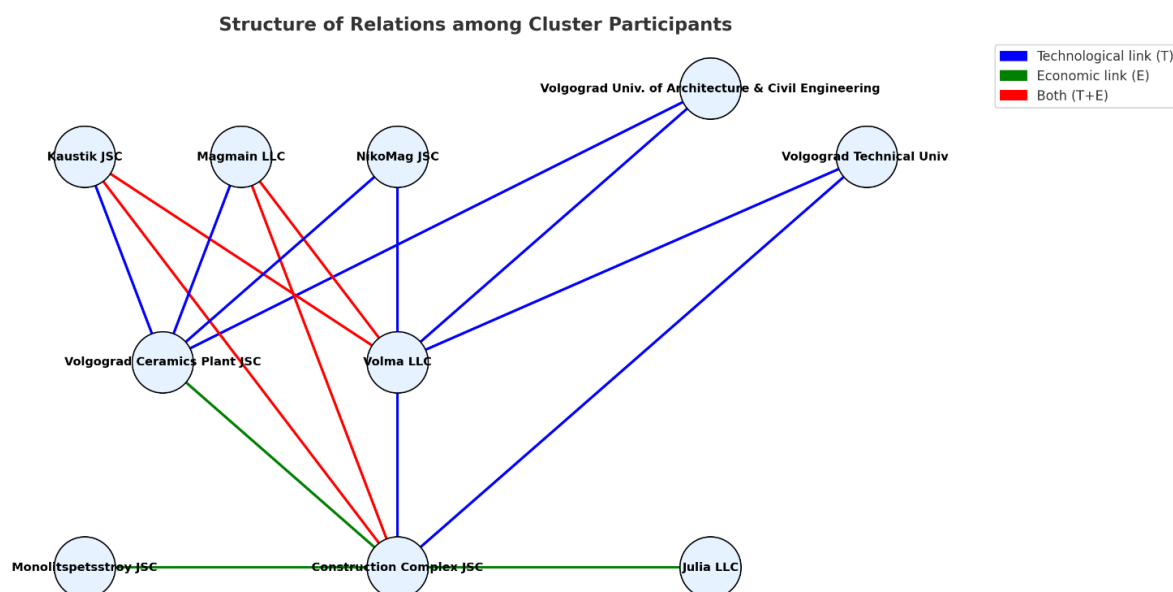


Figure 1. The structure of interrelations among the participants of the Volgograd Construction Materials Cluster. *Source:* Compiled by the author based on the data of the Russian Cluster Observatory, Institute for Statistical Research and the Economics of Knowledge (ISSEK) [14].

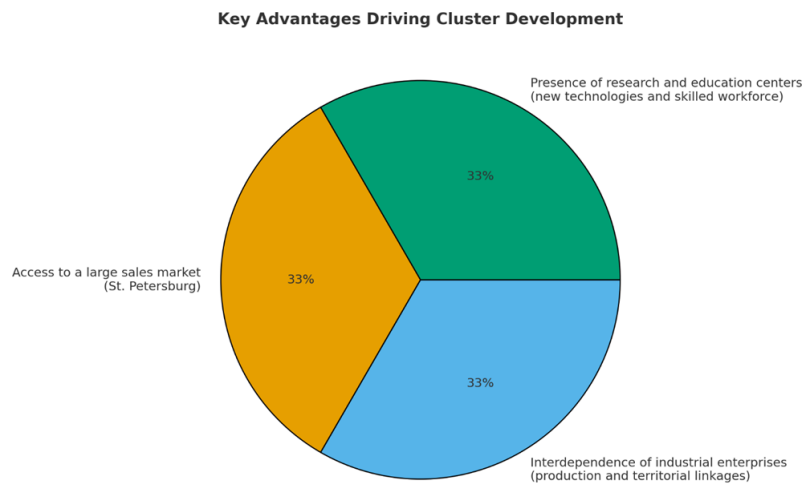


Figure 2. Structural distribution of the key factors ensuring the development of the Leningrad Construction Materials Cluster. Source: Compiled by the author based on the data of the Russian Cluster Observatory, Institute for Statistical Research and the Economics of Knowledge (ISSEK) [10, 14]

As shown in Figure 1, universities provide scientific research support and human capital development to the cluster. Within the cluster, producers of chemical raw materials (*Kaustik, Magmain, NikoMag*) supply technological resources to the main manufacturing enterprises. The final products are produced and delivered to the market by *Volma*, the *Ceramics Plant*, and the *Construction Complex JSC*. Service and infrastructure companies (*Julia LLC, Monolitspetsstroy*) complement the cluster through economic integration. Thus, the production chain within the cluster is effectively coordinated, which helps reduce logistics costs and increase overall efficiency.

Based on successful cluster development practices, the *Leningrad Construction Materials Cluster*, which began to be established at the end of 2020, currently comprises more than 30 enterprises [14]. The production volume of construction materials within the cluster traditionally depends on the pace of construction activities in Saint Petersburg - the largest consumer of these materials. The cluster specializes in the production of ready-mixed concrete, Portland cement, aluminous cement and similar hydraulic cements, ceramic tiles and slabs, ceramic construction bricks, building blocks, and other prefabricated construction products. The cluster's competitive advantages are illustrated in Figure 2.

As shown in *Figure 2*, the main advantages stimulating the development of clusters are evenly distributed among three key factors: the presence of scientific and educational infrastructure (33%), the mutual integration of industrial enterprises (33%), and access to a large sales market (33%).

This proportional distribution indicates that innovation potential, production cooperation, and market capacity act as complementary factors in shaping the competitiveness of clusters.

A successful example of cluster development is the *Moscow Innovation Cluster*, established in 2018. Within its structure operates the *Moscow Composite Cluster (MCC)*, which unites 44 participants and employs more than 42,000 people. The cluster produces innovative construction materials used not only in Moscow but also in other regions of Russia and neighboring countries.

Analyses show that within such clusters, research centers, equipment suppliers, educational institutions, and logistics service providers integrate to ensure the joint utilization of economic, technological, and infrastructural resources. This integration contributes to cost reduction, profit growth, deeper specialization, and the improvement of production processes through the adoption of innovative technologies.

Research findings indicate that the operational mechanism of successful clusters is determined by a number of fundamental factors. These factors are systematized and presented in Figure 4. The effective implementation of these factors ensures the sustainable development of clusters and enhances the competitiveness of industrial sectors. The results reveal that state support (20%) and transport-logistics capacities (20%) are the most decisive factors in the formation and development of clusters. This demonstrates that both institutional and infrastructural provisions are essential prerequisites for the stable functioning of clusters.

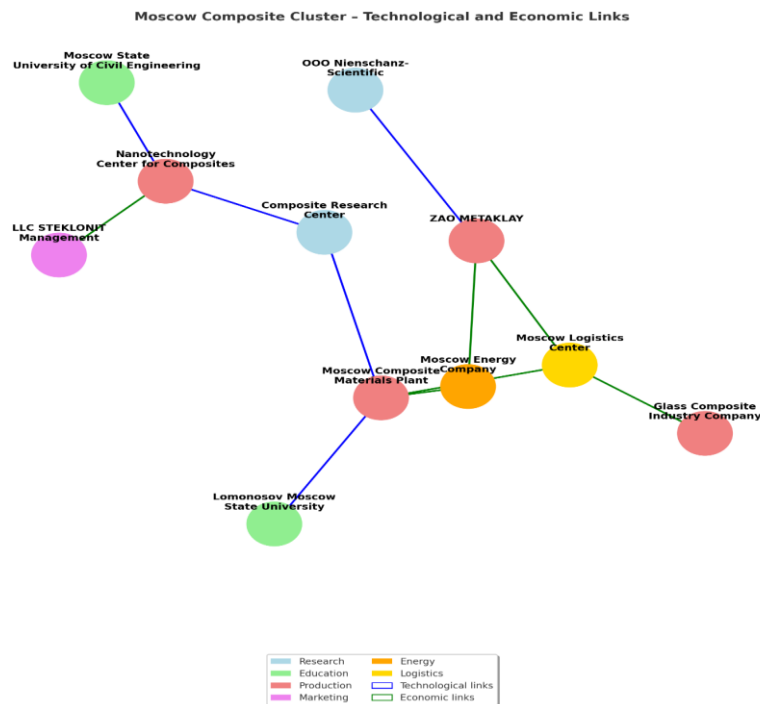


Figure 3. The structure of interrelations among the participants of the Moscow Composite Cluster. *Source:* Compiled by the author based on the data of the Russian Cluster Observatory, Institute for Statistical Research and the Economics of Knowledge (ISSEK) [12].

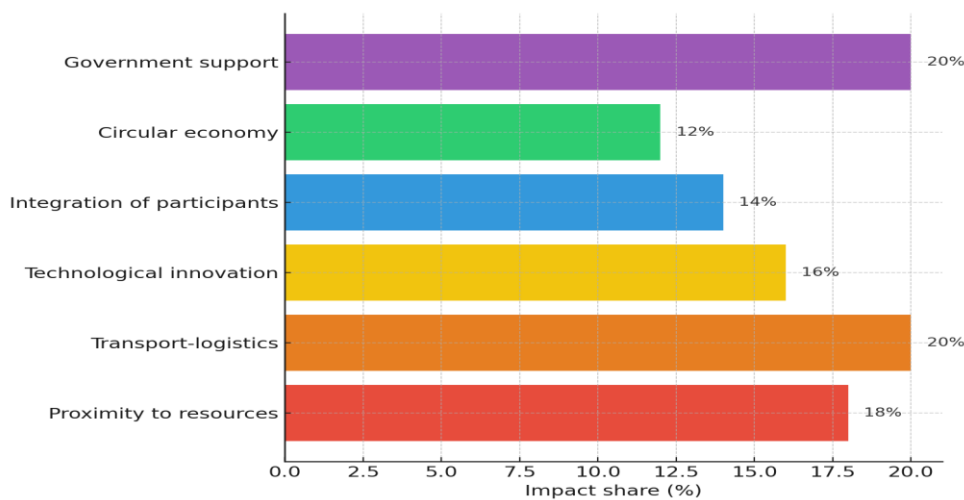


Figure 4. The share of key factors ensuring the successful performance of clusters. *Source:* Compiled by the author based on the data of the Russian Cluster Observatory, Institute for Statistical Research and the Economics of Knowledge (ISSEK) [14].

Proximity to resources (18%) and technological innovation (16%) play a crucial role in reducing production costs and increasing competitiveness. Meanwhile, participant integration (14%) and the application of circular economy principles (12%) serve as additional advantages that strengthen the cluster’s synergistic effect. This distribution confirms that the development of clusters is based not only on technological interconnections but also on strong economic and institutional support mechanisms.

Based on the analysis of successful cluster models, it can be concluded that the Baku and Absheron–Khizi economic regions are among the areas with the highest industrial potential for the establishment of a construction materials cluster in the Republic of Azerbaijan. Although fully developed industrial clusters have not yet been formed in these regions, the initial signs of cluster development can already be observed in certain sectors. The dense geographical concentration of existing enterprises and the similarity of their production activities create favorable conditions for

the emergence of cluster characteristics. One of the most promising areas in this regard is the construction materials industry.

According to statistical analyses, during the research period (2015–2022), the Baku economic region maintained a dominant share in the overall production of construction materials. On average, during these years, the region accounted for 33.5% of total asphalt production, 7.3% of gravel, crushed stone, and river stone production, 90.4% of cement output, 15.4% of construction sand extraction, 73.0% of limestone for construction, 92.7% of building lime, 58.0% of ready-mixed concrete, 28.3% of glass, 35.4% of metal structures, 19.8% of steel pipe, and 95.1% of rebar production [9, 13].

During the research period, the Absheron–Khizi economic region accounted for 14.4% of asphalt production, 12.4% of gravel, crushed stone, and river stone production, 2.4% of cement production, 1.0% of construction sand extraction, 14.8% of limestone for construction, 0.4% of building lime, 1.5% of ready-mixed concrete, 70.6% of glass production, 12.1% of metal structures, and 80.1% of steel pipe output (Figure 5).

On average, during the study period, the Baku economic region accounted for approximately 50% of the total volume of construction materials produced in the country, while the Absheron–Khizi economic region contributed around 20%. These economic indicators demonstrate the leading position of the Baku and Absheron–Khizi regions in the production of construction materials. The region's favorable industrial infrastructure and strong raw material base represent key factors stimulating the further development of this sector.

It should be noted that the Absheron region, serving as the central hub of the construction sector, accounted on average for 60.5% of total investments allocated to construction and installation works during the research period (2015–2022), including 52.8% in the Baku economic region and 7.7% in the Absheron–Khizi economic region [5]. This highlights its role as the main center of intensive construction activity in the country. Figure 6 illustrates the spatial distribution of enterprises related to the construction materials industry across regions of the Absheron area, as well as the dynamics of their formation within the framework of state program implementation during the period 2004–2022 [2, 3].

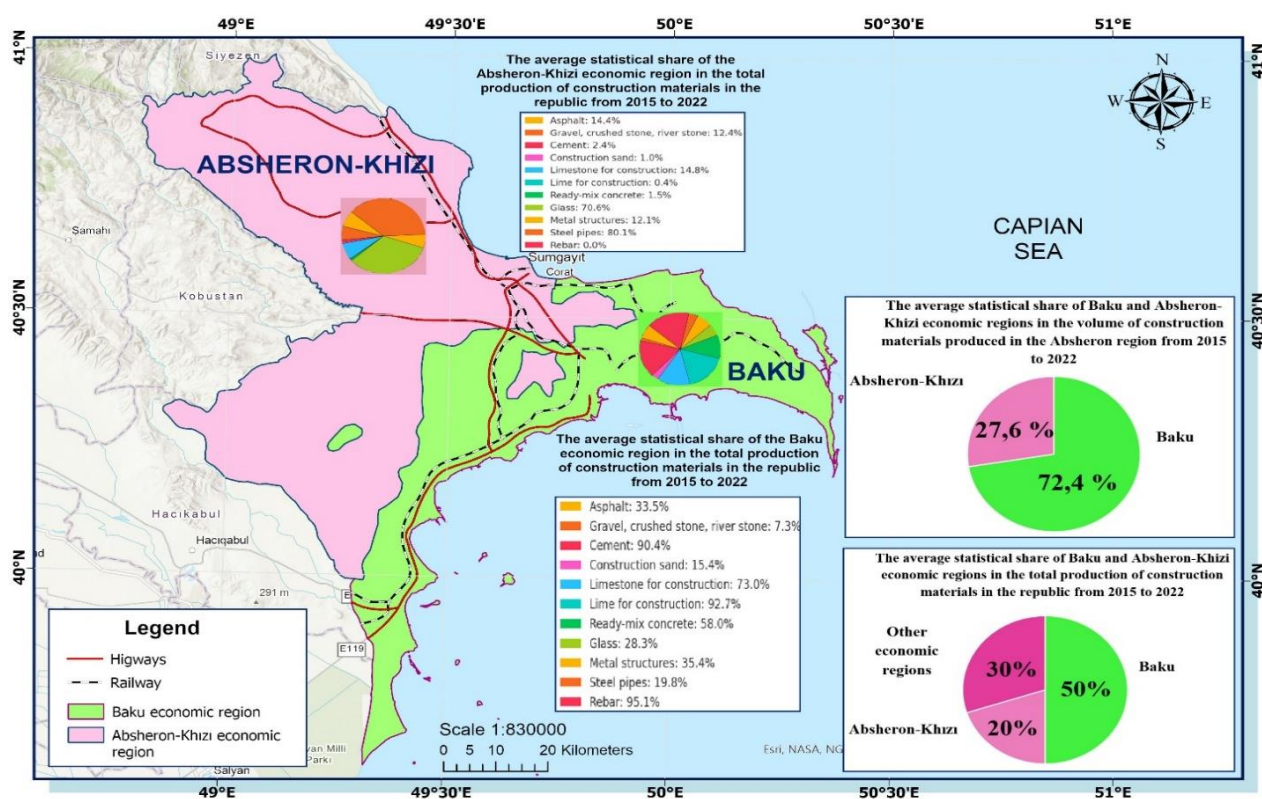
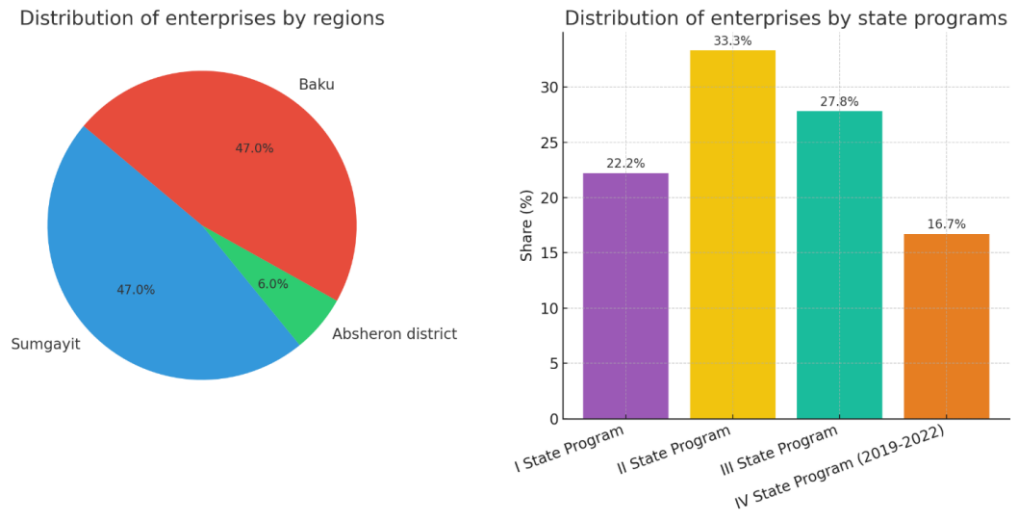


Figure 5. Average statistical share of the Baku and Absheron–Khizi economic regions in the total production of construction materials (2015–2022). Source: Compiled by the author based on the materials of the State Statistical Committee of the Republic of Azerbaijan [9, 13].



Source: Compiled by the author based on the materials of the State Statistical Committee of the Republic of Azerbaijan [5]
Figure 6. Regional and program-based structural distribution of construction materials enterprises in the Absheron region

During the implementation of the *State Programs on the Socio-Economic Development of the Regions*, 47.0% of all enterprises commissioned for the production of construction materials in the Absheron region were established in the city of Sumgayit, 6.0% in the Absheron administrative district, and 47.0% in the city of Baku (Figure 6).

During the implementation of the first state program, 22.2% of enterprises serving construction materials production were commissioned; during the second program — 33.3%; and during the third program - 27.8%. It should be noted that the fourth state program is still ongoing, and 16.7% of the newly built enterprises were commissioned between 2019 and 2022 (Figure 6).

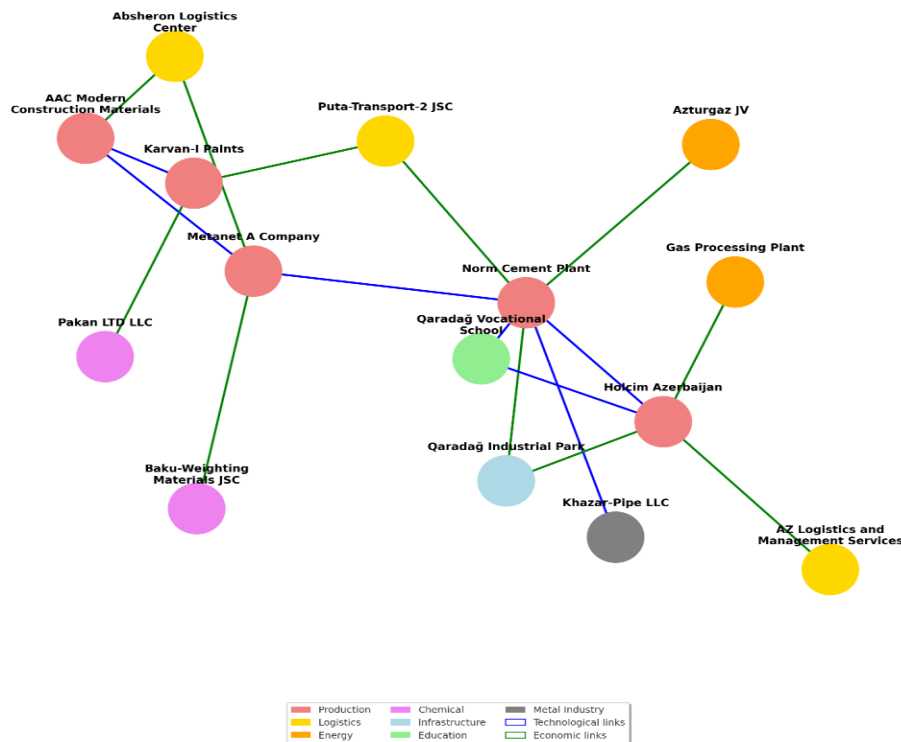
During the research period (2015–2022), the development of the construction materials industry (CMI) in the Absheron region was supported by the availability of raw material reserves, technological capacity, transport infrastructure, and an adequate labor force - the region accounted, on average, for 31.0% of the total labor force in the country during the study years. This represents a positive condition for industrial growth.

It has been substantiated that the natural resource potential of the study area offers far greater opportunities for the efficient spatial organization of the construction materials industry than those currently utilized. Specifically, only 34% of the total construction raw material deposits in the region (100 deposits categorized as “A”) are currently under exploitation - including 50% of limestone deposits and 30% of clay deposits - while the remaining 64% remain as reserves [12].

Advantages of Transforming Garadagh into a Cluster. The Garadagh administrative district of

the Baku economic region plays a crucial role in the production of construction materials in the Republic of Azerbaijan. The region possesses strong potential for the formation of the *Garadagh Construction Materials Cluster*. More than 30 manufacturing enterprises, service sectors, and logistics centers operate within the district.

The concentration of enterprises engaged in the production of limestone, cement, concrete, and other construction materials significantly enhances the cluster potential of the area. It should be noted that approximately 80% of all construction materials production enterprises in the country are concentrated within the Absheron region. Although around 85% of the region’s total construction materials output is concentrated in the Garadagh district, the limited level of technological cooperation among enterprises indicates the necessity of implementing integrated cluster-based models. Figure 7 illustrates the potential cluster model of the construction materials industry within the Garadagh economic zone. In this model, major manufacturing enterprises such as Norm Cement, Holcim Azerbaijan, Mətanət A, AAC Modern Construction Materials Plant, and Karvan-L Paint Company are represented as the central elements. The production activities of these enterprises are carried out in close integration with raw material and energy supply sectors (Azturqaz, Gas Processing Plant), chemical industry enterprises (Pakan LTD, Baku Weighting Agents JSC), the metal industry (Khazar-Boru LLC), and logistics centers (Putatransport-2, AZ Logistics, Absheron Logistics Center).



Source: Compiled by the author based on the data of the official website of the Executive Power of Garadagh District, Baku [7].
Figure 7. Model of inter-enterprise economic and technological integration for the formation of a construction materials cluster in the Garadagh industrial zone

Although the Garadagh district, with its vast territory, rich raw material base, developed transport infrastructure, and industrial park, possesses substantial potential for cluster formation, it does not currently function as a cluster. The absence of a *Garadagh Construction Materials Cluster* can be explained by the following factors:

- Weak interconnections – the synergy and integration among enterprises remain insufficient;
- Lack of formal structure – there is no state-supported infrastructure or established management mechanism for cluster coordination;
- Innovation gap – the limited number of research and educational centers restricts the cluster's innovation potential;
- Human resource constraints – the system for training and upskilling professional workers is underdeveloped.

The establishment of a construction materials cluster in the Garadagh administrative district could contribute to the full realization of the district's economic potential and enhance its recognition in international markets. In this regard, *state support* and the *active participation of the private sector* play a decisive role. Some researchers argue that, under conditions of globalization and

increasing international competition, the most effective way to ensure the survival of small firms is through their integration within cluster structures [11]. Overall, the selection of potential areas for the establishment of a construction materials cluster in the Absheron region can be carried out based on several key criteria. These include the proximity of existing infrastructure, accessibility of raw material resources, availability of transport networks, population density, and the economic-geographical characteristics of the area.

One of the most promising areas in this respect is the city of Sumgayit, located within the Absheron–Khizi economic region. The presence of a well-developed chemical industrial zone, easy access to petrochemical products and various construction raw materials, a developed transport infrastructure, and the existence of higher and vocational education institutions that train qualified specialists all indicate the strong potential for cluster formation in the region (*Table 1*).

Although the *Chemical Industrial Park* and the *Sumgayit Technologies Park* currently operate in the city of Sumgayit, there remains a need to establish a *Construction Materials Cluster*, as its objectives and areas of activity differ from those of the existing industrial parks.

Table 1
Some enterprises operating in the city of Sumgayit that could become potential participants of the construction materials cluster

No.	Name of the Enterprise	Field of Activity
1	Sumgayit Technologies Park	Production of energy products and various types of construction materials
2	Sumgayit Chemical Industrial Park	An industrial park bringing together more than 20 enterprises operating in various fields, primarily in the petrochemical industry, including construction materials production
3	Steel Pipe Plant of Azertechnoline LLC	Production of steel pipes based on Turkish, German, Italian, and Chinese technologies
4	Concrete Products Manufacturing Plant	Production of high-quality concrete products (concrete pipes and paving stones)
5	Institute of Polymer Materials of the Azerbaijan National Academy of Sciences, 'Neftqazavtomat' Scientific-Industrial Enterprise of the Ministry of Defense Industry of Azerbaijan	Enterprise specialized in the design, production, and technical maintenance of automation systems for the oil and gas industry
6	"Ethylene-Polyethylene" Plant of Azerikimya Production Union	Production of chemical products such as ethylene and polyethylene

Source: Compiled by the author based on the data from the official website of the Executive Power of Sumgayit City [8].

4. Conclusion

The conducted research has revealed that during the period 2015–2022, the Baku and Absheron–Khizi economic regions accounted for 50% and 20%, respectively, of the total construction materials production in the Republic of Azerbaijan. In particular, the concentration of 85% of production in the Garadagh administrative district and 47% of newly established enterprises in the city of Sumgayit demonstrates the high spatial density of industrial enterprises and the optimal geo-economic conditions for clustering in these territories.

The analysis indicates that the establishment of technological and economic linkages between numerous cement, lime, concrete, and paint manufacturing enterprises operating in Garadagh and the chemical and polymer industry facilities located in Sumgayit will create favorable conditions for the formation of an integrated cluster model of the construction materials industry in the region.

International experience - particularly the examples of cluster development in Russia and European countries - confirms that such integration has the potential to increase production efficiency by 15–20% and innovation turnover by 25–30%. Similarly, the formation of a Garadagh–Sumgayit–centered cluster would be of significant scientific and practical importance, as it would contribute to reducing production costs, ensuring the rational use of resources, expanding export opportunities, and enhancing the industrial competitiveness of the region.

Consequently, the application of the cluster model in the construction materials industry can foster new synergistic linkages within the indus-

trial system of the Baku and Absheron–Khizi economic regions, thereby ensuring the sustainability of both regional and national economic development.

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**TİKİNTİ MATERIALLARI SƏNAYESİNDƏ
KLASTER MODELİNİN TƏTBİQ İMKANLARI:
BAKİ VƏ ABŞERON-XIZI İQTİSADI
RAYONLARININ SƏNAYE COĞRAFİYASI
KONTEKSTİNDƏ**

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Xülasə. Məqalədə Azərbaycan Respublikasının aparıcı sənaye mərkəzlərindən olan Bakı və Abşeron-Xızı iqtisadi rayonlarında tikinti materialları sənayesinin məkan təşkilində və inkişafında klaster modelinin tətbiqinin zəruriliyi elmi baxımdan təhlil olunur. Tədqiqatda Bakı iqtisadi rayonunun Qaradağ inzibati rayonu və Abşeron-Xızı iqtisadi rayonuna daxil olan Sumqayıt şəhərində tikinti materialları klasterlərinin formalaşması və inkişaf imkanlarının müəyyənləşdirilməsi əsas diqqət mərkəzindədir. Tədqiqat nəticələri göstərir ki, sənaye müəssisələri, elmi-tədqiqat institutları, xidmət sahələri və digər əlaqəli strukturlar arasında qarşılıqlı inteqrasiyanın və əməkdaşlığın gücləndirilməsi tikinti materialları sənayesinin səmərəliliyinin artırılmasında mühüm rol oynayır. Tikinti materialları sahəsində beynəlxalq klaster təcrübələrinin təhlili göstərir ki, Qaradağ rayonu və Abşeron-Xızı iqtisadi rayonunda yerləşən Sumqayıt şəhəri belə bir klaster modelinin yaradılması üçün yüksək sənaye potensialına malikdir.

Açar sözlər: Tikinti materialları, klaster modeli, məkan təşkilatı, istehsal müəssisələri, iqtisadi əlaqələr.

ECONOMIC-GEOGRAPHICAL CHARACTERISTICS OF THE FORMATION OF THE ECONOMIC STRUCTURE IN THE SHIRVAN-SALYAN ECONOMIC REGION

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Abstract

In the Shirvan-Salyan economic region, which is the focus of our study, the presence of oil, natural gas, and iodide-bromine waters provides an opportunity for the development of fuel-energy and chemical industry sectors. At the same time, there is great potential for the development of light and food industry sectors based on the processing of agricultural products. However, the economic difficulties that emerged during the transition period led to a decline in output in the region's leading economic sectors and changed their role in the economy. At present, an economic-geographical analysis of the changes occurring in the formation of the economic structure in the Shirvan-Salyan economic region, and the study of new economic management principles, are required. It is precisely in this context that the research conducted has led to the identification of new economic management principles.

1. Introduction

In the modern era, the formation and future development of the sectoral and spatial structure of the economy are influenced by economic principles (supply and demand). Natural-geographical conditions and economic-geographical factors can also be included among these influences. As a result, leading sectors of the economy such as industry, agriculture, socio-cultural service facilities, transportation-communication lines, etc., develop to varying extents. However, it should not be forgotten that the development of the leading sectors of the economy at the regional scale is measured at different levels. The formation of this diversity is determined primarily by factors such as the availability of natural resources and their utilization, the specialization directions of industrial and agricultural sectors, the labor skills of the population, their consumer potential, the economic-geographical position, etc.

Studying the current state of the sectoral structure of the economy, its historical-geographical development characteristics, and its prospective development directions is of significant scientific and practical importance. In the current context, it is necessary to determine the unique characteristics of regions and the ways to efficiently use the existing potential opportunities. To

this end, the continuous conduct of scientific research is one of the essential conditions.

The object of the research is the economic-geographical characteristics of changes in the economic structure, studied using the example of the Shirvan-Salyan economic region. This economic region is located in the east of the country, in the lower reaches of the Kura and Araz rivers, on the shores of the Caspian Sea. The area's favorable economic-geographical position is determined by its location on the "North-South" and "Silk Road" transport corridors.

The Shirvan-Salyan economic region comprises the Shirvan city district and the Bilasuvar, Hajigabul, Neftchala, and Salyan administrative districts. Its area is 6.08 thousand km², and its population at the beginning of 2024 was 494.8 thousand people, including 231.3 thousand urban residents. The share of the economic region in the country's total area is 7.02%, and in total population 4.86%, including 4.17% of the urban population [5, s. 69, 83-88]. The role of this economic region in the country's economic structure is determined by the development of oil and natural gas extraction, electricity production, and the chemical, light, and food industry sectors. In agriculture, cotton-growing, grain cultivation, and fruit-growing are the leading sectors [9, 12]. The major urban centers of the region, Shirvan and

Hajigabul, are located on international and national transportation-communication routes and play a significant role in establishing regional economic-geographical connections.

2. Materials and Methods

In conducting the research, data from the Azerbaijan State Statistical Committee on industry, agriculture, and population employment were used, as well as census materials for the years 2009 and 2019.

The analyses were carried out with the help of mathematical-statistical methods, comparative analysis, and a historical-geographical approach.

3. Analysis and Discussion

For many years, the shelf zone of the Caspian Sea and oil-gas production have played an important role in the formation of a stable sectoral structure of Azerbaijan's economy. The high level of resource extraction has caused the oil-gas industry and its export to assume a leading position in the economic structure [9, 11]. These sectors provide the main portion of the country's GDP and industrial output. Calculations and analyses show that in 2007, 63.08% of the country's GDP was provided by industrial sectors. In the period up to 2022, there were few fundamental changes in this share, and it was recorded at 59.16% (Table 2). For many years, more than 90.0% of the country's industrial output has been accounted for by the oil-gas industry. Therefore, the share of other economic sectors remains low. This situation has arisen because enterprises in the machine-building, metallurgy, and chemical industries - sectors which are typically strategic and leading - operated weakly or not at full capacity, and their technological equipment became outdated, resulting in a failure to produce competitive products. For this reason, their share in the economic structure has remained low.

Agriculture, the second most important sector of the economy, accounts for only about 7–8% of GDP [4]. Here too, the significance of stra-

tegitically important sub-sectors that have high soil and climate potential is low, productivity is poor, and the measures taken to develop the sector are insufficient. Consequently, the share of agriculture remains small, and the volume of agricultural production does not permit the establishment of robust light and food industry sectors. As a result, a serious imbalance has emerged among the shares of various sectors in the structure of the national economy. To address this problem, substantial measures of state importance need to be implemented.

The Economic Region's share in the national economic structure. In the Shirvan-Salyan economic region, the sectoral structure of the economy - and its role in the spatial organization of the national economy and in socio-economic development - is primarily determined by the oil and gas resources and their exploitation, electricity production, and the specialization of its agricultural sectors (Table 1). Although these sectors developed over many years, they underwent fundamental changes during the years of independence. These changes are reflected both in the shifting share of individual sectors in the region's economic structure and in changes in the region's role within the country's socio-economic potential.

The territory of the Shirvan-Salyan economic region is small, and it contains few large mineral deposits of national significance. The modest oil and natural gas extraction in the region takes place in Neftchala and Salyan districts and in the Shirvan city area. Neftchala district has iodide-bromide underground brine waters, and an iodine-bromine plant operating as part of the chemical industry functions there based on these resources. However, extraction of the available natural resources is carried out at a low level. The output of the iodine-bromine plant in Neftchala and the generation capacity of the thermal power station in Shirvan city are both low.

Table 1

Share of the Shirvan-Salyan Economic Region in the National Economic Structure (%)

Economic Sector	Periods			
	2007	2010	2016	2022
Industrial output	1,08	1,04	0,13	1,13
Agricultural output	5,72	5,66	7,23	6,58
- Crop production	5,00	5,31	6,84	6,37
- Animal husbandry	6,93	6,04	7,57	6,79
Output of main sectors	1,88	1,67	2,00	1,78
Investments in fixed capital	2,45	1,41	1,55	1,82

Sources: Azerbaijan's Regions – 2007. Baku: SSC, 2008, pp. 34–39 (711 p.); Azerbaijan's Regions – 2010. Baku: SSC, 2011, pp. 40–45 (768 p.); Azerbaijan's Regions – 2016. Baku: SSC, 2017, pp. 22–27 (804 p.); Azerbaijan's Regions – 2022. Baku: SSC, 2023, pp. 22–27 (865 p.)

The share of the Shirvan-Salyan economic region in the national economic structure is characterized by very low values. First of all, the region's contribution to the country's main sector output has fluctuated between only about 1.67–2.00% since 2007. This figure is very low and has not changed appreciably for a long time; indeed, one can say there was even some decline after 2007. Additionally, the share of industry in the output of the main sectors in the Shirvan-Salyan economic region remains low relative to the national total. For instance, while the region's industrial output constituted 1.08% of the national figure in 2007, by 2022 it was virtually unchanged at 1.13%. Only in 2016 did its share drop to 0.13%. This indicates that in the intervening period, the region had very few industrial facilities of national significance, their production capacity was weak, and their potential to impact overall industrial output was not at the desired level [10].

The Shirvan-Salyan economic region is one of the agricultural regions of the country. Its flat terrain, abundant sunshine, favorable agro-climatic resources, and irrigation water supply allow for the formation of a diversified agricultural structure. The leading agricultural sectors in the region include cotton farming, grain cultivation, animal husbandry, and melon-vegetable growing [7]. However, productivity in these sectors is low; for many years no higher-yield crop varieties have been introduced, and local peasant-farmer operations have limited capacity to acquire them. Therefore, agriculture makes a weak contribution to the region's total output, and its share changes little over time. For example, in 2022 the Shirvan-Salyan economic region produced 6.58% of the country's agricultural products, which is considerably lower than in 2016 (Table 1). Even the two main branches of agriculture - crop production and animal husbandry - have low shares in national output. The share of crop production in the country was 6.37% in 2022, having increased only slightly since 2007, and in the case of animal husbandry one can observe a slight decline.

Investments directed to fixed capital are the main source for the development of economic sectors, the efficient spatial organization of the economy, and the creation of new production and service facilities. They are also a key condition for enhancing the role of regions in the country's development. Although investments are a driving factor of extensive growth, the utilization of local natural-geographical conditions and natural reso-

urce potential remains an important factor as well. However, the volume of centrally directed investments in this economic region is low, and these funds do not suffice for the construction of large-scale facilities, especially enterprises based on processing agricultural products. The share of capital investments going into the region's economy was 2.45% in 2007, but in subsequent periods it ranged only between about 1.4–2.0% (Table 1). Therefore, increasing the volume of capital allocated to the region is essential.

There is a great need to develop an infrastructure network to serve agriculture in the Shirvan-Salyan economic region. This includes creating production infrastructure networks, building warehouses and cold storage facilities, establishing machine-tractor stations (MTS), and organizing vocational-technical education centers.

Economic Structure of the Administrative Districts. The formation of the economic structure in the regions takes place over long historical periods. Agriculture has continuously maintained a leading role. If sources of natural resources of significant economic value are present, then facilities established on the basis of their extraction and processing exert influence on the formation of the economic structure.

In most cases, because a monostructural economy exists in many regions, its composition is determined by one or a few enterprises and by the economic sector to which they belong. Changes to this structure occur when new facilities are built. [9, 12].

In the Shirvan-Salyan economic region, the economic structure is mainly determined by changes in the shares of the industry and agriculture sectors, and by the changing roles of the two leading branches of agriculture within that sector, as well as by the allocation of investments. In this economic region, the majority of output in the leading sectors falls to industry. However, for many years the industrial share has remained virtually unchanged. Since 2007, industrial sectors have provided roughly 36–38% of the region's total output (Table 2). This indicates that for many years the creation of large industrial enterprises in the region has progressed at a slow pace, and the volume of output has not been sufficient to alter the region's contribution within the country.

In Shirvan city, one of the important industrial centers of the country, the bulk of output is provided by industry. The share of oil and gas extraction in the city's industrial output is particularly high. Nevertheless, in recent years, because no

new large enterprises have been established, the share of industry in the city's output has been declining. In the administrative districts, an industrial output share on the order of 20% is considered relatively high. In this regard, the newly established automobile assembly plants in Neftchala and Hajigabul districts, the cannery in Bilasuvar, and oil-gas extraction in Salyan have played a major role. A high industrial share in these administrative districts was observed in 2022; previously, this indicator was recorded at significantly lower levels.

Agriculture is among the leading economic sectors in the region. The share of this sector in the region's total output generally ranges between 27–29%, and in 2022 agricultural production accounted for 27.86%. Therefore, increasing the share of agriculture in the economic structure will require establishing agro-parks, specialized farms, seed-growing farms, and livestock breeding complexes..

In Shirvan city - one of the country's important industrial centers - the majority of output is contributed by industry. However, the share of industry in the city has actually been trending downward. In 2022, the industrial sectors' share of the city's output was recorded at 68.45%, whereas in 2010 this figure stood at 80.61%. Thus, even though many industrial facilities in the city are of regional or national importance, their output share is small and their role in shaping the city's industrial profile is limited (Table 2).

The administrative districts of the region are primarily zones of agricultural production. Consequently, in each district, agriculture occupies a leading place in the value of total output. Individual districts can contribute on the order of 30–50% of their total output through agriculture. Factors influencing this share include the area under cultivation of strategically important crops and the output value of those products, their procurement prices, the largely consumptive nature of agriculture, and how the output of these sectors is valued.

In 2022, the highest agricultural share in output was recorded in Hajigabul district (47.76%), and the lowest in Neftchala district (33.12%). An analysis of the period since 2007 indicates that the share of agriculture in total output did not change drastically in the administrative districts, although some shifts are evident. For example, analysis of the data shows that after 2007 the share of agriculture in the economic structure increased in Bilasuvar district, but decreased in Hajigabul, Neftchala, and Salyan districts. Two factors played a

leading role here and made their impact felt. The first was changes in the cropping structure of agriculture and in the volume of output produced. The second was related to changes in output of other economic sectors - primarily industrial production - or the creation of networks of important socio-cultural service facilities.

It is important to track changes in the share of the two main branches of agriculture (crop production and animal husbandry) in the administrative districts. The products of each of these branches have distinct roles in feeding the population, ensuring food security, and enabling the creation and operation of processing enterprises. Therefore, although which branch occupies the leading position may not be strategically critical at the national level, this factor often needs to be taken into account. Under current conditions (and on average for the economic region), animal husbandry holds the leading role in agricultural output in all the administrative districts except Bilasuvar. However, the dominance between these branches varies in certain years. In the farming areas within the Shirvan city territory, the bulk of output is provided by animal husbandry, which overwhelmingly predominates. In Bilasuvar district, given its favorable natural-geographical conditions, agro-climatic resources, and irrigation water for crop cultivation, crop production plays a very large role. Bilasuvar is the administrative district with the largest sown area of grain crops, and it occupies a leading place in the region for wheat and barley harvest. Therefore, crop production's role there is great. Although the proportionate share of crop production has declined since 2007, it still maintains absolute primacy at present.

In Hajigabul district, about one-third of agricultural output comes from animal husbandry. The gap between the two branches has steadily widened in favor of animal husbandry. This is because crop production's share, which was 47.6% in 2007, fell to 33.68% by 2022. The relatively small role of crop production in the district is also influenced by a smaller cultivated area compared to surrounding districts. For instance, while neighboring districts have over 40 thousand hectares of arable land, Hajigabul has only about 26.3 thousand hectares [7]. This is because parts of the district's territory are occupied by the Great and Little Kharami mountain ranges, the Pirsaat River's channel, and the reservoir built there. Thus, the area available for cultivation is relatively limited.

Table 2

Key indicators of the economic structure in the Shirvan-Salyan economic region (%)

Administrative Unit	Year	Structure of leading sectors of the economy, %			Structure of agriculture, %			Share of investments	
		Production by main sectors	Industrial product	Agricultural product	Agricultural product	Crop production	Animal husbandry	In the country	In the economic district
Shirvan city	2007	100,0	74,13	0,28	100,0	22,28	77,72	0,72	29,54
	2010	100,0	80,61	0,70	100,0	15,42	84,58	0,23	16,40
	2016	100,0	73,29	1,02	100,0	11,42	88,58	0,17	10,69
	2022	100,0	68,45	0,82	100,0	15,54	84,46	0,62	33,98
Bilasuvär district	2007	100,0	1,00	30,15	100,0	73,35	26,65	1,11	45,46
	2010	100,0	4,98	51,93	100,0	64,98	35,02	0,33	23,04
	2016	100,0	12,13	43,39	100,0	71,20	28,80	0,26	16,60
	2022	100,0	27,74	37,82	100,0	68,81	31,19	0,24	13,26
Hajigabul district	2007	100,0	1,64	48,95	100,0	47,64	52,36	0,43	17,48
	2010	100,0	1,84	37,62	100,0	36,79	63,21	0,48	33,63
	2016	100,0	2,06	56,76	100,0	30,52	69,48	0,13	8,30
	2022	100,0	20,44	47,76	100,0	33,68	66,32	0,23	12,83
Neftchala district	2007	100,0	22,11	49,31	100,0	58,15	41,85	0,08	3,08
	2010	100,0	23,92	44,93	100,0	54,85	45,15	0,12	8,28
	2015	100,0	10,83	33,12	100,0	44,28	55,72	0,53	34,35
	2022	100,0	23,14	33,12	100,0	47,30	52,70	0,31	17,19
Salyan district	2007	100,0	18,81	45,11	100,0	42,12	57,88	0,11	4,44
	2010	100,0	15,83	40,25	100,0	35,00	65,00	0,26	18,65
	2016	100,0	21,01	32,89	100,0	31,32	68,68	0,47	30,06
	2022	100,0	20,89	42,38	100,0	49,46	50,54	0,41	22,74
Region total	2007	100,0	36,15	24,42	100,0	54,50	45,50	2,45	100,0
	2010	100,0	36,61	27,63	100,0	48,34	51,66	1,41	100,0
	2016	100,0	31,12	29,62	100,0	43,24	56,76	1,55	100,0
	2022	100,0	37,63	27,86	100,0	48,83	51,17	1,82	100,0
Republic of Azerbaijan	2007	100,0	63,08	8,00	100,0	62,44	37,56	100,0	-
	2010	100,0	58,70	8,14	100,0	51,56	48,44	100,0	-
	2016	100,0	46,97	8,19	100,0	45,76	54,24	100,0	-
	2022	100,0	59,16	7,52	100,0	50,42	49,58	100,0	-

Note: The table shows industry and agriculture's output shares; other sectors are omitted due to incomplete data

Source: Azerbaijan's Regions – 2007. Baku: SSC, 2008, pp. 34–39 (711 p.); Azerbaijan's Regions – 2010. Baku: SSC, 2011, pp. 40–45 (768 p.); Azerbaijan's Regions – 2016. Baku: SSC, 2017, pp. 22–27 (804 p.); Azerbaijan's Regions – 2022. Baku: SSC, 2023, pp. 22–27 (865 p.)

At present, in Neftchala and Salyan districts, the difference between the shares of crop production and animal husbandry is small. However, since 2007, these districts have exhibited opposite trends. In Neftchala district, the share of crop production has tended to decrease, whereas in Salyan district it has tended to increase. In both districts, cotton-growing and grain-growing are key agricultural activities. In recent years, though, a reduction in water flow in the Kura and Araz rivers and difficulties in irrigation have led to a decrease in cultivated area. In Neftchala district, the sown area declined from 60.8 thousand hectares to 46.2 thousand hectares between 2020 and 2022 [7]. This has created conditions for the share of animal husbandry to rise. A reduction in

cultivated area has also been observed in Salyan district.

Investments are one of the main avenues for developing the economic sectors of the administrative districts, restructuring their economic structure, utilizing natural-geographical conditions and resource potential, creating new jobs, and organizing and improving socio-cultural services. However, the volume of investments directed to the regions remains low. This low level of investment is not sufficient for building production and service facilities, creating new jobs, or ensuring the socio-economic and demographic development of the regions.

Analyses show that the share of this economic region in national capital investment does not rise

above about 0.3–0.5% (see Table 2). This is because the Absheron economic region occupies the leading position in capital investments. Even the share of Shirvan city in total national investment was only 0.62% in 2022. In that year, Neftchala district's share was 0.31%, Salyan district's 0.41%, and Hajigabul and Bilasuvar districts' shares were on the order of 0.23–0.24% [2, p. 22–27].

An analysis of the distribution of investments across the administrative districts shows that more than one-third of all capital investment in the region goes to Shirvan city (33.98%). As a result, very small amounts of investment reach the other districts. For Hajigabul and Bilasuvar districts this figure is about 12–14%, and for Salyan district it is 22.74%. In certain years, when projects of special significance are implemented and economic facilities are built in specific districts, the share of investments going to those administrative districts can rise to as high as 30–35%.

4. Conclusion.

Based on the analysis conducted, the following conclusions can be drawn:

- In the Shirvan-Salyan economic region, the extraction of oil and gas has ensured that industry occupies a leading place in the economic structure of its constituent districts. However, because production in these sectors is currently at a low level, it cannot substantially influence the development of other economic sectors in the districts.

- Agriculture spans the entire country and its various regions, covers large areas, and holds a leading place in the employment structure of the population. However, the share of agriculture in the country's GDP has remained low for many years. In this sector, the incomes earned by the population are at a low level. As a result, the share of agricultural output in the administrative districts remains low.

- The low level of capital investment in the administrative districts has a limited effect on enhancing their role in the country's socio-economic development. This is because the funds allocated encounter difficulties in the construction of large-scale regional and national facilities. It is necessary to increase the volume of investments allocated in order to ensure the development of the administrative districts.

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ŞİRVAN-SALYAN İQTİSADİ RAYONUNDA İNFRASTRUKTUR SAHƏLƏRİNİN ƏRAZİ TƏŞKİLİ

N.H.Eminov

Xülasə. İnfrastruktur sahələri əhalinin məskunlaş-ması, məşğulluğunun təmin edilməsi, sağlamlığının bərpası və istirahətinin təşkilində, təsərrüfat sahələrinin fəaliyyətində əhəmiyyətli yer tutur. Bura daxil olan obyektlər şəbəkəsinin sıx-lığı, göstərdiyi xidmətlərin və onu əhatə edən əhalinin sayı ərazilərin inkişaf sə-viyyəsindən, şəhərlər və qəsəbələrin inkişafından, ye-rinə yetirdiyi funksiyalardan, əhalisinin sayından və iq-tisadi po-tensialından asılıdır.

Azərbaycanın regionlarında, o cümlədən Şirvan-Salyan iqtisadi rayonunda infrastruktur sahələri üzrə göstəricilərin əksəriyyəti orta respublika səviyyəsindən xeyli aşağıdır. Bu göstəricilərin aşağı olması səhiyyə, ticarət, pullu xidmətlər, məişət xidməti və turizm sa-hələrinə özünü daha aydın şəkildə özünü göstərir. Ona görə ki, keçid dövrünün çətinlikləri, ayrılan vəsaitlərin azlığı, işçilərin sosial müdafiəsinin aşağı səviyyəsi müəs-sisələrin sayının azalmasına, işçilərin ixtisar edil-məsinə gətirib çıxarır. Ona görə bu sahələrə ay-rılan vəsaitlərin çoxaldılması, özəl müəssisələr şə-bəkəsinin yaradılmasına imkan verilməsi vacibdir.

Məqalədə regionun infrastruktur sahələrinin inki-şafının müasir vəziyyəti, mövcud problemlər, onların həlli yolları təhlil edilir.

Açar sözlər: iqtisadiyyat, istehsal, sənaye, yana-caq-energetika, kənd təsərrüfatı, investisiya.

FUEL AND ENERGY RESOURCES AND PRIORITY DIRECTIONS FOR DEVELOPMENT OF ELECTRIC POWER COMPLEXES IN THE COUNTRIES OF THE TURKIC WORLD

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Abstract

The article examines the current state of the power complexes of the Turkic World Countries (TWC), including the total reserves of existing energy carriers and their per capita consumption, the generation capacity of various types of power plants, and electricity production. Here, the economic indicators of the TWC's energy complexes are analyzed, and their share indicators among the world's countries are calculated. The article also discusses the impact of local natural resources in these countries on the development of energy complexes and the issues of expanding the use of renewable energy sources (RES), as well as the similarities and differences between the Turkic States. In writing the article, relevant literature samples on energy and statistical materials of relevant agencies were used, as well as schemes and diagrams.

1. Introduction

The rapidly accelerating globalization processes in the modern era have led to several fundamental changes in the political and economic development of the world's countries. These changes, in turn, have led to the improvement of financial and monetary systems through the application of modern economic innovations at both the international and national levels, the organization of efficient use of natural resources, the development of various economic sectors, and the further increase in competition for world markets. In such a situation, a group of countries distinguished by their geostrategic importance, favorable natural conditions, rich natural resources, and human resources has emerged on the modern political map of the world, which includes the Turkic States. In recent years, the integration of independent Turkic states (Azerbaijan, Turkey, Kazakhstan, Uzbekistan, Turkmenistan, and Kyrgyzstan) into the political, economic, and cultural life of the world and their role in the international economy have been increasingly strengthened. The total trade turnover of the Turkic states with the countries of the world, which occupy the most important geostrategic position in Eurasia, is 1.3 trillion, and within the

framework of the Organization of Turkic States (OTS), it is 60 billion. This is evidenced by the fact that their foreign trade turnover has reached USD 1.5 trillion (approximately 4-5% of foreign trade turnover) and their Gross Domestic Product (GDP) is over USD 1.5 trillion. Turkic states, which have an area of 4.8 million km² (3.3% of the world's land area), abundantly endowed with diverse natural resources, especially fuels such as oil, natural gas, coal, and uranium [3].

2. Material and method

In writing the article, research materials and statistical data related to the energy sector of the International Energy Agency (IEA), EAEC (Eurasian Energy Space), and the Energy Agency of the Republic of Kazakhstan were used. When conducting the research, preference was given to the use of statistical, comparative analysis, etc., methods.

3. Analysis and discussion.

3.1. Azerbaijan: Energy Sector Overview. Azerbaijan, with a territory of 86.6 thousand km², ranks sixth in area and fourth in population among the Turkic states. It accounts for about 0.06% of the world's land area (148.94 million km²) and nearly 0.4% of the total area of the Turkic states (22.1 million km²). The country's population of

10 million people makes up 0.13% of the global population (7.95 billion) and 3.5% of the population of the Turkic states (287 million). In terms of economic size, Azerbaijan generates around USD 161.4 billion GDP, which equals 0.15% of global GDP (USD 105 trillion) and 2.1% of the GDP of the Turkic states (USD 7.7 trillion). The fuel and energy sector plays a decisive role in the structure of the national economy and contributes significantly to GDP formation.

Azerbaijan is rich in natural resources. It holds about 0.2% of the world's total reserves of primary energy resources (1,428.6 billion tons of oil equivalent) and 1.1% of Eurasian reserves (307.8 billion tons of oil equivalent). Of this, crude oil accounts for 1.48 billion tons of oil equivalent (0.4% globally; 5.8% in Eurasia), while natural gas stands at 1.86 billion tons of oil equivalent (0.6% globally; 2.2% in Eurasia). The country's per capita consumption of energy carriers is about 1,070 kg per person, which is lower than the global average of 1,238 kg and almost half the Eurasian average of 2,041 kg.

Despite its relatively small territory, Azerbaijan's proven recoverable oil and condensate reserves are estimated at 1.5 billion tons, while natural gas reserves amount to 2.5 trillion cubic meters. About 70% of its territory is regarded as highly prospective for hydrocarbons, and nearly 90% of these resources are located in the Caspian Sea. The country's leading oil fields are mostly offshore, such as Gunashli, Azeri, Chirag, Alov, Dan Ulduzu, Inam, Oghuz, Ashrafi, and Karabakh, while important onshore fields include Bibiheybat, Pirallahi, Yasamal, Mollakend, Muradkhanli, Garachala, and Siyazan. In terms of natural gas, the main offshore fields are Shah Deniz, Umid, and Absheron, whereas the most significant onshore fields include Garadagh-Gobustan and Guzdek-Zira.

Azerbaijan also possesses notable oil shale reserves. The largest deposits are concentrated in Jangichay (73.4 million tons), Kichik Siyaki (56.3 million tons), Boyuk Siyaki (56.2 million tons), Kecheller (51.9 million tons), and in the Gobustan region, where the total forecast reserves are estimated at 430–450 million tons. However, although these resources have the potential to satisfy domestic fuel demand, they remain largely undeveloped and are not yet used in the country's energy balance.

Azerbaijan's rich natural fuel resources have stimulated the development of several economic sectors, with the energy industry occupying a

central place. Energy production, which has been steadily expanding since the early 20th century, has become one of the most strategically significant sectors of the national economy. In 2021, Azerbaijan accounted for approximately 0.1% of the global installed power generation capacity (8,072,850 MW) and 1.7% of the total capacity in Eurasia (459,760 MW), with an installed capacity of 7,965 MW.

Of this total, 6,694 MW was provided by thermal power plants (84.0%), 1,157 MW by hydropower plants (14.5%), 66 MW by wind farms (0.8%), and 48 MW by solar plants (0.6%) [6]. Electricity production amounted to 27,889 million kWh, which represented 0.09% of global generation (28,322.97 billion kWh) and 1.6% of Eurasia's output (1,670.88 billion kWh). This level of production fully satisfied Azerbaijan's domestic electricity demand. As in many other Turkic states, thermal power plants remain dominant, generating 26,465 million kWh (94.8%), while hydropower accounted for 1,277 million kWh (4.5%), combined heat and power plants for 91 million kWh (0.3%), and other small hydropower stations for 56 million kWh (0.2%).

Per capita electricity consumption in Azerbaijan reached 2,033 kWh/person, which is lower than the global average of 3,102 kWh/person (1.5 times less) and the Eurasian average of 4,064 kWh/person (1.9 times less) [6].

The country's largest power plants include the Azerbaijan Thermal Power Station (2,400 MW), Southern TPP (780 MW), Sumgayit TPP (525 MW), Northern TPP (409 MW), Baku TPP (106 MW + 105 MW units), Mingachevir HPP (424.6 MW), Shamkir HPP (380 MW), and Yenikend HPP (150 MW), among others. Recent statistics show a steady increase in capacity. By 2023, the installed capacity of Azerbaijan's thermal power plants had risen to 8,322 MW, of which 6,633 MW came from conventional fossil-fuel plants and 1,689 MW from newly commissioned facilities, including biomass-fired and modernized units [12].

3.2. Turkey: Energy Sector Overview. Turkey, with a territory of 783.5 thousand km² and a population of 84.68 million, accounts for 0.6% of the world's land area and 3.5% of Eurasia, as well as 1.11% of global population and 28.5% of Eurasia's population. It is the second largest country in area and the largest in population among the Turkic states. Turkey's GDP in 2021 was USD 2,965.4 billion, corresponding to 1.7% of the world's GDP and 38.0% of the GDP of Turkic states [9].

The country's total energy reserves are estimated at 3.776 billion tons of oil equivalent, representing 0.2% of the world's total reserves and 1.2% of Eurasia's reserves. Crude oil accounts for 0.079 billion tons (0.02% globally; 0.3% in Eurasia), natural gas for 0.005 billion tons (0.0018%; 0.006%), and coal for 3.692 billion tons (0.4% globally; 1.8% of Eurasia). Per capita energy consumption was 1,424 kg/person, which is 1.1 times above the global average but 1.4 times below the Eurasian average [9]. Major natural fuel resources include coal (reserves of 11.4 billion tons, Erengil-Zonguldak deposit, the largest brown coal deposit in the Middle East), oil (47–50 million tons in southeastern and southern Turkey and the Chukurova lowlands), and natural gas (7.0 billion m³ in the Tigris upper reaches, Batman, Eregli-Sinop, and Adana regions). Recent discoveries of oil and gas in the Eastern Mediterranean are expected to further boost the economy [4, p. 122].

In 2021, Turkey had an installed power generation capacity of 99,820 MW, accounting for 1.24% of global capacity and 21.7% of Eurasian capacity. Thermal power plants contributed 47,820 MW (47.9%), hydroelectric plants 31,493 MW (31.5%), other hydroelectric units 10,607 MW (10.6%), additional hydroelectric units 7,816 MW (7.8%), geothermal plants 1,676 MW (1.7%), and other sources 408 MW (0.4%) [9]. Electricity generation reached 334,723 million kWh (1.1% globally; 20% in Eurasia), with thermal plants producing 222,623 million kWh (66.5%), hydroelectric plants 55,927 million kWh (16.7%), other hydroelectric units 31,437 million kWh (9.4%), additional hydroelectric units 13,943 million kWh (4.2%), and geothermal plants 10,793 million kWh (3.2%).

Turkey's power plants primarily rely on imported oil and gas as well as local coal, with the fuel mix including fuel oil (31%), natural gas (28%), and coal (28%) [4, p. 122]. Per capita electricity consumption was 3,337 kWh/person, approximately twice the global average but 1.9 times below the Eurasian average. The largest power plants are the Euphrates River HPP cascade: Atatürk (2,405 MW), Karakaya (1,880 MW), Keban (1,330 MW), Birecik (672 MW), and Karkamish (189 MW) [9].

To meet growing electricity demand, Turkey has begun constructing 19 new HPPs in South-eastern Anatolia, along with nuclear power plants planned by TAEC. The AKKUYU NPP units, with a combined capacity of 1,114 MW, started construction between 2018 and 2022 in the Mersin region [14]. In recent years, as in other Turkic

countries, Turkey has also been experiencing increases in the production capacity of power plants. This is evidenced by the fact that in 2023, the production capacity of the country's power plants reached 107.27 million kWh (including thermal power plants at 47.81 million kWh and RES at 59.46 million kWh (hydroelectric power plants—31.96 million kWh, wind power plants—11.81 million kWh, solar power plants—14.00 million kWh, and geothermal power plants—1.69 million kWh) [12].

3.3. Kazakhstan: Energy Sector Overview. Kazakhstan has an area of 2,724,900 km² (2.09% of the world; 12.2% of Eurasia) and a population of 19.01 million (0.25% globally; 6.39% of Eurasia). The country ranks first in terms of area and third in terms of population among the countries of the Turkic world countries. Its GDP is 545,187 billion dollars (0.3% of the world; 7.0% of Eurasia). [7]. Kazakhstan, which is very rich in natural resources, has a total energy reserve of 34,908 billion tons of oil equivalent (2.4% of the world; 11.3% of Eurasia), of which 6,350 billion tons of oil equivalent (1.8% of the world; 25.2% of Eurasia), 3,455 billion tons of natural gas equivalent (1.2% of the world; 4.1% of Eurasia), and 25,102 billion tons of coal equivalent (3.1% of the world; 12.8% of Eurasia). The sufficient availability of energy carriers in the country also had a positive impact on per capita consumption, which amounted to 2537 kg/person, which was 2 times higher than the world indicators and 1.2 times higher than the Eurasian indicators [7]. Kazakhstan, which ranks 6th in the world in terms of the richness of its minerals, has a sufficient number of valuable fuels, including gunpowder, zinc, tungsten (1st place), silver, chromite (2nd place), copper, fluorite (3rd place), molybdenum (4th place), gold (6th place), etc., natural resources. These include oil (reserves of 20–25 billion tons); according to preliminary estimates, the Caspian sector of the country is considered more promising in this regard, and its reserves are estimated at 13 billion tons of oil equivalent. Main deposits: Uzen, Metilay, Karajambash, Kalamkas, Tengiz, Kenkiyak, Karachiganak, Kumkol, Kashagandyr, etc.), natural gas (the country's main gas deposits, estimated at 6 trillion m³, and ranking 12th in the world in terms of reserves, are located in the West Kazakhstan region), coal (the deposits with a projected reserve of 164 billion tons are mainly located in Karaganda, Pavlodar, Kostanay, and Ekibastuz (50 million tons of coal are extracted from this deposit per year; in recent years, the Maykoben and Torgay coal basins have also be-

gun to be exploited)) [4, p. 37], uranium (in 2022, Kazakhstan provided 43% of the world's total uranium production, and the presence of sufficient reserves in these deposits (worldwide 21% (II place), which gave impetus to the construction of the country's first nuclear power plant (currently the Mangistau nuclear power plant) in Aktau in 1972)), etc. can be an example [13]. In Kazakhstan, the fuel needs of the energy industry are completely met by natural resources such as local oil, gas, coal, and uranium. The current generation capacity of power plants operating in the country based on the use of these resources reaches 26803 MW (0.34% in the world; 5.83% in Eurasia), of which the majority are 21956 MW of thermal power plants (81.9%), 2806 MW of hydroelectric power plants (10.5%), 672 MW of hydroelectric power plants (2.5%), and 1369 MW of hydroelectric power plants (5.1%) [7].

In recent years, increases in the total generation capacity of existing power plants and electricity production have been observed in Kazakhstan. Thus, in 2021, electricity production in the country reached 115,074 million kWh (0.4% in the world; 6.9% in Eurasia), of which 102,494.0 million kWh was provided by thermal power plants (89.0%), 9,208 million kWh by hydroelectric power plants (8.01%), 1,747 million kWh by hydroelectric power plants (1.52%), and 1,625 million kWh by hydroelectric power plants (1.42%). Per capita electricity consumption in the country was 4,572 kWh/person, which was 1.4 times higher than the world average and 1.1 times higher than the Eurasian average. The largest HPPs in the country are Ekibastuz-1 TPP (4000 MW), Ekibastuz-2 TPP (1000 MW), and Aksu TPP (2400 MW); Cascade stations: Shulba, Bukhtarma, and Oskemen HPPs (on the Irtysh River), Kapchagay HPP (on the Ili River), Chardara HPP (on the Syrdarya River), etc. It should be noted that although Kazakhstan has a sufficient number of RES, their share in electricity production is still very small. The country's hydropower potential alone is estimated at 163 billion kWh, of which 62 billion kWh is technically usable, and 27 billion kWh is economically viable [13].

Statistical indicators for 2023 show that the total generation capacity of Kazakhstan's power plants reached 26,884 MW, and most of this, namely 20,221 MW, was again non-renewable (thermal power plants using organic fuels), and 5,663 MW was renewable energy sources (thermal power plants burning biomass (14 MW), hydroelectric power plants (2,903 MW), hydro-

electric power plants (1,440 MW), and solar power plants (1,306 MW) [12].

3.4. Uzbekistan: Energy Sector Overview. Uzbekistan ranks 4th in terms of area and 2nd in terms of population among the TDCs. The country has an area of 447.4 thousand km² (0.35% in the world; 2.01% in Eurasia) and a population of 34.56 million people (0.46% in the world; 11.6% of Eurasia). Its GDP is 300.171 billion dollars (0.1%; 3.85%) [11].

In Uzbekistan, which has a total reserve of energy carriers of 3.247 billion tons of oil equivalent (0.23% in the world; 1.05% in Eurasia), the share of crude oil is 0.126 billion tons of oil equivalent (0.03% in the world; 0.5% in Eurasia), natural gas is 2.353 billion tons of oil equivalent (0.8%; 2.8%), and coal is 0.768 billion tons of oil equivalent (0.09% in the world; 0.3% in Eurasia). However, despite the fact that the per capita consumption of energy carriers in the country has reached 1102 kg/person, this is still 1.1 times lower than the world average and 1.8 times lower than the Eurasian average [11].

Uzbekistan is a country that is very rich in natural resources. The country's fuel resources include oil (reserves are estimated at 5 billion tons, and the main deposits are located in the provinces of Kashgar, Bukhara, Surkhandarya, Namangan, Andijan, Fergana, etc.); natural gas (reserves are 5 trillion m³; the largest gas fields are Gazly (initial gas reserves are estimated at 470 billion m³), Uchkir, Zevardi, Mubarak, etc.); and coal (in the Surkhandarya region, Shargun (37.3 million tons) and Baysun (15.6 million tons), and gray coal reserves are concentrated in the Angren field (1926.7 million tons). The country's coal reserves are completely used for local electricity production; uranium (the discovered reserves of which reach 55 thousand tons, which may give impetus to the development of nuclear energy in this country in the future), etc., can be an example [4, p.78].

The energy industry of Uzbekistan is mainly represented by thermal and hydroelectric power plants. In 2021, the current production capacity of these power plants was increased to 16,700 MW, which is 0.21% in the world and 3.64% in Eurasia, of which 14,543 MW were thermal power plants (87.09%), 2,052 MW were hydroelectric power plants (12.29%), 1 MW was wind power plants (0.001%), and 104 MW were solar power plants (0.64%). In the same year, the power plants operating in the country produced 71,413 million kWh. The majority of the electricity (0.2% in the world; 4.2% in Eurasia), i.e., 66391 million

kWh, was provided by thermal power plants (93%), and 5022 million kWh by hydroelectric power plants (7.0%) [11]. Although the per capita electricity consumption in the country was 1610 kWh/person, this was 1.9 times lower than the European indicators and 2.5 times lower than the Eurasian indicators.

Observations show that in recent years, taking into account the growing electricity demand, the country has increased its focus on developing nuclear energy (for this purpose, an agreement was signed with Russia on the construction of a 330 MW nuclear power plant in 2024) and the use of renewable energy sources. An example of this is the construction and commissioning of wind and solar power plants in the Navai, Jizak, Samarkand, and Surkhandarya regions and the planning of the construction of 10 large KES with a total capacity of 10.3 GW in the Karakalpakstan Autonomous Republic. In addition, Uzbekistan, which is implementing the "Sunny House" program in the field of "Green Energy," plans to build another 11 solar and wind power plants with a total capacity of 4.8 GW (worth USD 4.4 billion) under an agreement concluded with China (2023). Thus, Uzbekistan plans to increase the total production capacity of renewable energy sources by another 20 GW by 2030, bringing its share in the energy balance to 40% and, starting from the same year, export excess green electricity (approximately 10-15 billion kWh) to foreign countries [5].

At the end of 2023, as in other Turkic states, increases were observed in Uzbekistan's existing energy sources. The generation capacity of power plants was increased to 17,901 MW, of which 15,232 MW came from non-renewable energy sources (thermal power plants running on organic fuel) and 2,669 MW from renewable energy sources (hydro power plants—2,415 MW; wind power plants—1 MW; solar power plants—253 MW) [12].

3.5. Turkmenistan: Energy Sector Overview. Turkmenistan has an area of 488.1 thousand km² (0.38% of the world's area; 2.19% of the Eurasian area) and a population of 6.342 million people (0.09% in the world; 2.13% in Eurasia). The country ranks third in terms of area and sixth in terms of population among the TDCs. Its GDP is \$104.31 billion (0.06% in the world; 1.34% in Eurasia) [10].

The total reserves of energy carriers available in Turkmenistan are estimated at 13.171 billion tons of oil equivalent (0.9% of the world, 4.2% of Eurasia), of which 0.127 billion tons of oil

equivalent (0.03% of the world; 0.5% in Eurasia) are crude oil, and 13.171 billion tons of oil equivalent (4.7% of the world; 15.7 billion tons of oil equivalent) are natural gas. As in Kazakhstan, the per capita consumption of energy carriers in this country is higher than both the world (2.6 times) and Eurasian indicators (1.6 times), reaching 3296 kg/person [10]. In Turkmenistan, which has rich oil and, in particular, natural gas reserves, all economic sectors are developed based on the use of these reserves. Of the 144 oil and gas fields discovered in the territory, 40 (Caspian, Bukhara-Khiva, Mary, Lebap, etc.) are exploited. The main oil fields are Goturtepe and Barsagelmez; the natural gas fields are Shadliq, Achak, Naib, etc. In some regions of the country, which ranks 4th in the world in terms of natural gas reserves and 11th in terms of production, coal deposits are found, albeit small [4, p. 101].

In 2021, the current generation capacity of Turkmenistan's thermal power plants reached 6,511 MW (0.08% in the world; 1.42% in Eurasia), of which 6,510 MW (99.9%) were thermal power plants and 1 MW (0.1%) was hydroelectric power plants. In the same year, the country produced 22,534 million kWh of electricity (0.07% in the world; 1.3% in Eurasia), most of which, namely 22,528 million kWh (99.9%), was provided by thermal power plants, and a small part by hydroelectric power plants.

Examples of power plants operating in Turkmenistan include Mari State DRES (1685 MW), Turkmenbashi Thermal Power Plant (420 MW), Balkanabad HPP (360.2 MW), Abadan HPP (321 MW), Ashgabat HPP (254.2 MW), Ahal HPP (254.2 MW), Avaz HPP (254.2 MW), and Dashaguz HPP (254.2 MW), as well as Hindigush, "Vatan," Darvaz, Lebap, etc. [10].

By the end of 2023, the production capacity of existing energy sources in Turkmenistan was increased to 7002 MW, of which 7000 MW was again allocated to thermal power plants operating on fossil fuels, and only 2 MW to hydroelectric power plants [12].

3.6. Kyrgyzstan: Energy Sector Overview. Kyrgyzstan, which ranks fifth in terms of area and population among the Turkic world countries, has an area of 199,951 km² (0.16% of the world's area; 0.9% of the Eurasian area) and a population of 6.654 million people (0.09%; 2.24% of Eurasia). The country's GDP is 36.549 billion dollars (0.02%; 0.4%) [8]. The total reserves of natural energy carriers in Kyrgyzstan are estimated at 0.568 billion tons of oil equivalent (0.04% of the world's area; 0.18% of the Eurasian area), of

which 0.008 billion tons of oil equivalent (0.002%; 0.03%), 0.007 billion tons of natural gas equivalent (0.002%; 0.008%), 0.553 billion tons of oil equivalent (0.002%; 0.008%), and 0.553 billion tons of oil equivalent (0.002%; 0.008%) are accounted for by coal (0.06%; 0.2%). The relatively low natural resource potential of the country compared to other Turkic states has led to the fact that the per capita consumption of energy carriers (494 kg/person) is 2.5 times lower than the world indicators and 4.1 times lower than the Eurasian indicators [8]. Despite the fact that Kyrgyzstan's industrially significant oil reserves, located mainly in the Fergana Valley, are estimated at 11.6 million tons and natural gas reserves at 4.9 billion m³, their exploitation is still unsatisfactory. For this reason, local coal reserves are used more widely in all industrial sectors, including the energy industry. About 70 coal basins with reserves of 30 billion tons are located in the country, mainly in the Osh, Jalal-Abad, Issyk-Kul, and Naryn regions [4, p. 68]. The main place in the energy complex of Kyrgyzstan is occupied by hydroelectric power plants and partly by thermal power plants. In 2021, the total generation capacity of hydroelectric power plants in Kyrgyzstan was 3869 MW (0.05%; 0.85%), of which the majority, namely 3135 MW, fell to hydroelectric power plants (81.0%) and only 734 MW to thermal power plants (18.9%) [8]. Of the 14815 million kWh of electricity produced in Kyrgyz hydroelectric power plants in 2021 (0.05% in the world; 0.8% in Eurasia), most of the electricity, namely 13976 million kWh, was provided by hydroelectric power plants (94.3%), and a small part was provided by thermal power plants (5.67%). The total hydropower potential of the country is estimated at 163 TWh/year, of which 99 TWh/year is technically feasible and 55 TWh/year is economically feasible [8]. The fact that the rivers of Kyrgyzstan have such a large hydropower potential opens up wide opportunities for more efficient use of this

energy in the future. The largest HPPs in the country are Ashakhinarin Cascade HPP (2870 MW), Toktogul (1200 MW), Kurpsay (800 MW), Tash-Kumir (450 MW), Shamaldisay (240 MW), Uch-Kurgan (180 MW), etc. The indicators for 2023 indicate a slight increase in the total production capacity of power plants operating in Kyrgyzstan. Thus, the energy capacity of renewable and non-renewable energy sources was increased to 4134 MW, of which 3210 MW was accounted for by HPPs and 924 MW by TPPs, respectively [12].

As can be seen, the Turkic states have quite rich natural fuel resources: oil, natural gas (Azerbaijan, Kazakhstan, Turkmenistan, and Uzbekistan), uranium (Kazakhstan, Uzbekistan), coal (Turkey, Kazakhstan, and Uzbekistan), shale (Azerbaijan), etc. In our research, the current state of the total reserves of existing energy carriers of the Turkic world countries, per capita energy carrier consumption, total production capacity of power plants, and electricity generation at these plants were analyzed, and their share indicators with the countries of the world and among themselves were calculated in percentages. The conducted analyses show that currently the total reserves of energy carriers of the TWC are estimated at 59.02 billion tons of equivalent units, and most of this falls on Kazakhstan and Turkmenistan, and a relatively small part falls on Turkey, Azerbaijan, Uzbekistan, and Kyrgyzstan (Figure 1).

Observations show that there are also differences in the per capita consumption of energy carriers among the Turkic states. Thus, if in Turkmenistan and Kazakhstan these indicators are higher than the world and Eurasian indicators in 2021 (1.2-2.6 times), then in Azerbaijan, Uzbekistan, and Kyrgyzstan they are lower (1.1-4.1 times), and in Turkey they are higher (2.6 times) and lower (1.6 times), respectively.

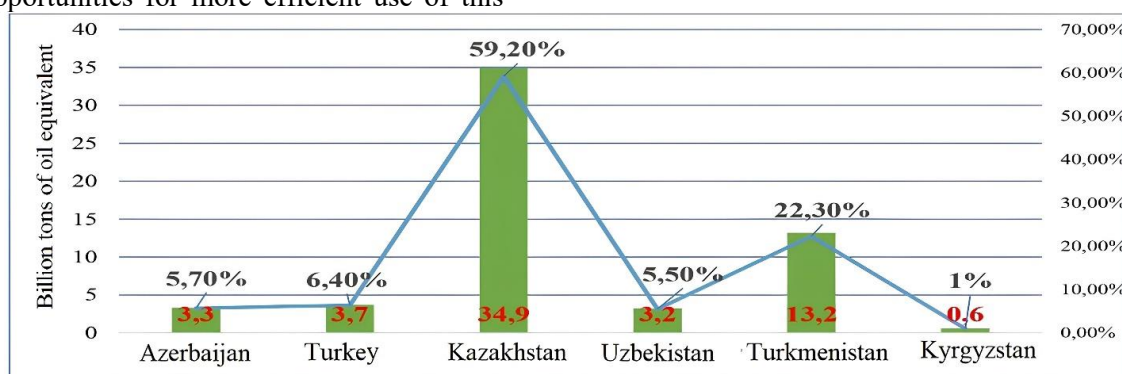


Figure 1. Total reserves of energy carriers of the Turkic World Countries (billion tons of oil equivalent) and their share by country (%) in 2021

Studies show that the total generation capacity of the ES operating in the Turkic world countries in 2021, which reached 161667.0 MW, is unevenly distributed across countries, with the highest percentages observed in Turkey and Kazakhstan and relatively low indicators in Uzbekistan, Azerbaijan, Turkmenistan, and Kyrgyzstan (Figure 2).

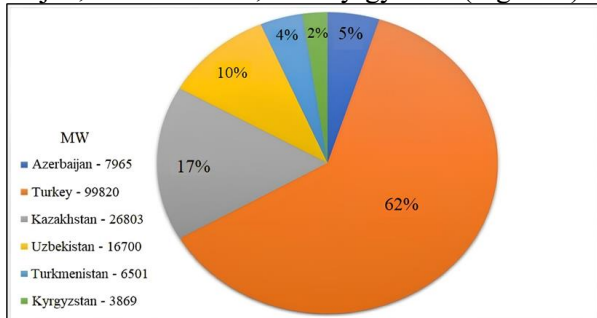


Figure 2. Share of total production capacity of ES in the TWC by country (in %), 2021

It should also be noted that in all Turkic states (except Kyrgyzstan: in this country, 81.0% of the production capacity of power plants is accounted for by HPPs), a significant part of the total energy capacity of existing power plants is accounted for by thermal power plants, and the rest is accounted for by other energy sources. The high share of thermal power plants in the fuel-energy balance of the countries is explained by the richness of fuel raw materials available in their territories. Observations show that one of the similar features among the Turkic states is that they have sufficient renewable energy sources. That is why interest in the use of environmentally friendly renewable energy sources such as solar and wind in Azerbaijan, Kazakhstan, and Uzbekistan; solar, wind, and hydropower in Turkey; and hydropower in Kyrgyzstan is growing. This is also proven by the fact that in recent years, the share of renewable energy sources in the energy capacity of countries has reached 20.5% in Turkey, 7.6% in Kazakhstan, and 1.4% in Azerbaijan (these figures are relatively low in Uzbekistan, Turkmenistan, and Kyrgyzstan, varying between 0 and 0.64%). As a result of the calculations, it was determined that in 2021, 586453.0 million kWh of electricity were produced in the power plants operating in the Turkic states, and the highest percentages were recorded in Turkey, Kazakhstan, and Uzbekistan, while the relatively low figures were recorded in Azerbaijan, Turkmenistan, and Kyrgyzstan (Figure 3).

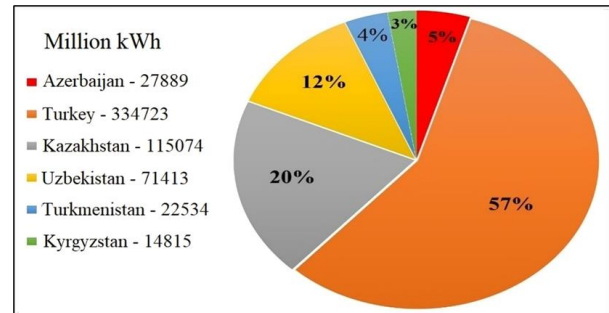


Figure 3. Share of electricity generation in TWC's power plants by country (in %), 2021

Conclusion and suggestions. From the conducted analyses, it can be concluded that the countries of the Turkic world have rich fuel and energy resources, and the efficient use of these resources has led to substantial economic growth in the volume of GDP of the countries, the generation capacity of existing RES, annual electricity production, etc. The gradual expansion of the use of RES in the countries has created conditions for the satisfaction of the demand for electricity in the places, the reduction of dependence on imported energy, and, on the contrary, the export of excess electricity to countries around the world. In general, the strong development of the fuel and energy complex, which is one of the most strategic sectors of the economy in the Turkic states, has led to the further expansion of the cooperation relations of these states in the political-economic, transport, trade, and energy fields both in their internal geopolitical regions and within the framework of the TCT, and most importantly, to their successful integration into the world's most dynamic network of economic and trade relations. If the countries of the Turkic world continue to strengthen political and economic relations among themselves, including the implementation of many valuable projects such as the South Caucasus Corridor (SCC), the South Caucasus Pipeline (SCP), the Trans-Anatolian Pipeline (TANAP), the Trans-Adriatic Pipeline (TAP), etc., which are part of the Southern Gas Corridor (SGC), this may lead to the development of newer sectors of the economy in these countries, the independent use of their natural resources without being influenced by various power centers, and also a significant change in the geopolitical and economic situation of the world in their favor.

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TÜRK DÜNYASI ÖLKƏLƏRİNİN YANACAQ-ENERJİ EHTİYATLARI VƏ ELEKTROENERGETİKA KOMPLEKSLƏRİNİN PRIORITYET İNKİŞAF İSTİQAMƏTLƏRİ

Z.M.Məmmədova

Xülasə. Məqalədə Türk Dünyası Ölkələrinin (TDÖ) elektroenergetika komplekslərinin müasir vəziyyəti, mövcud enerjidaşıyıcılarının ümumi ehtiyatı və onun adambaşına düşən istehlakı, müxtəlif tip elektrik stansiyalarının generasiya gücü və elektrik enerjisi istehsalı kimi məsələlərə baxılır. Burada TDÖ-nün energetika komplekslərinə aid iqtisadi göstəricilər təhlil edilmiş, onların dünya ölkələri arasında pay göstəriciləri hesablanmışdır. Məqalədə həmçinin bu ölkələrdə mövcud olan yerli təbii ehtiyatların energetika komplekslərinin inkişafına təsirindən, bərpa olunan enerji mənbələrindən (BOEM) istifadənin genişləndirilməsi məsələlərindən, eləcə də Türk Dövlətləri arasında mövcud olan oxşar və fərqli xüsusiyyətlərdən bəhs edilir. Məqalənin yazılmasında energetikaya aid müvafiq ədəbiyyat nümunələrindən və aidiyyət agentliklərinin statistik materiallarından istifadə edilmiş, sxem və diaqramlar verilmişdir.

Açar sözlər: elektroenergetika, istilik-elektrik stansiyası (İES), su-elektrik stansiyası (SES), bərpa olunan enerji mənbələri, enerjidaşıyıcıları, istehsal, istehlak.

HISTORICAL AND GEOGRAPHICAL SETTLEMENT CHARACTERISTICS OF THE MIL-MUGHAN ECONOMIC REGION

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Abstract

The article analyzes the historical settlement of the Mil-Mughan economic region, tracing its development stages from antiquity to the modern period, and explores the area's historical and archaeological monuments. An analysis of the historical-geographical features of the Mil-Mughan plain highlights that a significant part of the territory was traditionally used as winter pastures.

The study reveals that most permanent settlements were concentrated along the banks of the Kura and Araz rivers, while the establishment of new settlements in the early and mid-20th century was largely associated with the construction of new irrigation canals. The article also investigates demographic changes and migration processes from the 19th century up to the 1970s, as well as the founding of Russian villages in the winter pastures of the Shahsevan - considered the local population - resulting from Tsarist policies implemented in the Mughan region.

1. Introduction

The study of historical settlement patterns across the economic regions of our country plays a crucial role in understanding the past of our people. In ancient times, the geographical environment had a significant influence on human society and its settlement. In Azerbaijan, the Mil-Mughan plain – with its favorable natural conditions, rich resources, diverse vegetation, abundant rivers, and freshwater lakes – served as a cradle for the earliest human settlements.

This territory became one of the earliest centers of agriculture and animal husbandry. Archaeological excavations have uncovered elongated river stones fashioned into various tools for tilling the soil, the earliest plows, as well as grinding and rubbing implements, demonstrating that the inhabitants of this area had been cultivating and using cereal crops since ancient times. Historical evidence confirms that the carriers of this culture were pastoral and agricultural tribes whose homeland coincided with the regions where the ancestors of domestic animals lived and where wild species of wheat and barley grew.

The proximity of this territory to the Caspian Sea contributed not only to the development of farming, herding, and household activities but

also to traditional occupations such as fishing and hunting. The geographical location of the Mughan plain positioned it as a crossroads linking southern and northern Azerbaijan and, at the same time, as a connector at the intersection of ancient cultures. Examining the evolution of this development and the formation of settlements up to the modern period represents one of the key directions in the study of population geography.

In the investigation of historical settlement in Azerbaijan, the contributions of historians such as Q. Qeybullayev [9], K. Shukurov [2], V. Piriyeu [12], T. Najafli [11], F. Agasioglu [3], and others have been of great importance. Likewise, archaeologists including K. Mammadov [10], T. Aliyev [6], F. Babayev [5], M. Rahimova [13], among others, as well as geographers such as Z. Eminov [4], E. Badalov [4], and others, have played a significant role in advancing research on this subject.

The analysis of the topic employs a combination of methods, including historical-geographical, systemic analysis, comparative, statistical, and other approaches.

2. Analysis and discussion

Mil-Mughan, located in the central part of Northern Azerbaijan, is a political-historical ter-

ritory and one of the earliest cultural centers of human settlement. Owing to its favorable geographical position, rich natural resources such as pastures and arable lands, agro-climatic conditions, and flat relief, it became a cradle where human society first emerged and developed. This area, situated at the confluence of the Kura and Araz rivers, was especially fertile in ancient times, making it an attractive site for early settlement.

The Mil-Mughan plain encompassed the central part of the Aran region. The word Aran is believed to mean “warm lowland” or “winter pasture.” In the early Middle Ages, this name was applied to the whole of Northern Azerbaijan, referred to in sources as Arran, al-Ran, or Aran. It is assumed that the term Aran may also be linked to the name of a tribe - possibly the Aran tribe - that lived within the confederation of Scythian-Massagetae tribes in Northern Azerbaijan during the 2nd–1st millennia BCE. The use of this name spread widely across the vast Turkic world.

Archaeological research in the Mil-Mughan territory has revealed that Mesolithic and Neolithic settlements existed here, and that the density of early agricultural settlements identified in the Mil-Karabakh plain, particularly north of the Gargarchay River, has no parallel in the Caucasus. During the Eneolithic period, more than 150 settlements were studied in the South Caucasus, the majority of which were located south of the Kura River - in the Mil-Karabakh and Mughan regions - mainly along small rivers (such as Misharchay and Injachay) and freshwater lakes.

The largest settlement, Alikomektepe (Mughan), is notable for its rectangular architectural structures, similar to those found around Lake Urmia, whereas in the Kura valley, circular-plan architecture prevailed [1].

In the Mil-Karabakh region, excavations at the Qalatapa monument uncovered the ruins of one of the Albanian cities [5]. This city was founded in the 3rd century BCE, and during the 1st century BCE and the 2nd century CE it experienced urban development, including craftsmanship, trade, and construction. Following the Mongol invasions, however, the city was reduced to ruins. Qalatapa is located near the village of Salmanbəyli in the Aghjabadi district, at the confluence of the Gargarchay and Gavurark rivers. This territory once belonged to the province of Uti.

According to Strabo, in this province there were the cities of Aynian (Enian) and Anariaka [6]. Aynian was a walled city, known for its crafts

and copper-smithing. In Anariaka, there was a temple associated with divination. These cities are believed to have existed in the 4th–3rd centuries BCE. It is assumed that the city of Enian was founded by the Albanian tribe of Khan or Khan-Khan. K. V. Trever noted that Enian, once called Khan-Khan, initially belonged to the province of Uti and later to Paytarakan (Fig. 1) [7].

The historical stages of settlement in the Aran territory can be briefly characterized as follows. In the earliest stage (9th–4th/5th millennia BCE), that is, during the Mesolithic, Neolithic, and Eneolithic periods, the densest settlements in the Caucasus were concentrated in the Mil-Karabakh plains - particularly between and along the banks of the Gargarchay, Khachinchay, Kondalanchay, and Kuruchay rivers.

The subsequent stage (from the mid-5th millennium BCE to the 8th century BCE) corresponds to the Bronze and Iron Ages. During the Bronze Age, the so-called “Kura-Araz culture” emerged, initially marked by the “Stone Box Graves” phase, and by the late 3rd millennium BCE the rise of class-based society was evident. In the period of the “Wooden Grave-Kurgan culture,” the Mil-Karabakh plains again exhibited dense settlement, whereas the Mughan and Shirvan plains showed weaker habitation, and settlement along the Caspian coast was temporary [4].

In this region, during the 3rd–2nd millennia BCE, tribes such as the Qamar-Saka, Gargars, Qashqars, and Caspians inhabited the land, while in the 1st millennium BCE, the area was settled by the Uti, Albanians, Aran, Sadak, Samak, Sharvan, Gugars, Shirak, and Ganja tribes—many of them associated with the Saka confederation.

In the early medieval stage (from the 7th century BCE to the 7th century CE), the left bank of the Kura River belonged to the Massagetae state, while the Mil-Mughan plains were part of the territories of Manna and Media. In the 4th century BCE, the Albanians—one of the largest tribes of the Massagetae—established a state whose territory encompassed the whole of Northern Azerbaijan, preserving its independence until 705 CE.

During this period, alongside the indigenous ancient tribes inhabiting the region, there was also a significant influx of migrant Turkic tribes—including the Huns, Bulgars, Gängars, Savirs, Khazars, and others—who settled in the lowland areas.

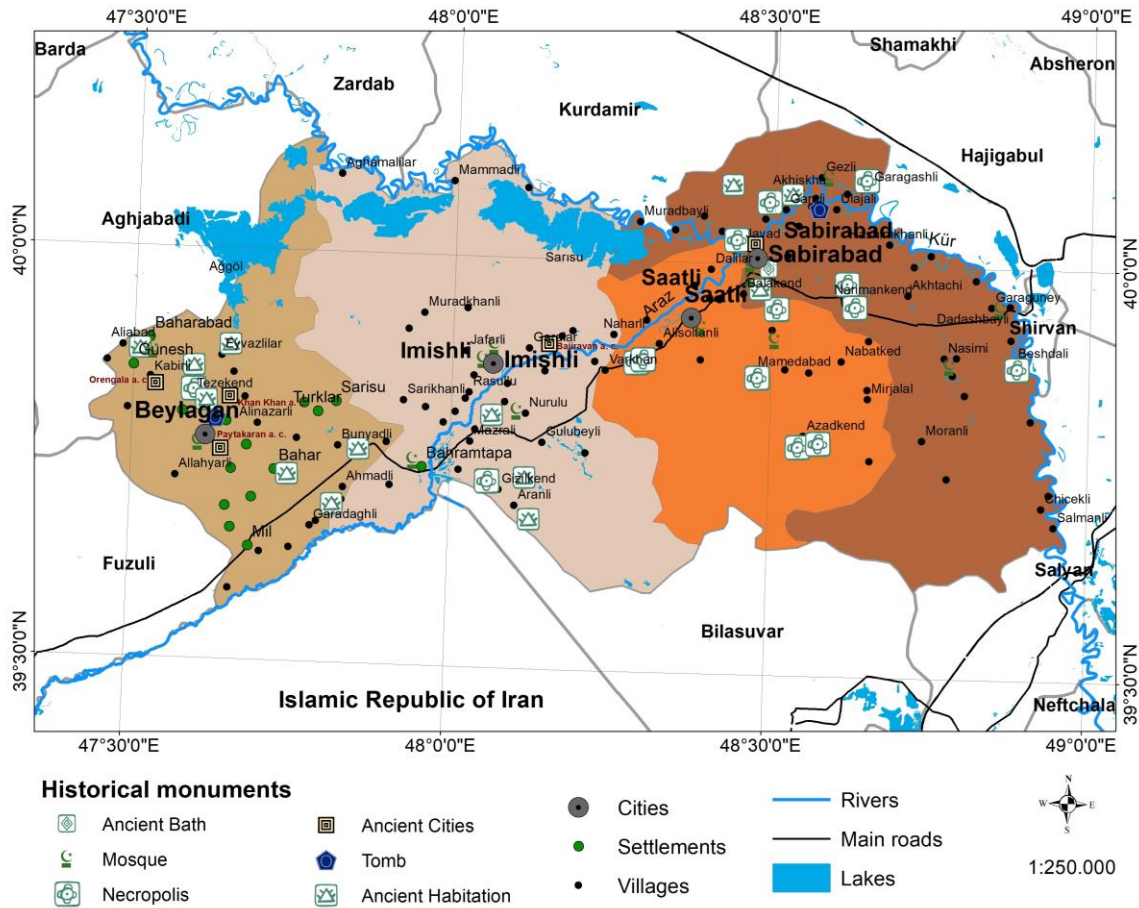


Figure 1. Cultural, historical and archaeological monuments in the Mil-Mugan economic region

In the middle stage, covering the period from the 7th to the 15th centuries CE, Arran was incorporated into the Arab Caliphate from the late 7th to the 10th centuries. During this time, the majority of the population embraced Islam, and the migration of Arab tribes into the lowland areas led to new settlement patterns. The Rabi'a tribe settled in Arran, while the 'Awdi tribe established themselves in Mughan [12].

The era of Arab civilization in Azerbaijan was marked by the emergence of Eastern Islamic-type cities. Among these were Beylaqan, Mughan, Barzand, Varsan, and Kiran. In the 9th–10th centuries, Azerbaijani cities transformed from small fortified settlements into major administrative-political, commercial-craft, and cultural centers. At that time, cities typically consisted of a citadel (narinqala), an inner town (shahristan), and a suburb (rabad).

Arab scholars referred to the language of Barda and the Arran population as the "Arranian language," which was in fact an evolved form of an ancient Turkic language. This language was spoken by the Gargars, Albanians, Utis, Pechenegs, Kangars, and others [2].

During the 11th–12th centuries, the Seljuk state flourished in the North Caucasus, and new waves of Turkic migration intensified. Tribes such as the Ayrum, Shamli, Baydilli, Takla, Inalli, Qaraman, Ahmadli, Aydinli, and Imirli settled across wide territories, with the largest concentration in Arran [9].

In the 12th–13th centuries, under the rule of the Atabegs, both the economy and culture experienced remarkable prosperity, accompanied by the settlement of Oghuz tribes in Arran. It is no coincidence that the 12th century is often referred to as the "Golden Age" of Azerbaijani culture. During this period, the major cities of Arran included Barda and Beylaqan, while in Mughan the principal urban centers were Mughan, Bacravan, Barzand, Bilasuvar, Mahmudabad, and Hamshahra.

In the Mongol era, numerous Mongol-Turkic tribes and clans—such as the Sulduz-Chobani, Jalair, Qurgan, Kingit, Sunit, Ongut, Tatar, Oirat, Dolan, Alar, Uran, Alet, as well as others—settled in the region, accompanied by nearly 200,000 Turkic families. Arran and Mughan served as the winter pastures of the Ilkhanids, while Karabakh

was used as summer pastures. During this period, the Bayat, Qajar, Afshar, and Quman tribes also established themselves in Azerbaijan.

The incoming groups were divided into two categories: the Uighur Turks and the Turkicized Mongols [12].

During the 13th–14th centuries, under the Mongol invasions, not only the city of Beylaqan but also Mughan and Baciravan were destroyed and turned into ruins. In the period of the Ilkhanids, the Mil-Mughan territory became a winter pasture, while Uighur Turks and Mongol tribes settled in these lands.

In the 15th century, when the Qara Qoyunlu and Aq Qoyunlu dynasties came to power, their respective tribes established themselves in Arran - first the Qara Qoyunlu, and later the Aq Qoyunlu - settling around ancient homelands and their surrounding areas. Among these were the Saatli, Sadli, Barani, Chagirli, Takla, Baharli, Alpaut, Kabirli, and other tribes, which made these territories their place of residence.

The new stage (from the 16th century to the early 20th century) marked the first time in history that the whole of Azerbaijan was united as a single state under the Safavid dynasty. During this period, Arran was divided into two beylerbeyliks: the Mil-Karabakh plains were incorporated into Karabakh, while the remaining territories were assigned to Shirvan.

In the 16th century, the Qizilbash tribes, and later in the 17th–18th centuries the Shahsevan tribes, established new layers of settlement. In the 1740s, the era of the khanates began. In the eastern part of the Shirvan plain the Shirvan Khanate was formed, while in its central part arose the Shaki Khanate. In the Mil-Karabakh plains, the Karabakh Khanate was established; in the Mughan plain, the Javad Khanate; and in the Salyan plain, the Salyan Khanate.

At the beginning of the 19th century, internal conflicts among the khanates prevented the formation of a unified state, which in turn paved the way for wars between Russia and Iran over the Caucasus. As a result, the territory of Arran was completely occupied and, under the Treaty of Gulistan in 1813, was incorporated into the Russian Empire. During this period, the Khan of Shirvan resettled 6,000 families in Mughan [4, p. 36].

The resistance of the local population against Russian forces led to the destruction of the cities of Javad and Baciravan, as well as the devastation of villages. The mass exodus of local inhabitants

created favorable conditions for the settlement of Russians and Ukrainians in the region. In the 1830s, the Mil-Mughan area was incorporated into the Shirvan Province, from 1840 into the Shamakhi Governorate, from 1859 into the Baku Governorate, and from 1869 it became part of the Javad District of this governorate. This administrative division remained in effect until 1929 [12].

The first Russian settlements in Mughan began in the 1860s. While in 1909 there were only 13 Russian villages, by 1918 their number had increased to 52 across the Mughan and Salyan plains. On the site of the former city of Javad, the town-type settlement of Petropavlovka was established in 1888. Its population stood at 1,467 in 1914, and 1,288 in 1923 [17].

With the establishment of the Azerbaijan Democratic Republic in 1918, Russians left these territories; however, after the Soviet government was established, they returned and resettled in 34 villages in Mughan. The central parts of the Mughan and Salyan plains served as winter pastures for the nomadic Shahsevan tribes. According to the 1870 census, the Shahsevan population numbered 74,700, with 12,450 tents, organized into 15 clans. In 1885, the Tsarist government prohibited their entry into Mughan, but those who accepted Russian subjecthood were allowed to settle there.

In the early 20th century, new Russian villages were founded along the newly constructed irrigation canals: 18 along the Middle Canal, 13 along the Azizbeyov Canal, 8 along the Bolgar River, and several others along different canals. This migration continued into the early Soviet period; in 1925, a segment of Shahsevan migrants from Iran accepted Soviet citizenship and settled in various villages, while those who did not were placed separately in eight distinct villages.

In the Mughan-Salyan plains, settlement was concentrated along riverbanks: there were 32 local villages along the Kura River and 35 along the Araz River [4].

The study of population change in the Mil-Mughan region during the late 19th and early 20th centuries has been carried out on the basis of census materials conducted first in Russia and later in the Soviet Union (Table 1). During this period, the territory was entirely incorporated into the Javad district, with the exception of the Beylaqan area, which was included within the Jabrayil district.

Table 1

Population of the Mil-Mughan Region between 1870 and 1939 (in thousands)

Districts and Regions	1870	1886	1897	1916	1926	1939
Javad	46,4	93,6	93,8	162,3	132,0	249,1
Beylagan	12,0	14,0	15,0	17,5	23,5	19,5

Source: Eminov, 2022, p. 102, Table 1.7.24.

Table 2

Changes in Population across Administrative Districts (in thousands)

Administrative Districts	1939		1959		1970		1959-1970 growth %
	total	city	total	city	total	city	
Saatly	-	-	25,2	5,9	44,3	6,6	75,8
Sabirabad	53,5	6,3	52,2	8,9	85,9	13,4	64,6
Beylagan	15,3	4,2	29,8	4,2	48,5	9,5	62,8
Imishli	34,5	2,3	36,6	10,5	59,7	20,4	63,1

Source: [4, s. 106, table.1.7.26.) and census materials

Between 1870 and 1886, the population of the Javad district more than doubled, which was primarily linked to the settlement of the Shahsevan tribes in the area. However, due to subsequent policies of resettling part of the Shahsevan population out of Mughan, no further significant growth was observed. From 1897 to 1916, the population increased rapidly, largely as a result of the resettlement of Russians into the region. In fact, between 1907 and 1916 alone, more than 20,000 Russians were settled in Mughan, which also led to the displacement of the Shahsevan from their native lands.

As a continuation of Tsarist policies, the Bolsheviks, through the involvement of Armenians and Cossacks in Mughan, carried out mass atrocities against Azerbaijanis in 1918–1919. After the establishment of Soviet power in 1920, these repressions continued under the labels of “müsavətçi”, “qolçomaq,” and “dindar” [4]. As a result, the population decreased by more than 60,000 between 1916 and 1926.

During the Soviet period, the administrative-territorial structure of Mil-Mughan underwent significant changes. In 1930, the districts of Imishli and Sabirabad were established, followed by Beylagan in 1939 and Saatly in 1943. With the creation of these districts, the settlements of Sabirabad and Imishli, and later Beylagan and Saatly, were granted township status. Subsequently, these settlements were elevated to city status: Sabirabad in 1935, Imishli in 1960, Beylagan in 1966, and Saatly in 1971.

Between 1948 and 1958, more than 100,000 Azerbaijani Turks were deported from Armenia, part of whom were resettled in the districts of Saatly and Sabirabad. Later, between 1958 and

1968, up to 30,000 Meskhetian Turks arriving from Central Asia were also settled in these areas [4]. In Beylagan district, Meskhetian Turks began to settle following their deportation from Georgia in 1944 and especially after 1958 [8].

Between 1939 and 1959, population change across the administrative districts was relatively modest, with the exception of Beylagan, where the influx of migrants from Western Azerbaijan led to rapid growth. During 1959–1970, the population increased 1.6–1.7 times, a rise largely attributable to both higher natural population growth and the resettlement of tens of thousands of Meskhetian Turks in the districts of Sabirabad, Saatly, and Beylagan.

In this period, the urban population of Imishli and Beylagan districts more than doubled. In 1960, the settlement of Bahramtapa (formerly Birmay, Imishli district) was granted township status, followed by Qahramanli (Beylagan district) in 1966.

3. Conclusion

The historical and geographical settlement of the Mil-Mughan plain has undergone major stages of development from ancient times to the modern era. Research indicates that this territory, owing to its geographical position and natural resources, has long been attractive to human settlement. The principal residential areas were concentrated along the banks of the Kura and Araz rivers, while in the 20th century new settlement centers emerged with the construction of irrigation canals.

At the same time, since the 19th century, the Mil-Mughan plain has witnessed significant demographic changes and migration processes. In particular, the establishment of Russian villages during the Tsarist period and population resettlement

ments under Soviet administrative divisions had a profound impact on the settlement structure. Historical sources reveal that the region has held great importance since antiquity as a center of agriculture, animal husbandry, trade, and craftsmanship, and it was situated along the Silk Road. In the Middle Ages, its largest city was Beylagan.

In terms of historical and cultural heritage, the region represents one of the country's richest areas, distinguished by its ancient settlements and archaeological monuments.

Proposals:

1. Expansion of historical-archaeological research – Conducting more in-depth scientific investigations and uncovering new archaeological findings in the Mil-Mughan plain would contribute to a better understanding of the region's history.

2. Development of tourism – The Mil-Mughan region holds broad opportunities for strengthening its historical, religious, and cultural tourism potential. In particular, its ancient settlements—such as the historic city of Beylagan—should be integrated into tourism routes.

3. Formulation of economic development strategies – Special projects should be developed to foster the growth of agriculture and industry by utilizing the region's historical and geographical potential.

Activities carried out in these directions can both preserve the historical and geographical significance of the Mil-Mughan plain and contribute to its socio-economic development.

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MIL-MUĞAN DÜZÜNÜN TARIXI-COĞRAFI MƏSKUNLAŞMASI XÜSUSİYYƏTLƏRİ

Bayramov E.A

Xülasə. Məqalədə Mil-Muğan iqtisadi rayonunun tarixi məskunlaşması qədim dövrdən müasir dövrə kimi inkişaf mərhələləri üzrə təhlil edilmiş, ərazinin tarixi-arxeoloji abidələri araşdırılmışdır. Mil-Muğan düzünün tarixi-coğrafi xüsusiyyətlərinin təhlili bu yerlərin böyük hissəsinin tarixən qışlaq olması ilə fərqləndirmişdir. Təhlillər nəticəsində müəyyən edilmişdir ki, daimi yaşayış məskənlərinin çoxu Kür və Araz çaylarının sahilində olmuş, XX əsrin əvvəli və ortaları yeni salınan məskənlər yeni çəkilən kanalların sahilində olması ilə bağlı olmuşdur. Məqalədə həmçinin XIX əsrdən XX əsrin 70-ci illərinə kimi əhali sayının dəyişməsi, miqrasiya proseslərini, çarizm dövründə Muğan ərazisində aparılan siyasət nəticəsində yerli əhalisi sayılan şahsevənlərin qışlaq yerlərində rus kəndlərinin salınması araşdırmaları aparılmışdır.

Açar sözlər: Mil-Muğan düzü, məskunlaşma tarixi, qədim şəhərlər, şəhər, miqrasiya

ECOGEOGRAPHY

DEVELOPMENT FEATURES OF NATIONAL PARKS AND PROSPECTS OF REGIONALIZATION

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Abstract

National parks are recognized as areas with significant tourism potential, offering diverse recreational resources that attract visitors seeking natural experiences and relaxation. In addition to tourism, these parks serve multiple functions, including nature conservation, education, scientific research, cultural preservation, and economic development. National parks play a critical role in protecting unique natural areas by implementing strategic measures aimed at addressing existing challenges and fostering sustainable tourism development. In recent years, efforts to establish a sustainable tourism infrastructure have facilitated the functional zoning of national parks. Functional zoning allows for the assessment of physical parameters to determine spatial similarities and define land-use values according to specific objectives. This process considers the distinctive characteristics of each territory, identifies promising recreational zones with varying degrees of ecological stress, and results in the creation of maps that reflect natural, historical, and tourism-recreational features. The present study examines the developmental characteristics of national parks, with a specific focus on the functional zoning of Samur-Yalama National Park as a case study.

1. Introduction

Although the evaluation of tourism resources has traditionally been a core topic within tourism research, it has gained renewed theoretical and practical significance in recent years. This type of assessment is particularly valuable for informing the development of regional tourism strategies and spatial planning concepts [2]. The technological dimension of resource evaluation enables the identification of the most promising forms of tourism activity across different seasons [1]. The concept of placement and planning of tourism facilities is considered the beginning of the initial stage of integration by involving socio-economic potential in tourism turnover from a regional perspective. Because tourism is a means for the efficient use of natural resources, the involvement of labor resources in tourism turnover, the promotion of production and tourism products, the improvement of service areas over time, and the introduction of tourism infrastructure to the world

market in line with modern standards. It is from this perspective that national parks in the world and in Azerbaijan are considered as objects with a complex territorial structure and requiring a multifunctional management system. Their use must ensure the preservation of the natural, aesthetic, and cultural-historical values attributed to both the legal landowners and the economic entities operating within the parks. A key instrument in shaping the long-term development and management strategies of national parks is the delineation of park boundaries and the implementation of functional zoning.

2. Material and method

The analysis conducted in this study was based on field research, supported by a range of scientific literature, archival materials from the Institute of Geography, and the application of Geographic Information Systems (GIS) technologies. Both empirical and theoretical research methods were employed to generate new knowledge.

Empirical methods were utilized for observation, comparison, and modeling, while theoretical approaches were applied to achieve logical interpretation, systematic structuring, synthesis, functional zoning, regionalization, and other forms of analytical assessment.

3. Analysis and discussion.

The determination of the boundaries of national parks and the scientific justification of these boundaries characterize the development features of the national park in the future. Because the boundaries of national parks should be based on the efficiency of management of the territory, should be aimed at its protection, stimulation of land use and determining the nature of relations with them. However, the implementation of zoning in national parks is studied in a comprehensive manner, taking into account the standards adopted in local and international practice.

The development characteristic of each national park must necessarily include, based on the criteria of certain typical natural, historical and cultural complexes within its territory, rare natural monuments and valuable anthropogenic objects that are distinguished by their unique landscape and aesthetics, and that help preserve ecological integrity [5]. Therefore, the zoning of national parks is of great importance. When zoning national parks, their borders should run along landscape types to the maximum extent, taking into account all natural complexes. In this case, the borders should be clearly drawn and they should be consistent with river beds, forest areas, roads, and appropriated lands. Along with this, perspective areas should be taken into account in accordance with the future development directions of national parks. These areas should be included in important and multifunctional procedural rules. Because they play a role as an intermediary in making certain decisions, such as choosing their future activities and areas that bring income to the economy.

In the process of developing schemes for various activities within the boundaries of national parks, it is essential to consider not only the protected core areas but also the surrounding buffer zones, ensuring that no harm is caused to the natural environment. Any proposed changes aimed at promoting overall development within these territories must comply with national legislation, relevant regulatory frameworks, and the specific statutes governing each national park. Land use planning should take into account the diversity of natural complexes, the presence and operations of economic entities, the lifestyle and

needs of the local population, the expected number of visitors, and other relevant environmental and socio-economic factors.

National park areas are defined as a sustainable strategy for conserving biodiversity, but in some cases their purpose is to provide services and value to multiple users. Zoning is the main tool used to manage these value requirements [3]. Important conditions for the development or use of zoning include the following [6]:

- decision-making through management programs;
- constant public support;
- emergence of subjective and contradictory values;
- availability of inadequate primary resource information, etc.

In general, the territories of national parks are characterized by significant spatial and ecological heterogeneity. As a result, initial planning efforts are typically undertaken to guide land use and the development of necessary infrastructure. However, in certain cases, conflicting objectives within national parks give rise to serious management challenges. A prominent example is the tension between the need to preserve pristine natural monuments and the simultaneous demand to provide unrestricted access to those same sites for tourism purposes. To address such conflicts effectively, it is essential to implement optimal architectural and functional zoning strategies that balance conservation priorities with sustainable visitor access and use.

Zoning within national parks is undertaken to ensure their more efficient and sustainable use. From a methodological standpoint, many researchers delineate zones primarily on the basis of landscape maps; however, aesthetic, cultural, and recreational values of the territory are also important considerations in this process. Subsequent stages of zoning involve specialized assessment work to identify and characterize key elements such as biodiversity, fauna, natural monuments, and sites of significant cultural value within the proposed park area. Additionally, it is crucial to consider the extent of ecological and economic use already occurring within the territory. In the zoning of each national park, particular attention is paid to maintaining an ecologically healthy environment while simultaneously maximizing the functional benefits derived from the land.

The zoning of national parks is closely linked to territorial management and involves the planned use of natural complexes, including the prior identification, protection, and regulation of areas

accessible to different groups of visitors. Effective zoning requires careful consideration of specific natural conditions and their individual components, as well as the strategic objectives of national park management. However, in such cases, it is not always necessary to implement overly complex functional zoning schemes; instead, a balanced and pragmatic approach tailored to the ecological and managerial context of the park may be more appropriate.

The primary purpose of zoning in national parks is to ensure the effective protection and management of functionally distinct areas. This requires the restructuring of land use based on varying levels of ecological integrity and economic activity. Within the framework of simplified management planning, the successful implementation of zoning plays a critical role in guiding conservation and development efforts. Moreover, the long-term development prospects associated with zoning should be aligned with national-level strategies, incorporating both the distinct characteristics of each zone and contemporary management policies. In this context, conducting targeted assessments during the zoning process enhances the relevance and effectiveness of sustainable tourism strategies, ensuring a balance between environmental protection and visitor engagement [7]. The zoning of protected areas designated for tourism use is theoretically grounded in the principle of efficient land use rather than the imposition of restrictive measures solely for management purposes. In such cases, the emphasis is placed more on the potential and availability of resources than on

strict biophysical constraints. Objective criteria are applied in the determination of functional zones, which may include the evaluation of alternative zoning schemes and the adoption of approaches based on natural conditions, landscape features, and resource availability. This resource-oriented perspective allows for greater flexibility and adaptability in planning, while still aligning with broader conservation and tourism development goals [4]. The primary criteria for determining the boundaries of functional zones within national parks are the predefined conservation objectives, which simultaneously serve as a foundation for addressing existing management weaknesses.

Both internationally and within Azerbaijan, national park territories are typically divided into various functional zones, each with distinct purposes and regulatory frameworks. To facilitate a more comprehensive analysis and practical implementation of these zones, this study proposes a conceptual framework entitled the “Sustainability Model of Functional Zones of National Parks” (Fig. 1). This model enables the identification of the activity focus for each functional zone and provides a basis for evaluating their management structures and overall sustainability.

- Reserve Area – observes the process of nature development in order to preserve the naturalness of nature without human intervention, completely eliminates economic and recreational impacts on the ecosystem, allows for scientific research, environmental monitoring and special environmental measures.

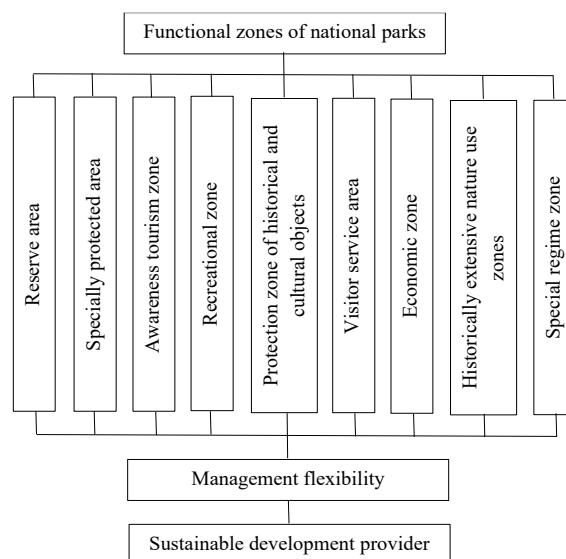


Figure 1. Sustainability model of functional zones of national parks

- Specially Protected Area – includes rare natural complexes, areas with unique and attractive recreational potential, natural monuments characterized by a high degree of sensitivity, for which it is impossible to establish a reserve regime, but which are considered extremely valuable from an ecological point of view, and constitute the ecological core of the protected area.

- Awareness Tourism Zone – shows visitors the diversity of the most valuable natural and historical and cultural monuments along specially organized tourist routes, organizes environmental education work, and also provides for the provision of tourists with places for overnight stays and recreation.

- Recreational zone – a form of organizing short-term and long-term recreation using the components of nature without affecting biological sustainability.

- Protection zone of historical and cultural objects – historical and cultural objects that are specially protected and registered as state monuments are presented to tourists without disturbing the appearance of the landscapes.

- Visitor service area – is created near the road and transport infrastructure to present the aesthetic values of the area and organize the comfortable rest of the guests, organizes various types of services: reception, accommodation, catering, organization of exhibitions, information service, sports games, socio-cultural events and others.

- Economic zone – regulates the efficient use of natural resources and ensures environmental protection, controls the activities of economic entities without harming nature.

- Historically extensive zone – of natural resource management are territories in which the local population has historically and currently carried out economic activities within the framework of relevant regulatory acts (in some sources they are called ethnoeconomic territories).

- Special regime zone – the location of a protected object in connection with the protection and management of borders.

The borders and regime of the functional zones of national parks are variable, and some adjustments may be made to them over time. Although these regulatory mechanisms are proposed on the basis of long-term monitoring observations, the final decision is approved at the state level. That is, the abolition of the borders and regime of functional zones or the increase in powers is

carried out after amendments are made to their use and protection.

4. Conclusion

The application of the proposed model and the generalizations derived from this research indicate that the structure of functional planning in national parks necessitates a comprehensive environmental management regime. This includes the development of tourism and recreational activities, the organization of tourist routes, the allocation of administrative and operational areas, and the facilitation of scientific research and environmental monitoring. For functional planning to be effective, zoning must be clearly defined and strategically aligned with the broader developmental objectives of the national park. High-value natural complexes should, as much as possible, be concentrated within a single zone to ensure their protection. Other zones should be designated for complementary functions such as environmental education, infrastructure development, tourism and recreation services, and leisure facilities. This approach ensures both the conservation of ecological assets and the sustainable development of tourism within national parks. These efforts necessitate the development of automated systems for the preparation and management of spatial databases, primarily through the use of Geographic Information Systems (GIS) technologies. GIS enables the schematic division of national park territories into functional zones, thereby supporting more precise and data-driven planning. The work undertaken in this context should be regarded as a long-term strategic planning document. In this study, we have applied functional planning methodologies using the case of Samur-Yalama National Park. We believe that the proposed planning approach will significantly enhance the future operational efficiency and sustainable management of the park.

As a result of our research on the functional zoning of Samur-Yalama National Park using a GIS-based approach, a detailed zoning map was developed (Figure 2). The analysis revealed that 28.3% of the park's total area is designated as specially protected zones, aimed at preserving ecologically sensitive and high-value natural areas. Economic zones, which encompass tourism-related enterprises, constitute 21.8% of the territory. Recreational areas account for 19.4%, while 12.2% of the land comprises historically utilized areas reflecting extensive human activity in earlier periods. Cognitive tourism zones, focused on educational and interpretive activities, represent 10.2% of the area. Visitor service zones

make up 5.7%, historical and cultural heritage sites occupy 1.6%, and special regime areas-subject to specific regulatory controls-cover the remaining 0.8%. This zoning distribution provides a foundation for sustainable management and balanced land use within the national park.

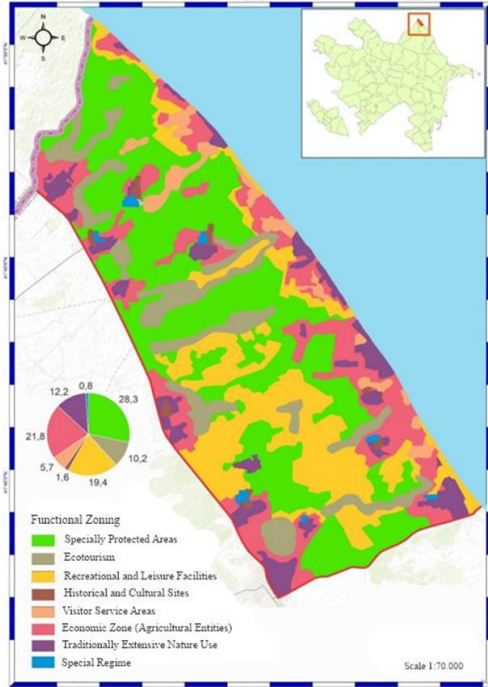


Figure 2. Functional zoning map of Samur-Yalama National Park

It should be emphasized that the primary planning decisions involve establishing the necessary regimes for the protection and utilization of the territory, encompassing both environmental and economic measures. These, along with other essential tasks, are codified within the principal planning document of the national park and serve a supportive function in guiding all subsequent management decisions. Effective planning delineates the overarching strategic directions for the national park as an integrated system, facilitating the coordination of all land users within its boundaries to contribute constructively to the preservation of ecological conditions.

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MİLLİ PARKLARIN İNKİŞAF XÜSUSİYYƏTLƏRİ VƏ RAYONLAŞDIRILMASI PERSPEKTİVLƏRİ

A.M. Əliyeva

Xülasə. Milli parklar zəngin turizm potensiyasına malik olan ərazi hesab olunur. Turistlər milli parklarda təbiətdən zövq almaq və istirahət etmək üçün rekreasiya ehtiyatlarına müraciət edir. Bu zaman təbiəti mühafizə, maarifçilik, elmi, mədəni, iqtisadi və digər istiqamətli tədbirlər həyata keçirilir. Milli parklar həmçinin unikal təbiət əra-zilərinin mühafizə prinsiplərini həyata keçirir, mövcud problemlərin aradan qaldırılması üçün tədbirlər paketi işləyin hazırlayır və turizmin perspektiv sahələrini inkişaf etdirir. Son illər bu istiqamətdə görülən işlər və davamlı turizm infrastrukturunun yaradılması üçün milli parkların funksional zonallaşdırılması və rayonlaşdırılması aparılır. Funksional zonallaşdırılma yolu ilə fiziki parametrlərin oxşarlıq səviyyəsi müəyyən edilir, təyinatı üzrə dəyər prinsipləri işlənilib hazırlanır. Rayonlaşdırılma aparıldıqda isə ərazinin yerli xüsusiyyətləri nəzərə alınmaqla onun fərqləndirici xüsusiyyətləri aşkar edilir, ekoloji cəhətdən müxtəlif dərəcədə gərginliyə malik olan perspektivli rekreasiya zonaları müəyyən olunur, təbii və tarixi xüsusiyyətlər, eləcə də turizm-istirahət mərkəzləri nəzərə alınmaqla xəritə tərtib edilir. Bu baxımdan, təqdim olunan tədqiqat işində milli parkların inkişaf xüsusiyyətləri araşdırılır, bir nümunə kimi Samur-Yalama Milli Parkının funksional zonal-laşdırılma üzrə rayonlaşdırılması verilir.

Açar sözlər: milli park, turizm, turizm infrastrukturunu, funksional zonallaşdırılma, rayonlaşdırılma.

TOPONYMY

GEOGRAPHICAL NAMES THAT PRESERVE THE TRACE OF THE QUSHCHU TRIBE

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Abstract

The Qushchu tribe is one of the ancient nomadic tribes that played an important role in the history of Azerbaijan and, more broadly, in the history of Turkic peoples. The presence of various geographical names associated with their name demonstrates the wide territorial spread of this tribe throughout history and its place in Turkic ethnography. This article analyzes the origin, history, geographical traces, and contemporary role of the Qushchu tribe in the Turkic world. The Qushchu tribe has long attracted the attention of different researchers, and various views exist regarding their origin. Most scholars assert that the tribe is of Turkic origin, while some specialists link them to the Mongols. However, the prevailing view is that the ethnonym Qushchu derives from the Turkic language and means “bird hunters” or “hunters of birds of prey.” This is further confirmed by the fact that among the Bashkirs, the Qushchus were known as “bird hunters,” which indicates that they were not of Mongol origin.

1. Introduction

Geographical names - toponyms - that exist in various regions of Azerbaijan play an important role in preserving the memory of the country's historical, cultural, and ethnic past. The traces of the Qushchu tribe have been preserved within these toponyms. In the ethnogenesis of Azerbaijani Turks, numerous Turkic peoples – including the Suvars, Bulgars, Khazars, Kipchaks, and Oghuz - played a fundamental role. The Qushchu tribe was also among these ancient Turkic tribes, and their traces in geographical names can be found not only in Azerbaijan but also across a wide geographical area (Central Asia, the North Caucasus, Bashkortostan, etc.). Historical sources indicate that the Qushchu tribe was among the nomadic peoples widely spread across the Caucasus, the northern and western regions of Azerbaijan, as well as Northern Anatolia and Central Asia. From the early periods of Turkic history, and particularly during the Middle Ages, representatives of this tribe played a significant role in various states and provinces. Let us consider the research conducted by scholars on this tribe:

- The Qushchus are associated with the Durbans (a group claimed to be of Mongol origin), yet it is emphasized that they themselves were a Turkic tribe. In the 12th century, they lived under the rule of the Durbans and adopted the Kipchak language.

- There is a direct connection with the “Qushchu” clan of the Kyrgyz. V.V. Radlov and other Russian researchers considered the Qushchus to be one of the ancient tribes of the Kyrgyz. This clan inhabited the Altai, Irtysh, and Eastern Tien Shan regions [15].

- It is known that the Qushchus, together with other nomadic Turkic peoples, migrated from Central Asia to Azerbaijan and the Caucasus [4].

- Some scholars link the Qushchus with the Kushans, particularly emphasizing the possibility of the Kushans being of Turkic origin. The Kushans had a historical presence in Azerbaijan and Central Asia, and their rulers were referred to as “Yabgu” (prince).

- There are also views connecting them with the Huns and the Black Huns. N.A. Aristov and M.H. Valiyev-Baharly classified the Qushchus as part of the Hun tribes [8].

2. Analysis and Discussion

The sources used in this research include scientific reports from the Institutes of Geography, History, Literature, Archaeology, and Ethnography; archival materials from the collections of the National Archives of the Republic of Azerbaijan; scholarly works, methodological guidelines, and literature produced by researchers in this field; as well as the results of the author's own scientific investigations.

The word "Qushchu" in ancient Turkic languages means "bird hunter" or "a person engaged with birds." This tribe was primarily distinguished by horseback hunting and a nomadic way of life. Within ancient Turkic societies, the Qushchus functioned not only as hunters but also as executors of certain military duties. Their traditions associated with birds - particularly falcons and hawks - hold a significant place in the cultural heritage of Turkic peoples [12].

Several villages, settlements, and geographical objects in Azerbaijan and neighboring regions bear the name of the Qushchu tribe. Settlements named Qushchu are recorded in Gazakh, Shaki, and other districts. The spread of these names reflects the historical distribution of the tribe and its influence in the territories where it once resided. The toponym has not remained merely a place name but has also become associated with certain tribal and family names, turning into a bearer of cultural and geographical memory:

Within the territory of the Republic of Azerbaijan:

- Four villages named "Qushchu" are located in the districts of Goygol, Yevlakh, Lachin, and Shamakhi.

- Geographical features such as "Qushchu Mountain" and "Qushchular Mountain" are registered in the Shamakhi and Khojavand districts [11].

- In Dashkasan district, the names "Qushchu village", "Qushchu temple", and "Qushchu mountain" are found.

- Three villages named "Qushchu-Ayrim", "Dondar Qushchu", and "Ashaghi Qushchu" exist in the Gazakh and Tovuz districts.

- Villages named "Dali Qushchu", "Dagh Qushchu", and "Chol Qushchu" are located in the Zardab, Siyazan, and Shabran districts [14].

- Villages with the names "Qushlar" or "Qushiler" are found in the Gabala and Kurdamir districts.

- "The toponym "Qushchular" is reflected in villages of the Goranboy, Jabrayil, and Khojavand districts.

- Two villages named "Ashaghi Qushchular" (Lower Qushchular) and "Yukhari Qushchular" (Upper Qushchular) are registered in the Shusha district.

- The ruins of "Qushlar" village are located in the Oghuz district.

- The family and clan names "Qushar" have been preserved to this day in the village of Ilisu, Gakh district [7].

Beyond the borders of Azerbaijan, in historical-ethnic areas:

- In Georgia's Marneuli district, there exists a village named "Qushchu" and a historical monument called "Qushchu Fortress".

- In various parts of the former Erivan Khanate and Erivan Governorate, three villages and geographical names existed under the names "Qushi", "Qushchu", and "Qushideresi" [6].

- In the Gazakh uyezd of the Ganja Governorate, "Qushchuyaya" was recorded as a mahal (district) name.

- In the districts of Abaran, Daralayaz, and Kapan of present-day Armenia, several villages named "Qushchu" existed until the late 19th century, after which they were either abolished or renamed [5].

- In the West and East Azerbaijan provinces of the Islamic Republic of Iran, as well as in the Qazvin province, there exists a city and several villages bearing the toponym "Qushchu".

The toponym "Qushchu" is, in general, one of the ancient ethno-toponyms widespread throughout the Turkic-Muslim world. On the one hand, this name reflects tribal affiliation; on the other, it expresses cultural and geographical identity. Its wide distribution is primarily associated with the historical migration and settlement of Turkic-rooted population groups. The preservation of these toponyms is significant not only for maintaining historical memory but also for the development of cultural tourism potential [10].

According to 19th-century sources, more than 30 geographical objects in Azerbaijan reflected the name of the Qushchu tribe. Villages named Qushi khutoru also existed in the Kuban province of Russia. Settlements of the Qushchu and Kossi tribes are recorded in Bashkortostan and the North Caucasus as well [1]. In addition, similar names are found in other parts of the Caucasus and in northern Turkey, confirming that the Qushchu tribe moved across a wide geography and that connections existed among Turkic peoples [13].

Historical significance. The study of the historical and geographical traces of the Qushchu tribe is important not only for reconstructing the

past but also for understanding the formation of the cultural identity of the contemporary Turkic world. Their traditions of horseback hunting, elements of folklore, and linguistic features have been preserved to this day, reflecting the depth of intercultural connections among the Turkic peoples [9].

In the modern era, the roots of the Qushchu tribe and their place among Turkic ethnoses are being studied in greater depth, particularly through ethnographic and genetic research [2]. This contributes significantly to understanding the shared history of the Turkic peoples and to strengthening national identities.

In the Middle Ages, the Qushchus formed a military unit, especially among the nomadic Turkic peoples, and held an important position in Batu Khan's army. Their name is mentioned in 12th-century Armenian sources, indicating their presence in the territory of Azerbaijan since ancient times. During the Shaybanid period (16th century), the Qushchu tribe occupied a prominent position among the nomadic Uzbeks. They later became integrated into the Kazakh, Turkmen, Uzbek, Bashkir, and other Turkic peoples [3].

3. Conclusion

The Qushchu tribe occupies a distinctive place in the Turkic world both historically and culturally. The spread of geographical names associated with their name demonstrates the tribe's presence across vast territories and its significance among Turkic peoples. The traditions and traces of this tribe continue to live on within the cultural heritage of Turkic nations today, and future research will further clarify their historical and cultural role.

Studies reveal that the name and traces of the Qushchu tribe hold an important place in the richness of Turkic ethnonyms. Their origin and history are multifaceted, and the Qushchus played a significant role not only in the history of Azerbaijan but also in the wider Turkic world. The ethno-toponyms preserved in geographical names provide evidence of the settlement of ancient Turkic peoples in Azerbaijan and neighboring regions.

The widespread distribution of geographical names linked to the Qushchu tribe confirms not only their existence during specific periods and in particular regions but also their deep roots within the cultural memory of Turkic peoples. Their nomadic lifestyle, horseback hunting, and bird-related traditions highlight their unique position in the Turkic ethnogenetic system.

Among contemporary Turkic peoples, the legacy of the Qushchu tribe is still preserved – particularly through traditions of falconry on horseback, as well as elements of folklore and language. For instance, in certain regions of Azerbaijan, the art of bird hunting and its terminology continue to reflect this ancient Turkic practice.

Moreover, the analysis of geographical names shows that the influence of the Qushchu tribe extends beyond Azerbaijan to other parts of the Caucasus, as well as the North Caucasus and Central Asia. This confirms that the tribe established wide-ranging nomadic and trade connections.

In future research, organizing ethnographic expeditions to explore the linguistic, cultural, and geographical traces of the Qushchu tribe, documenting traditional practices of bird hunting, and conducting genetic studies would be highly beneficial. Such efforts would help to more accurately determine the tribe's origins and its place within the broader system of Turkic peoples.

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QUŞÇU TAYFASININ İZİNİ YAŞADAN COĞRAFİ ADLAR

N.Q.Babayev

Xülasə. Quşçu tayfası, Azərbaycan və ümumilikdə türk xalqları tarixində mühüm rol oynamış

qədim köçəri tayfalardan biridir. Onların adı ilə bağlı müxtəlif coğrafi adların mövcudluğu bu tayfanın tarixən geniş ərazilərə yayılmasını və türk etnoqrafiyasındakı yerini göstərir. Bu məqalədə Quşçu tayfasının mənşəyi, tarixi, coğrafi izləri və müasir türk dünyasındakı rolu təhlil edilir. Quşçu tayfası uzun müddətdir müxtəlif tədqiqatçıların diqqətini çəkmişdir və onların mənşəyi haqqında fərqli fikirlər mövcuddur. Əksər alimlər bu tayfanın türk mənşəli olduğunu bildirir, bəzi mütəxəssislər isə onları monqollarla əlaqələndirir. Lakin əsas fikir odur ki, quşçu etnonimi türk dilindən gəlib və “quşbazlar”, “ahıcı quşların ovçuları” mənasını verir. Başqırdlar arasında da quşçuların “quş ovçuları” kimi tanınması ilə təsdiqlənir. Bu da onların monqol mənşəli olmadığını göstərir.

Açar sözlər: Quşçu tayfası, kuşanlar, Muğan xan, etnonim, oğuz eli, türk tayfaları.

INTERESTING SCIENTIFIC FACTS

QAFUR RASHAD MIRZAZADE: HIS LIFE, WORKS, AND CONTRIBUTIONS TO GEOGRAPHY

(on the occasion of his 140th anniversary)



A brief overview of Qafur Rashad's life path.

Among the prominent figures who played a significant role in the emergence of enlightenment ideas in Azerbaijan during the early and mid-20th century was Qafur Rashad Alakbar oğlu Mirzazade (06.05.1884, Shamakhi – 26.11.1943, Baku) – an educator, publisher-editor, pedagogue, geographer, publicist, translator, and editor.

Qafur Rashad was born on May 6, 1884, in Shamakhi district, into a poor family. At the age of seven, he began his primary education at a religious school (mollakhana) in Shamakhi (1890–1894) and then continued his studies at a six-year city school from 1894 to 1901. In his third year at the city school, his father, unable to afford the tuition fees, intended to withdraw him from school. However, because Qafur was an excellent student, the school administration decided to cover his expenses at the government's expense.

In 1901, at the age of 17, Qafur graduated from the six-year city school in Shamakhi. Since he did not have the financial means to continue his studies, he decided to work as a teacher. Later, from 1920 to 1922, he studied at the two-year Higher Pedagogical Institute in Baku, and in 1923 he was admitted to the Faculty of Economics at the Azerbaijan Polytechnic Institute, which he completed in 1927 at the age of 43. In 1901, Qafur Rashad also passed an examination before a special commission at the Alexander III Men's Gymnasium in Baku and received a certificate as an Azerbaijani language teacher.

In 1902, before reaching the age of 18, Qafur Rashad was appointed as a teacher at the primary school in the village of Lahij, Shamakhi district, where he worked from 1902 to 1907. During the first three years, since there was no dedicated school building in the village, classes were held in a cramped house. Later, with the help of the local residents – who were highly enthusiastic about education – a new school building was constructed, and the young teacher's working conditions improved significantly.

As a result, the number of children attending school increased year by year, and even adults began to show interest in becoming literate. Inspired by this, Qafur Rashad took the initiative to organize evening courses for adults and spent his free time in Lahij reading extensively. He read many books in Azerbaijani, Turkish, Persian, and Russian, thereby broadening his knowledge. In addition, Qafur Rashad regularly subscribed to the magazine *Molla Nasreddin* and read it to the attendees of the evening courses.

Through his dedicated work as a teacher in Lahij, Qafur Rashad earned the deep respect of the local community.

Recognized among the Baku intelligentsia as a knowledgeable and skilled teacher, Qafur Rashad was invited at the end of 1907 by the “Nashr-i Maarif” Charity Society to work at the teacher training courses (1907–1909). Later, he worked as a teacher at the “Rus-Muslim” school from 1909 to 1917. In 1917, he was invited to teach the mother tongue at the Baku Second Real School, and two years later, at the Baku First Real School. At that time, experienced teachers such as A. Shaig, Jamo Jabrayilbeyli, and Khudaverdi Kalantarli were also working at this school.

In 1919, the Baku First Real School had nearly 50 classes, but only one of them was a national (Azerbaijani) class. This class was headed by A. Shaig, while geography was taught by Qafur Rashad Mirzazade.

During the Soviet period, Qafur Rashad worked at the Azerbaijan State University, the Transcaucasian Cotton-Growing Institute, the Academy of Industry, the Institute of Industry, and the Azerbaijan State Scientific Research Institute.

Qafur Rashad actively participated in the social and cultural life of Azerbaijan in the early 20th century and published numerous publicistic articles in the periodical press on various social issues. In 1908, he published the book *Ayineyi-millət* (*Awaken, Brothers*), whose main idea was the criticism of political passivity and submission, and a call for national revival. Enlightenment was considered the main means of liberation in this work.

One of Qafur Rashad's most important contributions was his valuable work in providing national schools with textbooks. As the founder of school geography in Azerbaijan and the author of the first geography textbooks, Qafur Rashad Mirzazade also played a significant role in the development of national children's literature. His textbook *General Geography (Part One)* was published in 1911, and *General Geography (Part Two)* in 1916. His work *Geography of the Caucasus*, published in 1919, was the first textbook written in the national language among all Turkic-speaking peoples living in Russia.

He was also the founder of *Məktəb* (*School*) magazine (1911–1920), the second children's magazine in Azerbaijan after *Dəbistan* (1906–1908), as well as the founder of the first printing house of the same name that published literature for children.

Distinctive features of Qafur Rashad's geographical activities. When examining Qafur Rashad's work in the field of geography, it should be noted that his geographical legacy is very rich, with a total volume exceeding 120 printed sheets. In addition to being the author of several works on general geography and the geography of countries, Qafur Rashad also wrote works of a purely scientific and methodological nature. He began writing geographical works in 1909 and continued this activity until 1943. During this period, he created more than 20 geographical works, almost all of which – except for about four – were published.

It is possible to highlight the following distinctive features of Qafur Rashad Mirzazade's pedagogical and geographical activities:

1. First and foremost, Q.R. Mirzazade was a promoter of scientific knowledge, especially geographical knowledge. Throughout his life, he lived with this mission and with a passion for life. Honored Teacher of the Republic of Azerbaijan Nazim Nasraddinov, in his article "*The Qafur Rashad Mirzazade Phenomenon*" (2018), suggests that this may be related to the school education in Russian that Qafur Rashad received in

Shamakhi. The majority of teachers working at this school had received their education in Europe.

2. He emphasized the great importance of geography books, and books in general, in people's lives and in their cultural development:

- Starting from 1909, Qafur Rashad began writing geographical works – books, manuals, and articles – and continued this activity until 1943. Thus, over a period of 35 years, he created more than 20 geographical works, most of which were published, including: *Geography of the Caucasus* (1910), *General Geography* (Part I, 1911), *General Geography* (Part II, 1916), *Geography of Azerbaijan* (Part I, 1921), *Elementary Geography* (1922), *General Geography* (1923), *Dictionary of Geographical Terms* (1923), *Geography of Azerbaijan* (Part II, 1924), *Economic Geography of the USSR* (1941), and *Practical Work on the Map* (1943), among others. In his work *Geography of Azerbaijan*, Qafur Rashad explained the great significance of geography books as follows: "*The information presented here is not only statistical, but also viewed dynamically, showing as far as possible our progress and development in every field.*"

- Even before the above-mentioned works, in 1908 (when he was 24 years old), Qafur Rashad published his famous book *Ayineyi-millət* (*Awaken, Brothers*), written in the spirit of a call for national revival.

- The textbooks *Rəhbəri-sərf* (co-authored with Məmmədsadiq Axundov, 1910) and *Rəhbəri-hesab* (co-authored with Əbdürrəhman Əfəndizadə, 1910) by Q.R. Mirzazade were taught in schools for many years. The book *Rəhbəri-sərf* was devoted to the formation of our literary language, the fluency of the Azerbaijani language, and the precision of expressions.

3. He emphasized that traveling is essential for gaining life experience. Qafur Rashad loved to travel and frequently went on trips. He visited all districts of Azerbaijan, as well as Central Asia, Siberia, Georgia, Ukraine, and Belarus. His last journey took place in the Urals when he was 55 years old.

4. He placed great importance on using excursions in the teaching of geography and wrote about this:

"The teacher should take students on distant and nearby excursions to the greatest extent possible and have them write reports on their observations... Geography, which concerns the entire world, requires both distant and nearby excursions."

5. He recommended using a unique teaching methodology in the process of teaching geography.

6. He advocated for the extensive use of visual aids in geography lessons, giving priority to maps among them.

Qafur Rashad Mirzazade lived in Shamakhi until the age of 17, in Lahij until the age of 24, and spent 35 years of his life in Baku. In the last two years of his life, in addition to teaching, he worked as a researcher at the Azerbaijan State Scientific Research School Institute. In 1943, during the height of the war, he was sent to Shamakhi as a propagandist. Falling ill there, he was brought back to Baku and passed away on November 26.

The distinguished and phenomenal Azerbaijani intellectual Qafur Rashad Mirzazade devoted his entire life to serving the people and the state with his intellect and pen. He was buried as an ordinary citizen at Yasamal Cemetery, near the grave of General Aliaga Shikhliniski.

Qafur Rashad Mirzazade was not only an educator, scholar, pedagogue, and geographer but

also a courageous citizen and passionate propagandist. As early as 1911, in his work *General Geography, Part I*, he criticized the Tsarist administrative system, writing that the money collected from the people should be spent not on worsening their lives, but on improving their standard of living. He played a significant role in instilling a sense of resistance to the oppressive Tsarist regime among the people and in fostering confidence in revolutionary victory.

In addition to being an educator and scholar, Q.R. Mirzazade taught for 41 years. His greatest contributions were in the field of geography. Qafur Rashad is recognized in the history of Azerbaijani culture as the founder of the first geography textbooks in the mother tongue. Devoting all his energy to the scientific development and enlightenment of his people, Qafur Rashad's name continues to be mentioned today with great pride.

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