



## Assessment of Modern Natural-Ecological, Land and Agricultural Resources of the East Zangezur Economic Region of the Republic of Azerbaijan

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### ABSTRACT

The Republic of Azerbaijan exhibits significant regional variation in historical development, as well as ecological, economic, and geographical characteristics. This study focuses on the East Zangezur Economic Region, situated within the Lesser Caucasus, encompassing 744.8 thousand hectares. A combination of ecological, pedological, mathematical-statistical, visual, cartographic, and laboratory methods was employed in the investigation. Based on the analysis of fund and cartographic materials, a "Soil Map of the East Zangezur Economic Region" (scale 1:100,000) and a Digital Terrain Model Map were developed. An analysis of the distribution of agricultural lands by purpose within the economic region revealed that most of the land is used for pastures and livestock grazing 209.8 thousand hectares (69.03%) while cultivated agricultural land accounts for 59.3 thousand hectares (19.51%). Given the soil and ecological requirements of agricultural crops in the East Zangezur Economic Region, it is advisable to allocate more arable land for grain and vineyards in the Jabrayil district, while orchards, tobacco, potatoes, and vegetables should be prioritized in the Gubadli district. In the livestock sector, the Lachin district has the highest potential for meat (5.4 thousand tons) and milk production (23.9 thousand tons). Furthermore, the study analyzed the spatial distribution of mineral and non-mineral resources, as well as tourism assets, across administrative districts. Notable mineral deposits include the Soyudlu (Zod) gold deposit (125.5 tons), the Agyatag mercury deposit (1,050 tons), as well as deposits of onyx (1,756 tons), nephrite (801 tons), obsidian (2,337 tons), and perlite (4,473 thousand m<sup>3</sup>). These findings were integrated into a comprehensive resource distribution map for the East Zangezur Economic Region.

**Keywords:** East Zangezur, Soil cover, Mineral resources, Tourism, Agriculture.

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### INTRODUCTION

The economic development strategy implemented in various regions of the world aims to ensure sustainable and balanced growth, including the creation of a favorable environment that enables the formation of an environmental security system. This system supports a competitive economy based on the principles of sustainable development, social well-being that meets high standards, efficient use of natural resources, and reliable environmental protection. In this regard, scientists from different countries are conducting diverse research aimed at

ensuring regional economic development based on the efficient use of its natural resources. In the study of agricultural potential of lands in different regions, the integration of the analytical hierarchy process (AHP) and geographic information system (GIS) is used to determine the suitability of the land for major crops for the development of a sustainable agricultural system; the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Vise Kriterijumska Optimizacija i Kompromisno Resenje (VIKOR) models are also applied (Govoni et al., 2023; Kalaiselvi et al., 2024; Pujiono et al., 2024; Shaw et al., 2025; Wang, 2025; Saha & Gayen, 2025).

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To assess the natural resource potential of agricultural territories of the regions, point indicators of heat, moisture supply and soil fertility are used. Agroclimatic conditions were characterized based on average long-term data on the sum of air temperatures above +10°C and the amount of precipitation per year, and the assessment of soil properties is carried out according to the prevailing types of arable land (Aksenova & Shmidt, 2024). A Sustainable Agricultural Land Suitability Assessment (SALSA) for wheat and perennial crops is also being conducted using factors that affect yields and also indicate land degradation. (Kılıç et al., 2024). Reviews trends in the use of fertile land for non-agricultural purposes, especially at the rural-urban interface and on the outskirts of cities, which is a serious threat to food security in developing countries (Upreti et al., 2024).

In some regions, the use of renewable resources (biological, forest, soil, agroclimatic, water), as well as non-metallic building materials, is increasingly concentrated in compact areas near central locations and main transport routes, focusing on the use of "the best lands". As a result, the more successfully regional agriculture develops, the higher the resource-ecological dissonance (Danilov-Danilyan & Klyuev, 2023). Land Use and Land Cover (LULC) change serves as an important indicator of human land use patterns in regions, playing a key role in the conservation of natural resources. The main causes of LULC changes include agricultural expansion, policy changes, population growth, land scarcity, and biophysical factors. The consequences of such changes include biodiversity loss, depletion of forest resources, habitat alteration, reduced water quality and availability, and decreased crop yields. Thus, studying global land use patterns becomes a priority in addressing climate change issues and promoting sustainable development (Mir et al., 2025).

The assessment of soil resources suitable for agricultural crops (barley, wheat, and others) includes a quantitative evaluation of land and its classification by Land Mapping Units (LMU), as well as the creation of a land suitability map. Land suitability assessment utilizes data on climatic conditions, topography, and the physical and chemical properties of the soil, which are analyzed using ArcGIS Environment and the Priority Assessment Tool (PriEsT) (Abate & Anteneh, 2024). The integration of the liberated territories of the country into the economy and economic circulation required an update of economic zoning, as well as a more accurate and efficient allocation and distribution of productive forces and resources. To facilitate the development of the liberated territories and integrate them into the country's economy, as well as to enhance the effectiveness of planning in other economic regions, the President of the Republic of Azerbaijan signed a decree on July 7, 2021, concerning the new division of economic regions within Azerbaijan (On the new division of economic regions in the Republic of Azerbaijan, 2021). According to this decree, a new zoning system was introduced, and 14 economic regions were designated. These regions are grouped into five natural-economic areas: Greater Caucasus; Lesser Caucasus; Kura-Aras; Lankaran; Nakhchivan. The natural-economic regions largely correspond to physical-geographical provinces.

Each economic region has its own areas of specialization and unique characteristics. Various factors, including geographical, natural, and economic aspects, play a significant role in this process (Aliyev, 2021). Other important factors include employment characteristics, customs and traditions, and the national composition of the population. Effective and systematic management of economic regions is of great importance, along with the planning and implementation of priority projects, the development and application of financial and investment mechanisms by the state, and the creation of favorable conditions for developing alternative financing sources. Additionally, ensuring employment opportunities and boosting economic activity, developing social infrastructure, providing production and trade infrastructure, stimulating entrepreneurship, and fostering a favorable business environment are crucial elements of regional development (Aliyev et al., 2022).

Different regions of the Republic of Azerbaijan vary in terms of historical development, physical characteristics, and economic-geographical features. The new economic zoning of our republic will enhance the country's economic competitiveness, accelerate the reintegration of the liberated territories into the national economy, and facilitate more advanced planning and forecasting. At the same time, the role and significance of the new economic regions will increase in terms of attracting foreign investments more intensively, directing domestic investments in a targeted and efficient manner, creating new sources of financing, and diversifying the structure of value-added production (Guliyev, 2023). Modeling economic activity and fostering entrepreneurship for the sustainable and dynamic development of economic regions is an integral part of state policy. For example, to ensure the efficient allocation of funds from the Entrepreneurship Development Fund, priority areas have been identified for economic regions where interested and potential investors should be attracted.

We believe that in the near future, the development of high-tech industries in the newly established economic regions will be ensured, along with the implementation of more effective mechanisms for entrepreneurship development. These mechanisms include the creation of production and processing zones featuring flexible and efficient technologies, as well as the establishment of innovative and high-performing service enterprises. All of this indicates that socio-economic development in the new economic regions will be more dynamic and productive (Magerramov, 2021; Aliyev et al., 2022).

Recently, numerous studies have been conducted on the natural and ecological conditions, climate, relief, landscapes, vegetation, economy and agriculture of the Zangezur Economic Region (Ismayilov, 2023; Mammadova et al., 2025). Under the current circumstances, the East Zangezur Economic Region, defined based on the new territorial division, possesses significant natural and economic resources, as well as great potential for the development of various industries, including industry, tourism, agriculture, and the agrarian sector, particularly crop and livestock farming. The creation of the East Zangezur Economic Region

enhances Azerbaijan's strategic role on a global scale by a factor of one to five, as it aligns with key strategic objectives, such as: Revitalizing the newly established economic region; Accelerating the integration of Turkic-speaking states through the Zangezur Corridor; Increasing freight transportation between the West and East, North and South; Expanding international trade operations; Significantly developing the transport and logistics sector. These factors will create real potential for Azerbaijan to enhance its competitiveness multiple times over, as well as strengthen its political and economic power (Gahramanli, 2022). The main objective of our research was to assess the current natural-ecological, land and agricultural resources of the East Zangezur Economic Region of the Republic of Azerbaijan based on collected fund and personal studies. This territory had not been studied for 30 years, as it was under occupation and was liberated in 2020.

## MATERIALS & METHODS

The subject of our study, the East Zangezur Economic Region, was originally established in 1861 as the Zangezur Uyezd within the former Russian Empire and currently includes the administrative districts of Kalbajar, Gubadli, Jabrayil, Lachin, and Zangilan. Total area: 7448km<sup>2</sup>; the areas of the administrative districts are as follows: Kalbajar – 305km<sup>2</sup>, Lachin – 184km<sup>2</sup>, Jabrayil – 105km<sup>2</sup>, Gubadli – 08km<sup>2</sup>, Zangilan – 073km<sup>2</sup> (Fig. 1). Population: 343.5 thousand people. The research utilized ecological, botanical, mathematical-statistical, visual observation, cartographic, and laboratory analysis methods.

To generate the Digital Terrain Model (DTM) for the East Zangezur Economic Region, high-resolution elevation data was obtained from publicly available sources such as the Shuttle Radar Topography Mission (SRTM) and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) (Weibel & Heller, 1991; USGS, 2019). Additionally, satellite imagery and topographic maps were incorporated to enhance the accuracy of the dataset. To ensure the accuracy of the DTM, validation was conducted using available ground-truth data

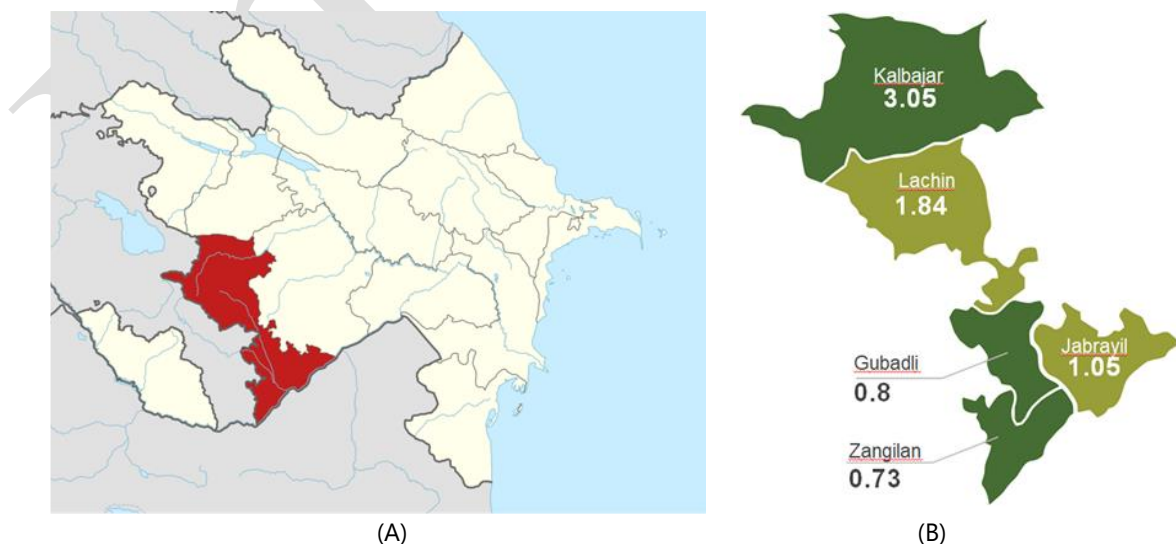
and cross-referencing with existing topographic maps. The final map was then exported in high-resolution formats for integration into reports and GIS applications. The Soil Map of Azerbaijan was used as the primary data source for mapping the soil distribution in the East Zangezur Economic Region. This foundational dataset was supplemented with additional spatial data to ensure accuracy and completeness. The soil cover of the region was vectorized using ArcGIS, converting raster data into vector format for better spatial analysis (McGee et al., 2005). Distinct soil areas were identified, categorized, and refined to ensure precise classification, the digitized data was adjusted to define accurate boundaries for different soil types.

## RESULTS & DISCUSSION

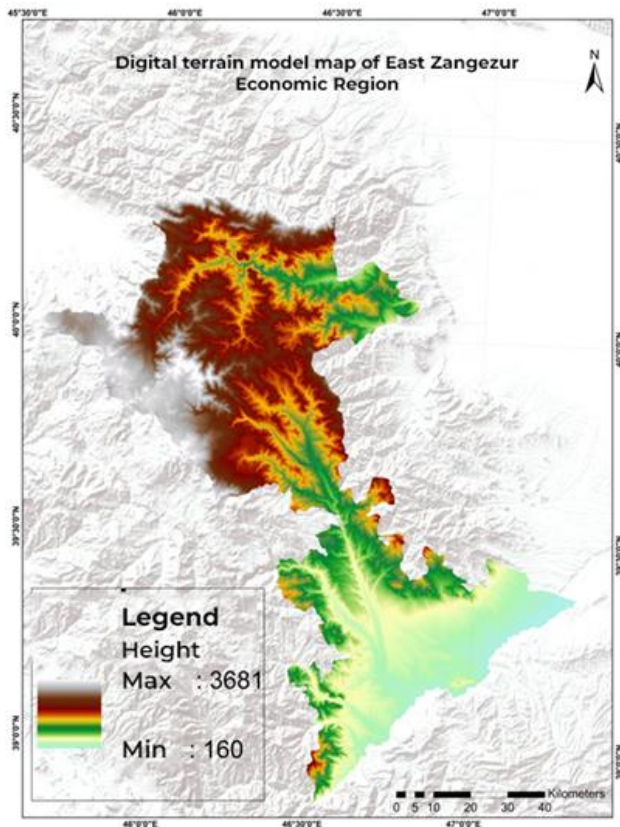
### Natural and Ecological Resources

#### Relief, Geology and Geomorphology

The East Zangezur Economic Region includes the Zangilan, Gubadli, Jabrayil, Lachin, and Kalbajar districts. It is located along the border with Armenia, in the East part of the Zangezur Plateau, which is surrounded by the Zangezur Range and extends over a vast area from Lachin and Kalbajar to Nakhchivan. The Karabakh Volcanic Plateau, which includes the Kalbajar and Lachin districts of the East Zangezur Economic Region, is located in the upper reaches of the Tartar and Hakari Rivers. We have developed a digital terrain Model Map of the economic region (Fig. 2). The Digital Terrain Model of the East Zangezur Economic Region provides a crucial representation of the region's topography. This dataset serves as a fundamental tool for environmental planning, infrastructure development, and economic analysis, supporting sustainable decision-making processes. According to the map, the elevation of the terrain extends in a wide strip from the northwest to the southeast, ranging from 3,681 meters to 160 meters. The foundation of the Karabakh Volcanic Plateau consists of ancient rock formations. During the Neogene and Anthropogene periods, lava flows from ancient fold-fracture fissures in the mountains covered the less fractured areas, shaping the current geomorphological structure.



**Fig. 1:** Map of the a) location of the study area and b) distribution by administrative districts.



**Fig. 2:** Digital Terrain Model Map of the East Zangezur Economic Region.

Major longitudinal faults run along the northEast and southwestern edges of the plateau, as well as in zones where dislocated Upper Mesozoic and Tertiary rocks emerge at the surface. Along the central axis of this area, numerous Pliocene and Pleistocene volcanoes, as well as thermal and cold mineral springs, are located. The watershed of the plateau is situated at an elevation of 3,000–3,500m and the terrain is relatively flat and undulating.

The Hakari inclined accumulative plain is composed of alluvial and partially alluvial-proluvial deposits dating back to the Late Pliocene. The age of volcanogenic-sedimentary rocks varies from Hakari to Absheron and plays a crucial role in shaping the plasticity of the Karabakh mountainous region's relief. Lava layers have formed a high-altitude plateau with steep and relatively short slopes (150–100m or less). The plateau narrows towards the deep valleys of the Tartar, Bargushad, and Yildrimsuchay Rivers. These lava layers were formed both in river valleys (Tartar, Minkend, Bargushad, Parichingil, Kirmizdag, and others) and on the plateau's surface.

The entire plateau surface was shaped primarily by Pleistocene lava eruptions. However, the Ahmadly Plateau consists of Pliocene and partially Quaternary lava deposits. The watershed of the plateau is characterized by high-altitude relief, and Holocene volcanic formations align with the Karabakh Volcanic Plateau. The largest rocky deposits in the Caucasus are found in Parichingil. The plateau is rich in mineral resources, including: construction materials; gold deposits (Zod Pass); mineral springs (Istisu, Minkend, etc.). The southern part of the East Zangezur Economic Region covers the lower reaches of the Okhchuchay and Hakari

Rivers. It rises to an elevation of 2,500 meters in the northwestern part of the Lower Araz Plain. This area is situated in the Hakarichay Basin, positioned between the Karabakh Range in the northeast and the Karabakh Upland in the southwest, featuring relatively low relief. Geologically, it lies within the extensive Goycha-Karabakh (or Goycha-Hakari) synclinorium, consisting of volcanogenic and volcanogenic-sedimentary rocks from the Jurassic, Cretaceous, Paleogene, Neogene, and Quaternary periods. To the southeast, this region merges with the Lower Araz synclinal depression, specifically in the valleys of the Hakari, Bargushad, and Araz Rivers. The depression is filled with volcanogenic-sedimentary, alluvial-proluvial deposits from the Upper Pliocene and Anthropocene periods. In the modern relief structure, the Lower Araz Depression connects the Hakari Plateau and the Araz River Valleys with inclined plains. The upper reaches of the Hakari River and the southern slopes of the Mihtoken Ridge exhibit watersheds with varying structural characteristics. In these areas, the terrain is smooth with gentle slopes, while the river valleys are characterized by relatively mild inclines.

### Climate

The mountain systems of the Lesser Caucasus play a crucial role in shaping the climate of the study area. These mountain ranges create a diverse range of climatic conditions, significantly influencing the climate of the lowland regions of Azerbaijan. The areas of the Lesser Caucasus up to 300–400m in height are characterized by hot summers and mild winters. The average temperature in the warm months (July, August) fluctuates between 24–26°C, the maximum reaches 35–37°C. The average temperature of the coldest month (January) is -1.0 to -3.9°C. In the foothills of the Lesser Caucasus, the first frosts occur in the third ten days of November, and the last ones in mid-March. The low and mid-mountain areas of the Lesser Caucasus are characterized by a mild climate. The average temperature of the warmest months fluctuates between 12–10°C, and of the coldest month is 1–2°C (Abdurahmanov, 2023a). The absolute minimum temperature is minus 27–28°C. Frost-free days last 200–230 days, and frosty days are observed from mid-November to the second half of April. The annual amount of precipitation fluctuates between 300 and 800 mm. In the warm months, heavy rains often occur, sometimes accompanied by hail. Permanent snow cover does not persist every year, and the snow that falls melts almost immediately. In severe winters, snow cover remains on the ground for 30–40 days. There are few winds here, mostly weak and moderate, with an average annual speed of 1.5–3m/s.

The favorable climatic conditions of the region allow for the development of various agricultural sectors, primarily: grain farming; viticulture (grape growing); potato cultivation; tobacco farming; fruit growing; sericulture (silk farming) and livestock breeding. The climate features allow growing agricultural crops here in ideal conditions. The middle and some high-mountain parts of the Lesser Caucasus are characterized by comparatively mild, warm summers. The sum of active temperatures here is 2500–3000°C. Depending on the altitude and steepness of the slopes, the average temperature of the warm months



fluctuates within wide limits and is 16-20°C. The maximum temperature reaches 30°C, and the absolute minimum is minus 22-25°C, and in some places even minus 27°C. The average temperature of the coldest months is minus 2-4°C. The first frosts usually begin at the end of October and continue until the end of April. The number of frost-free days is 150-200 days. Annual precipitation ranges from 300 to 1000mm and is often accompanied by hail, with hail falling 4-6 days a year.

### Hydrography

The region's hydrography is characterized by numerous rivers, tributaries, and reservoirs. The largest river in the northern part is Tartarchai. Additionally, smaller rivers such as Nargiz, Umudlu, Chechevitsa, and Maral flow directly into the Tartar River. The Khachinchay River originates in the mountains (Oyukhlu and Yildirim) located in the East part of the Tutkhun River and flows towards Agdaban. The rivers of the southern part of the study area are Araz, Okchuchay, Hakari and Basitchay. Rivers are primarily fed by snowmelt, groundwater and partially by rainwater (Mustafabayli, 2021). Water levels increase in the warm months due to snowmelt. The Hakari River, the largest in the region, originates at 2600m and has a valley divided into four main branches. The depth of tributaries such as Shelve and Gorchu is relatively shallow in the upper reaches and increases downstream. The river valley is divided into four branches, consisting of several expanding and narrowing sections. The distribution of the depths of the tributaries (Shelve, Gorchu, etc.) is relatively small in the upper reaches and gradually increases along the river. The southwestern river network belongs to the Araz River system, and the southeastern part to the Kura River. River density varies from 0.2 to 1 km/km<sup>2</sup>, depending on altitude and lava fragmentation. Flooding occurs during spring and early summer due to intense snowmelt. Late summer sees a significant drop in water levels, with groundwater as the primary source. The rivers are fed mainly by groundwater. The Big Alagol and Small Alagol, Zalhagol and Sarsang reservoirs are located on the territory of the economic region.

### Vegetation and Landscapes

The landscape of the East Zangezur Economic Region is dominated by alpine and subalpine meadows and forests. The region's vegetation is highly diverse and supports a variety of ecosystems, from forested areas to open meadows. The total area of forests in the region is 92,000ha (9% of the forests in Azerbaijan). 72% of these forests are mountainous forests with significant touristic and recreational value, primarily located in the Kalbajar and Lachin administrative districts. The forest resources of the East Zangezur Economic Region span 178.1 thousand ha. In the northern part of the region, the vegetation is characterized by: shrubby and sparse meadow vegetation; deciduous mountain forests (including oak, alder, and beech); subalpine and alpine meadows, typical of the higher elevations (Abdurahmanov, 2023b). The total forest resources of the East Zangezur Economic Region are 178.1 thousand hectares, and the distribution of these forest resources across different administrative districts can be seen in Fig. 3.

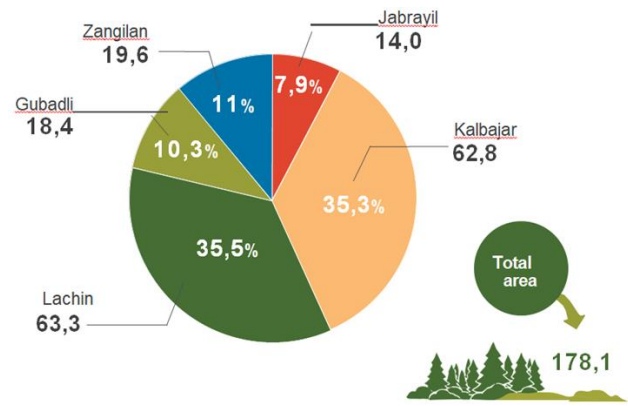


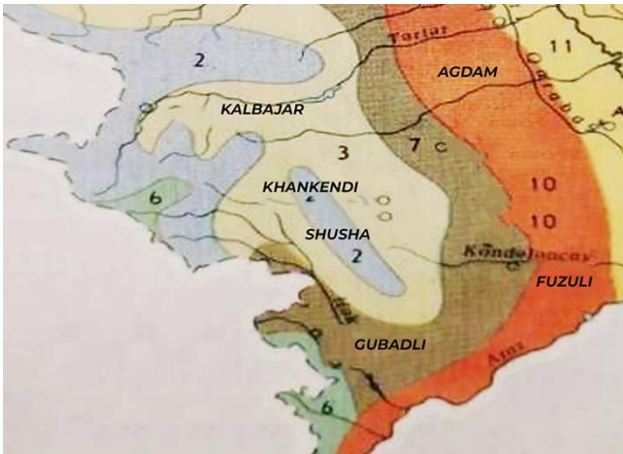
Fig. 3: Forest resources of the East Zangezur Economic Region.

As can be seen from the diagram, the Lachin and Kalbajar districts hold the largest share of forest resources, comprising 35.5% and 35.3% of the total forest cover, respectively. In contrast, the Jabrayil district has the smallest proportion, with only 7.9% of the forest resources (Abdurahmanov, 2023b). In the southern part of the territory, particularly in the Aras Plain, the climate is more arid, which has led to the development of steppe landscapes and shrubs that grow on light chestnut soils (Ibadullayeva et al., 2023). These areas are predominantly used as winter pastures for livestock. Juniper thickets are found along the Hakari River, while the Basitchay Reserve is home to naturally preserved East Plane Trees.

Based on the general landscape map of Azerbaijan, landscape zones existing in the East Zangezur Economic Region are identified (Fig. 4). As can be seen from the map fragment, high-mountain alpine and subalpine meadows are common, which are intensively fragmented and represent the highland vegetation zones. Broad-leaved forests and post-forest meadow-shrub landscapes are found in the middle mountain (Mustafabeyli & Gahramanov, 2023). Steppe and dry-steppe landscapes are present in the foothills and lowlands, where the terrain is sharply or moderately dissected. (Ibadullayeva & Huseynova, 2021). The concentration of environment-forming chemical elements significantly impacts the formation of morphological landscape units. In each natural zone, along with the leading ecological chemical element, there are 3 leading ones - P, N and K - and environment-forming ones - (Si, Al, Fe, Mg, Ca, Na, Mn, C, S, etc.) chemical elements related to the main types of rocks involved in the formation of soils in a particular area (Mustafabayli, 2023). Depending on the lithological composition, the rocks presented in the landscape belts of the East Zangezur region are rich in the following elements: basalts - Fe, Na, S, granites (liparites) - K, Ca, Na, clays - K, P, S, sands - Na, Ca, Fe, limestones - Ca, P, N.

### Soil Resources

The soil cover of the East Zangezur Economic Region has developed under the influence of diverse climatic, geomorphological, and hydrogeological factors. The mountainous terrain of the Lesser Caucasus gradually descends eastward, transitioning into the Kura-Aras Lowland, shaping the region's varied soil composition (Mamadov et al., 2024).

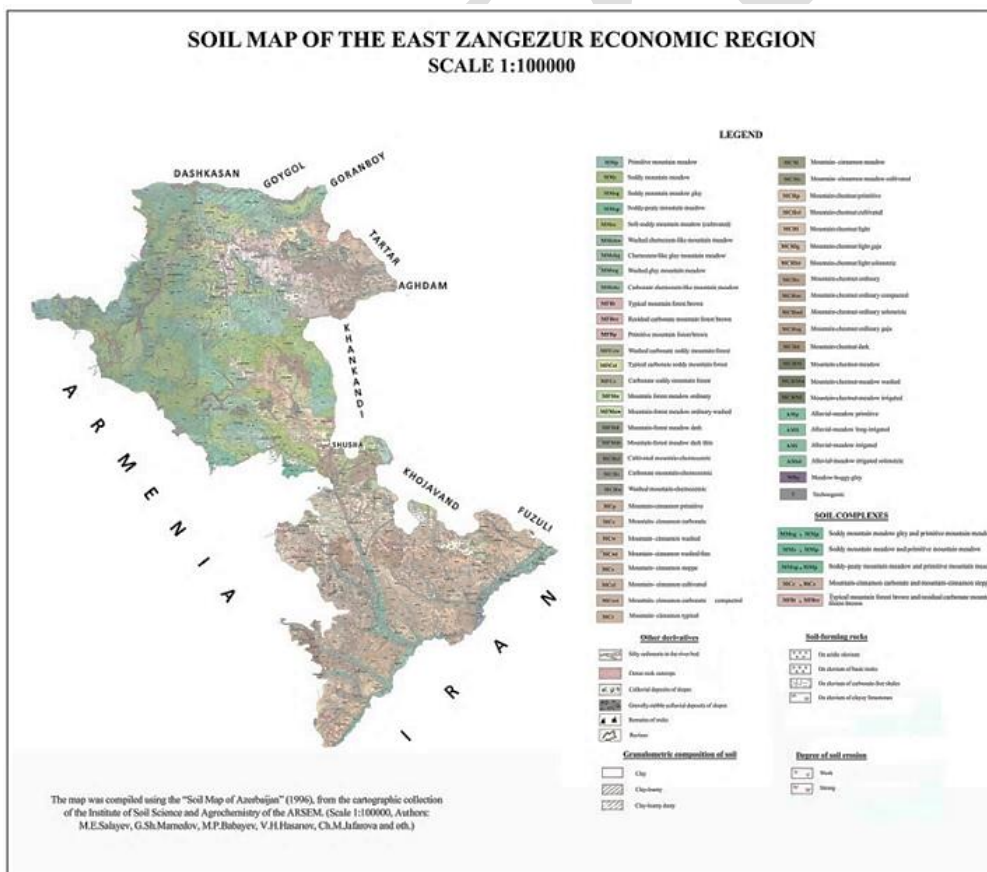


**Fig. 4:** Landscape zones of the East Zangezur Economic Region: 2 - alpine, subalpine meadows and meadow-steppe landscapes of intensely dissected highlands; 3 - broadleaf-forest and post-forest meadow-shrub landscapes of sharply dissected mid-mountain territories; 6 - arid forest-shrub landscapes of intensely dissected lowlands and foothills; 7 - steppe (partially forest-steppe) and dry-steppe landscapes of sharply and moderately dissected foothills and lowlands; 10 - semi-desert and arid-steppe landscapes of moderately dissected plains; 11 - semi-desert landscapes of moderately and weakly dissected intermountain plains and lowlands.

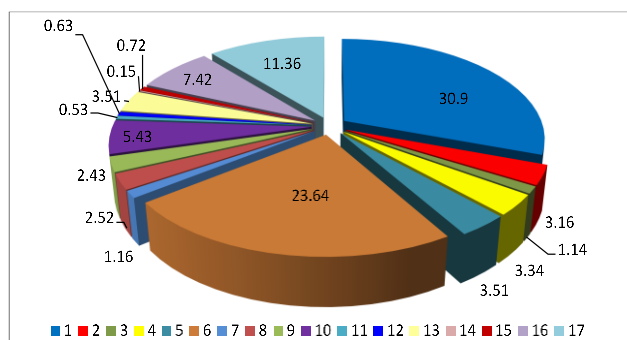
Here, on the alpine meadows of the highlands, mountain-meadow soils of various subtypes are widespread, in forested areas - brown mountain-forest and cinnamon mountain-forest, in mid-mountain and low-mountain areas - mountain-chnozem, mountain-gray-brown (mountain-chestnut), in the foothills and on the plains - gray-brown (chestnut), gray, gray-meadow and floodplain alluvial-meadow soil types. Excluding lands

covered by forest, the remaining soils, differing in their qualitative characteristics, were widely used in agriculture. In order to characterize the soil cover of the East Zangezur Economic Region, an analysis of the archive and cartographic materials stored in the fund of the Institute of Soil Science and Agrochemistry of the AR MES was carried out (Soil Map of Azerbaijan, 1996). As a result of the research, we prepared the "Soil Map of the East Zangezur Economic Region" at a scale of 1:100,000 (Fig. 5).

According to the legend of the soil map of the economic region, the distribution of resources by soil types in the study area is reflected in the diagram (Fig. 6). The total area of the economic region is 744.8 thousand hectares. According to the diagram, the soils of the East Zangezur Economic Region are grouped into 14 types and subtypes and are unevenly distributed over the area. According to our research, the predominant soils of the East Zangezur Economic Region are mountain meadow soils, occupying an area of 230,171 hectares or 30.90% of the total area. The study area includes primitive, meadow, meadow-peaty, chernozem and mountain-meadow-steppe subtypes of mountain meadow soils. Three subtypes of mountain-forest brown soils (typical, residual carbonate and primitive) are distinguished in the study area. Mountain-cinnamon soils occupy the second place in distribution - 23.64%. Of these, mountain cinnamon steppe soils predominate, spreading over an area of 52,210 hectares, and the second most common are washed soils, spreading over an area of 33,870 hectares. The total area of mountain forest-meadow soils, another type of soil in the high-mountain zone, is 24,895 hectares, or only 3.44% of the area.



**Fig. 5:** Soil Map of the East Zangezur Economic Region.



**Fig. 6:** Soil cover of the East Zangezur Economic Region: 1-mountain-meadow; 2-mountain-forest brown; 3-carbonate soddy mountain-forest; 4- mountain-forest meadow; 5-mountain-ferrous brown; 6-mountain-cinnamon; 7- mountain-cinnamon meadow; 8- mountain chestnut cultivated; 9- mountain chestnut light; 10- mountain chestnut ordinary; 11- mountain chestnut dark; 12-mountain chestnut-meadow; 13-alluvial-meadow; 14-meadow-boggy gley; 15-technogenic soils; 16 - soil complexes; 17 - other soils.

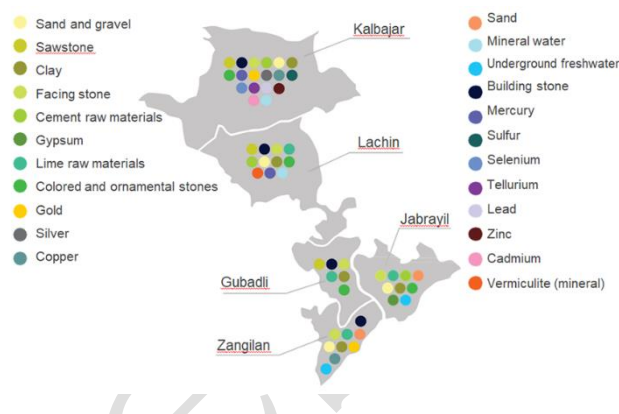
Mountain chestnut soils are widespread in the East Zangezur Economic Region over an area of 40,456 hectares (5.43%) and are represented by 4 subtypes: dark, ordinary, compacted and solonchek. According to the map legend, of the mountain chestnut soils, the most widespread in area are ordinary mountain chestnut soils, occupying 21,115ha. It should be noted that mountain chestnut-meadow soils occupy 0.63% of the area of the study object (4,666ha), and alluvial-meadow soils - 3.51% of the total area (26,145 hectares). Technogenic soils unsuitable for agricultural use are widespread over an area of 5,395 hectares (0.72%), and soil complexes - over an area of 55,275ha (7.42%).

The Soil Map of the East Zangezur Economic Region provides a structured representation of soil distribution in the area. It serves as a valuable resource for agricultural development, environmental management, and land-use planning, ensuring sustainable utilization of soil resources.

### Natural Resources and Mineral Deposits

The East Zangezur Economic Region has significant potential for the development of non-ferrous metallurgy. The territory contains deposits of gold, mercury, chromite, marble, perlite, decorative building stone, coral, and other minerals (Fig. 7). As shown in Fig. 5, the richest district in terms of mineral resources within the economic region is the Kalbajar district. The Kalbajar district is distinguished by its rich mineral and non-mineral resources. As a result of efforts by Azerbaijani geologists, several deposits have been discovered here, including gold (Soyudlu, Agdudzag, Zargulu, Agzybir, Gyzlitan, Gazikhanly, Galaboyun, etc.), chromite, tungsten, copper, molybdenum, lead, zinc, mercury, antimony, silver, asbestos, semi-precious and ornamental stones (nephritoids, jadeite, marble onyx, iridescent obsidian, garnets), mineral pigments, perlite, facing stone, travertine, listvenite and various types of tuff deposits. Among these, the Soyudlu and Agdudzag deposits have industrial significance and could support the development of a gold mining industry in the Kalbajar district. The Kalbajar district contains: Soyudlu (Zod) gold deposit with industrial reserves of 112.5 tons, and the Agdudzag and Tutkhun gold deposits with reserves exceeding 13 tons; 3 mercury deposits: Agyatag, Levchay, Chorbuly, with reserves exceeding 850 tons, and Kamyshly

and Aggaya with total reserves of 200 tons; Kilsali tuff deposit, with reserves of 10,941 thousand cubic meters; Keshdak clay deposit, with reserves of 1,312 thousand cubic meters; Kecheldag perlite deposit, with reserves of 4,473 thousand cubic meters; 2 facing stone deposits, with total reserves of 2.2 million cubic meters, Chepli sand and gravel deposit, with reserves of 2,540 thousand cubic meters; 4 marble onyx deposits, with excellent decorative properties (reserves of 1,756tons); nephroid deposit, with reserves of 801tons; 1 obsidian (camel's eye) deposit, with reserves of 2,337 tons; 1 listvenite deposit, with reserves of 1,067 thousand cubic meters, etc.



**Fig. 7:** Mineral Resources of the East Zangezur Economic Region.

### Mineral Water Resources

The primary mineral water resources are located in the Kalbajar district. The temperature of the natural thermal waters ranges from 22–25°C, with a spring discharge rate of 0.1–4L/s and mineralization of 4–5g/L. Istisu Goturlu: well depths range from 25–62 meters. Water temperature varies between 62–75°C, with some wells showing even higher temperatures. Thermal waters with a discharge rate of 1.0–2.0L/s and mineralization of 4.2–6.9g/L have been identified. All thermal waters in the zone are carbonic, sulfate-chloride-bicarbonate-sodium in composition, indicating similar formation conditions for the thermal waters of the Kalbajar district.

The quality of water varies depending on the temperature: in hot water, mineralization is up to 0.7g/L, and in cold water - more than 3g/L. Projected exploitable reserves are 2171.1m<sup>3</sup>/day. The "Istisu Mineral Water Bottling Plant" operates in Istisu, bottling thousands of glass bottles of mineral water daily and exporting them across Azerbaijan and to other republics. Additionally, large amounts of carbon dioxide are released with the hot mineral waters and are used during the bottling process. The area is also home to one of Azerbaijan's most famous resorts — the Istisu Resort.

### Tourism Resources

The East Zangezur Economic Region accounts for 33% of all tourism resources in the republic. Major mineral water sources include Upper and Lower Istisu, Turkhun, Keshdak, Goturlu (Kalbajar), and the cold mineral spring Minkend (Lachin), which have therapeutic value. The potential reserves of mineral springs and the natural beauty of their surroundings create favorable conditions for developing a



resort and health complex (Magerramov, 2021).

The landscape of the economic region is dominated by alpine and subalpine meadows and forests. The area of forests with rare tree species covers 92,000ha (9% of the republic's forests). Of these, 72% are mountain forests of tourist and recreational value, located in the administrative districts of Kalbajar and Lachin. The East Zangezur Economic Region is rich in historical and cultural monuments. World-famous architectural landmarks include the Ganjasar Monastery (13th century) in the Kalbajar district and the Khudavang Monastery (13th–15th centuries) on the banks of the Tartar River.

Historical and cultural monuments of national significance in the region include: Albanian temples in the villages of Childyran, Garnakar, and Gojagot (Kalbajar); Early and Middle Bronze Age settlements; Goy Castle (5th century), a cave temple in Aliguluushagy village and Refuges in Balalyasanly village (4th century) (Gubadli district); Tombs in Jijimli village (14th and 18th centuries), Iron Age burial mounds and Cave temple in Gochaz village (5th century) (Lachin district); Maiden Tower (12th century) in Amirkhanly village and Octagonal tomb (14th century) in Mammadbeyli village (Zangilan district) (Aliyev et al., 2022). Additionally, the Kalbajar-Lachin area has many local historical and cultural landmarks, including mosques, mausoleums, and ancient settlements (Fig. 8).

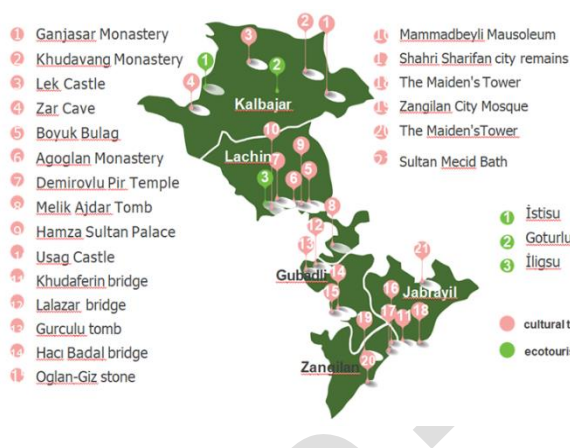


Fig. 8: Tourism Potential of the East Zangezur Economic Region.

Kalbajar is one of the oldest human settlements. The emergence and development of primitive humans in this area date back to the Quaternary geological period. Ancient settlements over 30,000 years old, rock carvings from 6,000 years ago, and samples of the ancient Turkic alphabet in the form of inscriptions on sticks were discovered in the Kalbajar district. Findings from these settlements, dating back to the 3rd millennium BC, include fragments of clay pots, grain grinding stones, agate and flint knives, and arrowheads. The discovered rock carvings provide insight into the economic, social, and cultural life of local tribes during the Bronze Age. Stone monuments in this area were created in Northern Azerbaijan during the early periods of fire worship, the spread of Christianity, and, from the 7th century, Islam. Kalbajar is home to several ancient cemeteries known as "Turkic Cemeteries," the largest of which are located in the villages of Alibeyli, Kalbajar, and Zar. These cemeteries are rich in gravestones, tombstones and domed monuments,

created over different centuries and varying in shape and size.

### Agriculture Resources

The foundation of the economy of the East Zangezur Economic Region is agriculture, particularly animal husbandry. The developed agricultural sectors included sheep breeding, cattle breeding, beekeeping, tobacco growing, viticulture, fruit growing, and grain production. The Zangilan and Gubadli administrative districts, as well as the river floodplains, offer favorable conditions for agriculture. Industrial enterprises in the region are based on the processing of agricultural raw materials, including meat and dairy products and carpet weaving. The East Zangezur Economic Region is a major agricultural hub, playing an important role in Azerbaijan's economy. Favorable soil and climatic conditions provide broad opportunities for the development of crop production and animal husbandry. Before the occupation, the region had well-developed agricultural sectors, including grain farming, viticulture, tobacco growing, fodder production, potato growing, vegetable growing, cotton farming, and animal husbandry (Shirinzade & Aliyev, 2023). The region accounted for: 14.3% of the grain, 31.5% of the grapes, 14.5% of the meat, 17.1% of the milk, 19.3% of the wool and 17.0% of the silkworm cocoons produced in the country. Additionally, the region was known for producing eco-friendly, high-quality agricultural products. Viticulture and tobacco growing have ancient traditions in these areas (Nadirov & Mammadova, 2023).

### Level of Land Use in Agriculture

It is known that up to 20% of Azerbaijan's territory, or 1,670.3 thousand hectares, has been liberated from occupation, including 680.8 thousand hectares of agricultural land, more than 10.7 thousand hectares of household plots (also suitable for agriculture) and 247.3 thousand hectares of forests (Valiyev, 2020).

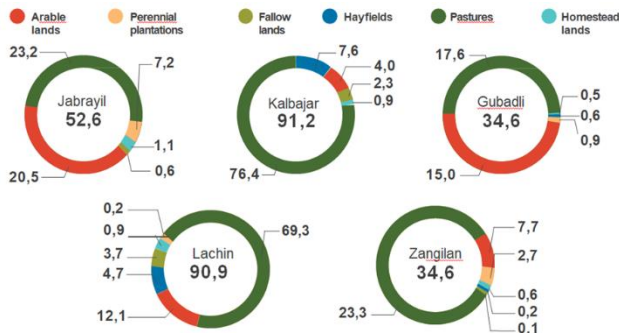
Based on the analysis of collected fund materials, diagrams were created to illustrate the level of land use for agricultural purposes in the East Zangezur Economic Region and by individual districts (Fig. 9). According to the diagram, most of the agricultural land in the Jabrayil district—23.2 thousand hectares (44.1%)—is used as pastures and 20.5 thousand hectares (39.0%) is arable land.

The largest area of summer pastures is in the Kalbajar (76.4 thousand hectares) and Lachin (69.3 thousand hectares) districts, while the largest area of winter pastures is in the Zangilan district (23.3 thousand hectares). The Jabrayil district has the largest areas of perennial plantations (7.2 thousand hectares) and crops (20.5 thousand hectares). The second-largest area of arable land is in the Gubadli district (15 thousand hectares), and the second-largest area of perennial plantations is in the Zangilan district (2.7 thousand hectares).

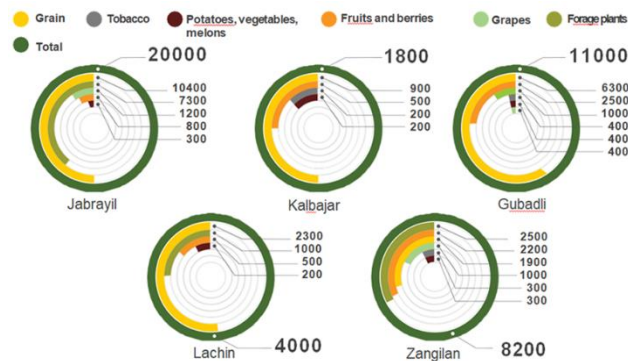
### Prospects for the Development of Agriculture in the East Zangezur Economic Region

After the liberation from occupation, specialists from the Ministry of Agriculture of the Republic of Azerbaijan developed forecasts for the agricultural development of the East Zangezur Economic Region. Below is a diagram (Fig. 10)





**Fig. 9:** Level of Land Use for Agricultural Purposes in the East Zangezur Economic Region.



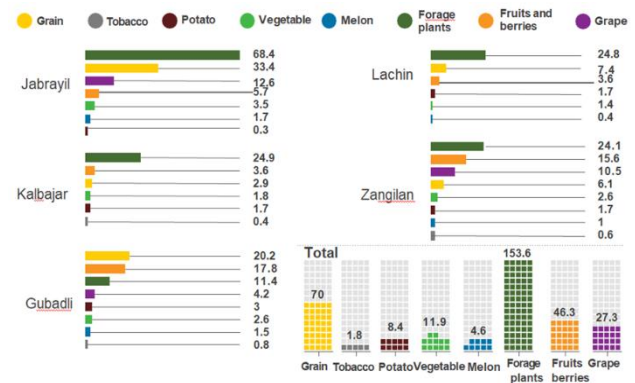
**Fig. 10:** Projected Structure of Arable Lands in the East Zangezur Economic Region.

showing the projected structural indicators of arable lands in the East Zangezur Economic Region, based on data provided by experts from the Agrarian Research Center of the Ministry of Agriculture.

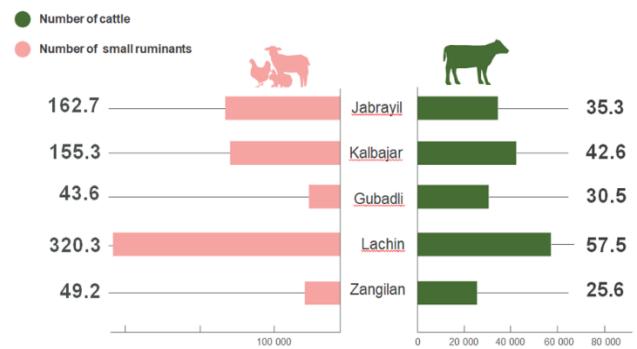
According to the forecasts: the largest area of grain crops will be cultivated in Jabrayil (10.4 thousand ha) and Gubadli (6.3 thousand ha) districts; the largest area of fruit and berry orchards will be planted in Gubadli (2.5 thousand ha) and Zangilan (2.2 thousand ha) districts; the largest area of vineyards will be planted in Jabrayil (1.2 thousand ha), Gubadli (1.0 thousand ha), and Zangilan (1.0 thousand ha) districts; the largest areas under tobacco cultivation will be in Gubadli (400ha) and Zangilan (300ha); the largest areas for potatoes and vegetables will be cultivated in Gubadli (400ha), Zangilan, and Jabrayil (300ha each).

Another interesting diagram is based on the forecasted crop production indicators in the East Zangezur Economic Region (Fig. 11). According to the diagrams, the highest grain production is projected in Jabrayil (33.4 thousand tons) and Gubadli (20.2 thousand tons) districts, grape production in Jabrayil (12.6 thousand tons) and Zangilan (10.5 thousand tons) districts, vegetable production in Jabrayil (3.5 thousand tons), and tobacco production in Gubadli (0.8 thousand tons). The forecast for livestock development in the East Zangezur Economic Region is shown in the diagram below (Fig.12).

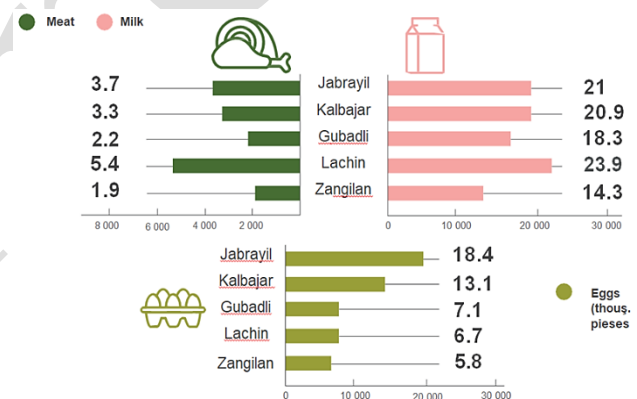
As shown in the diagram, Lachin District leads in both cattle (57.5 thousand head) and small ruminants (320.3 thousand head). It is followed by Jabrayil District (winter pastures) and Kalbajar District (summer pastures) (Khalilov & Jafarova, 2022). According to the projected livestock production scheme for the East Zangezur Economic Region,



**Fig. 11:** Forecast of Crop Production in the East Zangezur Economic Region.



**Fig. 12:** Forecasts for Livestock Development in the East Zangezur Economic Region.



**Fig. 13:** Forecast of Livestock Production in the East Zangezur Economic Region.

Lachin District has the highest potential for meat (5.4 thousand tons) and milk (23.9 thousand tons) production, while Jabrayil District leads in egg production (18.4 thousand units) (Fig. 13).

These resources, aimed at the development of the East Zangezur Economic Region, will further strengthen our country's power and influence in the region. The territory of the East Zangezur Economic Region, defined under the new division, has vast natural and economic resources, as well as potential for developing various industries, including industry, tourism, agriculture, and the agrarian sector, particularly crop and livestock farming.

## Conclusion

1. Based on the analysis of fund and cartographic materials, field, and laboratory studies, an assessment of the

current natural and ecological conditions of the East Zangezur Economic Region was conducted. A "Soil Map of the East Zangezur Economic Region" (scale 1:100,000) and a Digital Terrain Model Map (based on GIS technologies) were created, identifying the distribution of soil resources by types, subtypes, and species diversity of the studied area. The most common soils in the study area are mountain-meadow soils (30.90%) and mountain-cinnamon soils (23.64%).

2. 4. The distribution of mineral resources (gold, mercury, chromites, marble, perlite, facing building stones, corals, etc.) in the East Zangezur Economic Region by administrative districts has been analyzed, and a map-scheme has been compiled. The Kalbajar district, the richest in mineral resources within the economic region, is also renowned for its reserves of therapeutic thermal waters.

3. 5. The tourism potential of the East Zangezur Economic Region has also been analyzed. Its captivating nature, large deposits of mineral springs suitable for creating a resort and health complex, mountain forests with tourist and recreational value, and an abundance of historical and cultural monuments (early and middle Bronze Age dwellings, world-famous architectural monuments such as the Ganjasar Monastery (13th century), Khudavang Monastery (13th–15th centuries), and Albanian churches in the villages of Childyran, Garnakar, Gojagot, etc. clearly demonstrate the region's high tourist and recreational resources.

4. The land resources of the East Zangezur Economic Region were evaluated for their suitability for agriculture: the level of land use for agricultural purposes was determined by administrative districts. The largest area of summer pastures is in Kalbajar District (76.4 thousand hectares), while the largest areas of perennial plantations (7.2 thousand hectares) and cereal crops (20.5 thousand hectares) are in Jabrayil District. It was established that 209.8 thousand hectares (69.03%) of the region's agricultural land is mainly used as pastures and grazing areas.

5. The prospects for the development of agriculture in the East Zangezur Economic Region are considered, and the structural indicators of the projected arable land area are analyzed. The largest area for grain crops is planned in the Jabrayil (10.4 thousand hectares) and Gubadli (6.3 thousand hectares) districts, for fruit and berry orchards — in Gubadli (2.5 thousand hectares) and Zangilan (2.2 thousand hectares) districts, for vineyards — in Jabrayil (1.2 thousand hectares), and for tobacco, potatoes, and vegetables — in Gubadli (400 hectares). According to forecasts for the development of livestock farming in the East Zangezur Economic Region, Lachin district leads in the number of both cattle (57.5 thousand head) and small ruminants (320.3 thousand head). Lachin district has the highest potential for meat (5.4 thousand tons) and milk (23.9 thousand tons) production, while Jabrayil district leads in egg production (18.4 thousand head).

## DECLARATIONS

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**Data Availability:** Data can be requested with an appropriate reason from the corresponding author.

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## REFERENCES

- Abdurahmanov, F.T. (2023a). Analysis of climate indicators of the Eastern Zangezur region and evaluation of the role of agroclimatic resources in the development of agricultural areas. *Scientific Works of Nakhchivan University*, 4, 229-236
- Abdurahmanov, F.T. (2023b). The Analysis of the Transformation of Forest Landscapes in the Eastern Zangezur Region of Azerbaijan Based on Satellite Imagery. *Human Geography Journal*, 35, 20-27. <https://doi.org/10.26565/2076-1333-2023-35-02>
- Abate, S.G. & Anteneh, M.B. (2024). Assessment of agricultural land suitability for cereal crops based on the analysis of soil physico-chemical characteristics. *Environmental Systems Research*, 13, 60-65. <https://doi.org/10.1186/s40068-024-00333-y>
- Aksenova, Y.V. & Shmidt, A.G. (2024). Assessment of the Natural Resource Potential of the Agricultural Territory of Omsk Oblast. *Russian Agricultural Sciences*, 50, 331-339. <https://doi.org/10.3103/S1068367424700319>
- Aliyev, S.T. (2021). Strategic aspects of the creation of Karabakh and Eastern Zangezur economic regions. *Journal of Geostrategy*, 04 (64), 67-72.
- Aliyev, S., Ismailov, E., & Rustamova, G. (2022). Development prospects of the East Zangezur economic district. *Scientific Collection "InterConf"*, (122), 20-25.
- Danilov-Danilyan, V.I. & Klyuev, N.N. (2023). Russian Natural Resources' Sphere: Development Trends and Desirable Strategies. *Regional Research of Russia*, 13, 77-100. <https://doi.org/10.1134/S2079970522700484>
- Gahramanli, H.S. (2022). Main directions of the economic development of the East Zangazur Economic Region. *Scientific Research*, 2(6), 60-63. <https://www.doi.org/10.36719/2789-6919/10/60-63>
- Guliyev, E.A. (2023). The role of Karabakh and East Zangezur Economic Region s in the sustainable development of Azerbaijan. Monograph. Baku: Cooperative Publishing House.
- Govoni, C., D'Odorico, P., Pinotti, L. & Rulli, M.C. (2023). Preserving global land and water resources through the replacement of livestock feed crops with agricultural by-products. *Nature Food*, 4, 1047-1057.

- <https://doi.org/10.1038/s43016-023-00884-w>
- Ibadullayeva, S.J., & Huseynova, I.M. (2021). An Overview of the plant diversity of Azerbaijan. biodiversity, conservation and sustainability in Asia. Volume 1: Prospects and Challenges in West Asia and Caucasus (Eds. M. Öztürk, V. Altay, R. Efe), 431-479.
- Ibadullayeva, S., Gurbanov, E., Abdiyeva, R., & Abiyev, Y. (2023). Geobotanical zoning of Karabakh and East Zangezur. *Journal of Life Sciences & Biomedicine*, 5(78), 49-53. <https://doi.org/10.59849/2710-4915.2023.2.4949>
- Ismayilov, H.R. (2023). Some aspects of using the economic potential of the Karabakh and East Zangazur Economic Regions. *Construction Economics and Management*, 3, 1-10. <https://doi.org/10.58225/tim.2023-3-98-105>
- Kalaiselvi, B., Lalitha, M., Chakraborty, R., Dharumaran, S., Srinivasan, R., Ramamurthy, V., Lakshmi, K., Hegde R. & Archana K.V. (2024). Promoting Agricultural Sustainability in Semi-arid Regions: An Integrated GIS-AHP Assessment of Land Suitability for Encouraging Crop Diversification. *Journal of the Indian Society of Remote Sensing*, 52, 2221-2233. <https://doi.org/10.1007/s12524-024-01937-8>
- Khalilov, I. & Jafarova, F. (2022). The Prospects for Sustainable and Innovative Development of Livestock Farming in the Economic Regions of Karabakh and Eastern Zangazur in the Republic of Azerbaijan. Proceedings of the International Scientific Conference on Economics and Management Research (ISCER), 60, 86-108.
- Kılıç, M., Gündoğan, R. & Günel, H. (2024). An illustration of a sustainable agricultural land suitability assessment system with a land degradation sensitivity. *Environment, Development and Sustainability*, 26, 6085-6107. <https://doi.org/10.1007/s10668-023-02951-5>
- Mamador, Z., Abdullayeva, M., Gasimov, A. (2024). Spreading soils of different landscape type and theirs ecological situation (on of Lesser Caucasus). BIO Web of Conferences, 118, 02001. <https://doi.org/10.1051/bioconf/202411802001>
- Mammadova, S., Abdurahmanov, F., & Humbatov, M. (2025). Main Development Directions of Agricultural Areas in the Eastern Zangezur Region. BIO Web of Conferences, International Conference "Mountains: Biodiversity, Landscapes and Cultures", 151, 04012. <https://doi.org/10.1051/bioconf/202515104012>
- Magerramov, E.M. (2021). Priorities for the development of the Karabakh and East Zangezur Economic Region of Azerbaijan. Publishing House Scientific Library <https://www.doi.org/10.36871/ek.up.p.r.2024.03.07.015>
- McGee, J.A., Carleton, M., & Smith, A. (2005). Automated vectorization of scanned maps using GIS tools. *International Journal of Geographical Information Science*, 19(2), 129-146.
- Mir, Y.H., Mir, S., Ganie, M.A., Bhat, J.A., Shah, M.A., Mushtaq, M. & Irshad, I. (2025). Overview of Land Use and Land Cover Change and Its Impacts on Natural Resources. In: Jatav, H.S., Raiput, V.D., Minkina, T. (eds) Ecologically Mediated Development. Sustainable Development and Biodiversity, vol 41. Springer, Singapore. [https://doi.org/10.1007/978-981-96-2413-3\\_5](https://doi.org/10.1007/978-981-96-2413-3_5)
- Mustafabayli, H.L. (2021). On water resources in the territory of Karabakh and ways to use them efficiently. Risks of emergency situations in the liberated territories, Online conference. Baku, 147-148.
- Mustafabayli, H., & Gahramanov, M. (2023). Restoration of landscapes and protection of biodiversity in the Karabakh and East Zangezur Regions. *Endless Light in Science*, 9, 267-275. <https://doi.org/10.24412/2709-1201-2023-267-275>
- Mustafabayli, H.L. (2023). Application of biogeochemical indicators in the diagnosis of landscapes. *Endless Light in Science*, 18, 474-491. <https://doi.org/10.24412/2709-1201-2023-474-491>
- Nadirov, N., & Mammadova, S. (2023). Perspective of the Development of Irrigated Agriculture in the Garabakh and East Zangezur Economic Regions. *Bulletin of Science and Practice*, 9 (7), 137-143. <https://www.doi.org/10.33619/2414-2948/92/20>
- On the new division of economic regions in the Republic of Azerbaijan, (2021). Decree of the President of the Republic of Azerbaijan dated July 07, 2021.
- Pujiono, E., Sadono, R., Imron, M.A., Januar, H.I., Kuswandi, R., Kurniawan, H., Hadi, E.W., Saputra, M.H., Hidayah, I., Humaida, N., Sukmawati, J.G., Hadiyan, Y., Nugroho, W.A. & Hani, A. (2024). An agent-based model of agricultural land expansion in the mountain forest of Timor Island, Indonesia. *Journal of Mountain Science*, 21, 2263-2282. <https://doi.org/10.1007/s11629-023-8148-9>
- Saha, P. & Gayen, S.K. (2025). Assessment of agricultural land use suitability using TOPSIS and VIKOR models: a case study of Koch Bihar district, West Bengal. *Arabian Journal of Geosciences*, 18, 44-49. <https://doi.org/10.1007/s12517-025-12193-6>
- Soil Map of Azerbaijan (1996). Institute of Soil Science and Agrochemistry of the ARSEM. (Scale 1:100000, Authors: M.E.Salayev, G.Sh.Mamedov, M.P.Babayev and oth.)
- Shirinzade, N., & Aliyev, S. (2023). Directions of agribusiness development in Karabakh and East Zangazur. Scientific Collection "InterConf", 17, 09-15.
- Shaw, S.K., Sravani, N., Sharma, A. & Anand J. (2025). Assessment of probable zones of agricultural land suitability based on MCDM, probabilistic, and data-driven approach in Krishna District, India. *Environmental Monitoring and Assessment*, 197, 339. <https://doi.org/10.1007/s10661-025-13803-2>
- Upreti, A., Panta, H.K., Bhandari, T. & Timsina K. (2024). Agricultural land conversion: trends and drivers in Dhading, Nepal. *GeoJournal*, 89, 221-227. <https://doi.org/10.1007/s10708-024-11222-3>
- United States Geological Survey (USGS) (2019). Digital Elevation Models (DEM) and Their Derivatives. <https://www.usgs.gov>
- Valiyev, A.H. (2020). Assessment of the potential of agricultural soils in the occupied territories. *Agricultural Economics*, 3 (33), 60-70.
- Wang, C. (2025). Suggestions on Mineral Resources Management from the Perspective of Grass-Roots Government Openness in the Field of Natural Resources. In: Ismail, M.A., Wang, L. (eds) Development and Protection of Mineral Resources. MRGGE 2024. Springer Series in Geomechanics and Geoengineering. Springer, Cham. [https://doi.org/10.1007/978-3-031-78690-7\\_1](https://doi.org/10.1007/978-3-031-78690-7_1)
- Weibel, R., & Heller, M. (1991). Digital terrain modeling. In Maguire, D. J., Goodchild, M.F., & Rhind, D.W. (Eds.), *Geographical Information Systems: Principles and Applications* (Vol. 1, pp. 269-297). Longman Scientific & Technical.