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# ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

# ECOGEOGRAPHICAL RESEARCH OF THE LANDSCAPES OF THE EASTERN ZANGEZUR REGION BASED ON AEROSPACE IMAGES

Speciality: 5408.01 – Physical geography and biogeography, soil geography, geophysics and geochemistry of landscapes

Field of science: Geography

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## GENERAL CHARACTERISTICS OF THE WORK

**Relevance of the topic and degree of development.** The President of the Republic of Azerbaijan, Mr. Ilham Aliyev, signed a decree dated July 7, 2021, in order to develop our liberated territories and integrate them into the economy of the country, as well as to increase the efficiency of planning work in other economic regions. According to the decree, a new zoning was carried out in the country, 14 economic regions were allocated and the Eastern Zangezur Economic region was established. The region is rich in mercury, chromite, gold, construction materials and there are small wood reserves in the forests. The Eastern Zangezur region has favourable natural conditions for livestock breeding, grain growing, viticulture and fruit growing. In the pre-occupation period, these territories had high agricultural indicators. Most of the country's grain, cotton, grapes, meat and milk, wool and cocoon production was seen in these territories. Ecogeographical study of territorial landscapes will create broad opportunities for the proper organization of the economy in the study zone, the restoration of degraded landscapes in an economically efficient and affordable way, increasing economic profits, etc.

However, unfortunately, during the war that began after 1990, about 20% of our lands were occupied, which included the entire Eastern Zangezur region, which is our research zone. During the nearly 30 year occupation covering 1992-2020, the landscapes of the region were seriously changed by Armenian vandals, the territories were destroyed, the forest fund was destroyed and our natural resources were illegally plundered. For this reason, after the liberation of the Eastern Zangezur region and other occupied lands in 2020, monitoring was initiated by various organizations to assess the ecogeographical condition of the landscapes.

In the dissertation work, using GIS technologies, the ecogeographical status of the territorial landscapes was studied and relevant maps were compiled. Here, in addition to evaluating the natural conditions of the Eastern Zangezur region with literature and fund materials, maps of various periods, statistical reports, etc., an

analysis of the data covering the years 1990-2024 was also provided and a comparative analysis was conducted with the studies to date. Also, the forestation and deforestation coefficients covering the years 1990-2020 in the region were determined as a result of the analysis of satellite images, the forestation coefficient for 2024 was calculated and an ecogeographical study of landscapes and landscape components for about 30 years was conducted as a result of the analysis of space images.

**The object and subject of the research.** When writing the dissertation, the main object of research was the territory and borders of the Eastern Zangezur Economic Region, which was established on July 7, 2021, based on the decree of the President of the Republic of Azerbaijan, Mr. Ilham Aliyev, on the new division of the economic regions of Azerbaijan.

**The purpose and tasks of the study.** While studying the landscapes of the Eastern Zangezur region based on aerospace images, the following issues were taken into account:

- Analysis of the natural conditions of the Eastern Zangezur region
- Research of the climate of the study area and determination of agro-climatic reserves
- Study of the role of the modern state of landscapes in the formation and development of agricultural areas, analysis of their unity
- Research of the forests of the territory and determination of the calculation of the forest coefficient
- Analysis of the landscapes of the study area using spatial images and study of the ecogeographical status of the landscapes

**Research methods.** Historical-geographical, analytical, mathematical-statistical, comparative, cartographic and GIS technologies were used in the field of research. Using GIS technologies, spatial images of different periods specific to the research area were obtained from LANDSAT, AzerSky and Sentinel satellites, analyzed and maps were prepared based on the relevant results.

**Clauses defended:**

1. Study of the natural conditions (climate, soil and vegetation cover, water sources) of the Eastern Zangezur region, study of its impact on the formation of landscapes;
2. Study of the ecogeographical condition of the main components of the territorial landscapes, analysis of the forests of the region and monitoring their changes over time;
3. Study of the possibility of establishing agricultural areas in the study area and revealing the mutual unity of these agricultural areas and landscape components.

**Scientific innovations of the research work.**

- An analysis of the natural conditions of the territory of the Eastern Zangezur region (climate, soil and vegetation, natural water sources) was conducted and the factors that caused the change in natural conditions were identified.
- The climatic and agro-climatic conditions of the region were determined and the necessity of which directions should be taken when establishing agriculture was investigated.
- The surface temperature of the territory's soils was measured using GIS technologies of space images and the degree of vulnerability to various economic sectors was determined.
- The change in the degraded forest background in the study region during 1990-2020 was shown and the reasons for the impact on forest degradation were identified.
- The modern state of the landscapes of the studied territory and the factors affecting it were analyzed, the conditions before and after the occupation were compared using aerospace methods and the areas of degraded landscapes were identified.
- The role of the modern state of landscapes in the establishment and development of economic sectors was studied and the interaction of these economic sectors with landscape components was revealed.

**Theoretical and practical significance of research.** The results of the research work can be used in the scientific-research and project institutes of the Ministry of Ecology and Natural Resources of the Republic of Azerbaijan and the Ministry of Agriculture. The

obtained scientific results can play an important role in the restoration of landscapes in the Eastern Zangezur region.

**Approval and application.** Reports were made at scientific and practical conferences held in the republic and abroad on topics reflecting the results of the research; 1 Nation, 6 States, Common Media (media platform of Turkish-speaking countries) international social and humanities congress, Baku-2021; The XXXII International Scientific Symposium "Turk's Victory: from Chanakkale to Karabakh", Turkey-2022; Materials of the XXV republican scientific conference of doctoral students and young researchers (natural and technical sciences), Baku-2022; Republican scientific and practical conference on the topic "Heydar Aliyev's ideas: whole Azerbaijan and sustainable development" dedicated to the 100th anniversary of the Great Leader Heydar Aliyev, Baku-2023; International conference "Mountains: biodiversity, landscapes and cultures", Baku-2024; Republican scientific conference "Green Shusha - Green World", Baku-2024;

12 scientific articles and theses reflecting the results of the work on the topic of the dissertation have been published.

**The name of the institution where the dissertation work was performed.** The dissertation work was carried out at the Department of "Physical Geography" of the Faculty of Geography of Baku State University.

**The scope and structure of the dissertation.** The dissertation consists of an introduction, 4 chapters, a conclusion and a list of references. The total volume of the work is 128 pages. Chapter I – 16 pages, chapter II – 36 pages, chapter III – 30 pages, chapter IV – 31 pages, the conclusion is 2 pages. The research work uses 14 figures, 10 tables and a list of references with 93 titles. The dissertation has a mark volume of 195057.

## THE MAIN CONTENT OF THE RESEARCH

The introduction identifies the relevance of the topic, the purpose and objectives of the research, its theoretical and

methodological foundations and explains its scientific novelty and practical significance.

Chapter I of the dissertation is dedicated to **"Theoretical-methodological foundations of the study of landscapes of the Eastern Zangezur region".**

The territories of the Eastern Zangezur region, which have rich natural resources, biodiversity, wonderful nature, favourable climate and agro-climatic conditions, multi-level geological structure and various relief forms, have attracted the attention of travelers and researchers since ancient times and the study of the territory has begun. In general, the history of the study of regional landscapes is divided into 4 stages, each of which has gained significant importance for the next stage and has been further enriched. This can be grouped as follows:

1. Although the first stage was mainly descriptive in nature, in the following years geological-geomorphological, hydrological and climatic studies were conducted by V.H.Abikh, I.I.Khodako, A.I.Voeykov, I.V.Figurovsky, I.I.Zhilinsky, V.V.Dokuchayev, N.I.Kuznetsov, A.L.Reingard and others. However, the studies conducted during this period were either incomplete or were written with certain errors.

2. In the second stage, the Soviet authorities showed great interest in scientific research and therefore, extensive and comprehensive scientific studies were conducted. Because the study of the territory is important for the establishment of the economy. During this period, the incompleteness of the previous stage was completed and errors were corrected. Prominent scientists and researchers of this period include M.A.Qashqai, S.A.Azizbeyov, A.Shikhalibeyli, R.N.Abdullayev, S.M.Suleymanov, V.Y.Khain, M.A.Museyibov, A.A.Madatzadeh, A.J.Ayyubov, A.M.Shikhlinski, S.H.Rustamov, B.S.Jafarov, Sh.B.Kerimov, M.H.Mirzayev, S.I.Mirzayev, M.A.Suleymanov, V.Nabiyev, R.H.Dashdiyev, A.A.Mikayilov and others.

3. In the third stage, due to Azerbaijan's independence, the issue of researching the territory was reconsidered and the information from the previous period was further enriched. At this

stage, the emergence of new scientific fields and the process of their use in the study of territorial landscapes made the obtained information even more valuable, for this reason, excellent scientific works were created by K.Sh.Allahverdiyev, Y.G.Aliyev, A.P.Mammadov, M.A.Teymurov, E.Sh.Mammadbeyov, T.M.Salmanova, M.I.Yunusov, Y.A.Garibov and others.

4. In the IV stage, with the liberation of the territory of the Eastern Zangezur economic region from occupation, not only theoretical, but also practical study of landscapes began, which was a clear example of the ecological terrorist act carried out by the enemy against our landscapes. During this period, S.Y.Guliyeva, I.I.Mardanov, A.Z.Hajiyeva, L.H.Hasanaliyeva, A.H.Valiyev, F.F.Fikratzade, S.I.Hajiyeva, A.M.Asgarov, L.A.Jabbarly, Sh.Aliyeva, A.Musayev and others conducted interesting research.

In modern times, the use of aerospace (remote sensing) data has become widespread in order to increase the effectiveness of geographical research. This approach plays an important role, especially in the complex and multidisciplinary study of landscapes. The study of territorial landscapes based on aerospace images allows for the accurate and rapid determination of their spatial structure, dynamics, natural boundaries and functional characteristics. The study of landscapes based on aerospace images has a number of important advantages; Operability and large-scaleness, comparative analysis and tracking of changes over time, objective description of the territory, multidisciplinary, etc.

Due to the mentioned data, the study of landscapes using space research methods is currently widespread throughout the world.

K. Osinska-Skotak, M. Entezari, A. Esmaeily, S. Niazmardi, Z. A. Husseyn, D.K. Mozgovoy, D.N. Svinarenko, Y. R. Leong, S.E. Franklin, E.E. Dixon, D.R. Farr, M.J. Hansen, L.M. Mosca and others have conducted various types of landscape studies using this method. We have also applied all these methods to our own study, carried out an ecogeographic study of the landscapes of the Eastern Zangezur region based on aerospace images and obtained a number of results.

Chapter II of the dissertation is devoted to **"The main landscape components of the Eastern Zangezur region and their role in the creation of natural conditions".**

When we pay attention to the elevation and slope maps of the territory obtained as a result of the analysis of satellite images, it becomes clear that the Eastern Zangezur region, which has a total area of 7471 $km^2$ and includes the territories of Kalbajar, Lachin, Gubadli, Zangilan and Jabrayil and covers the southern and southeastern slopes of the Lesser Caucasus Mountains and the border zones of Azerbaijan, is mainly dominated by mountainous terrain, despite the presence of foothills and plains (Figures 1 and 2).

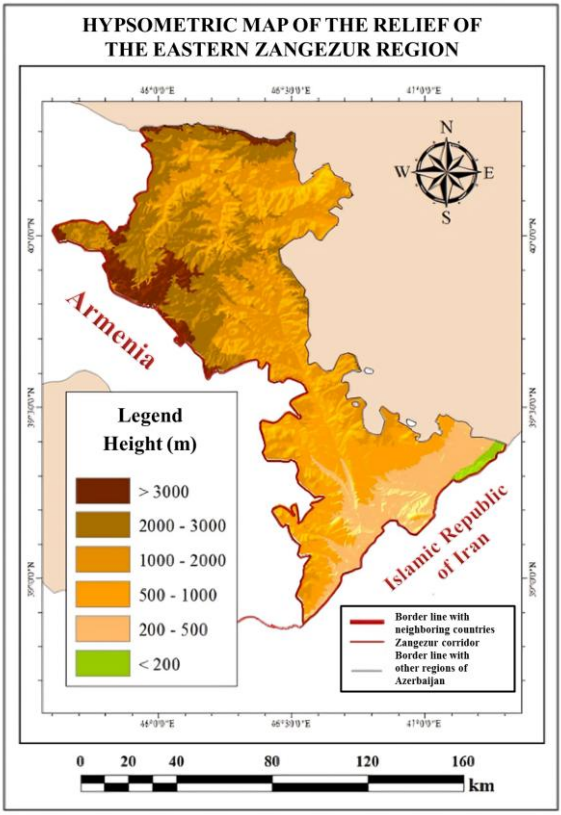


**Figure 1.** Hypsometry of the relief of the Eastern Zangezur region

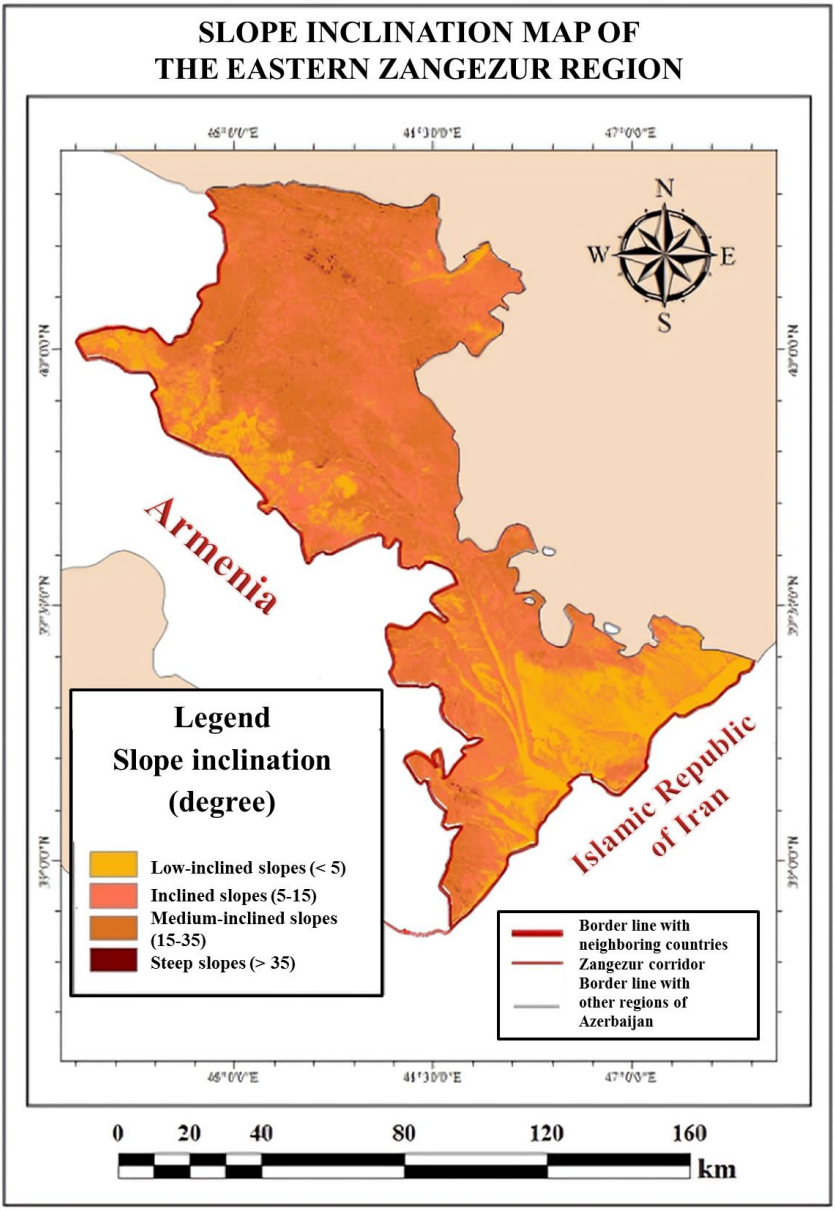


**Figure 2.** Slope inclination in the territory of Eastern Zangezur region

From the image reflecting the height of the land relief in Figure 1, we see that sharp hypsometric differences are observed in the relief of the Eastern Zangezur region, which varies between approximately 0–3500 m. The low-mountainous relief of the southeastern and eastern parts has led to the predominance of more anthropogenic landscapes (agriculture, residential areas). Here it is clear that the relief of the southern and southeastern parts is up to 500 m, the central and northeastern parts are up to 2000 m and the northern and northwestern slopes are up to 3000 m.

The slope inclination map presented in Figure 2 is of great importance for in-depth study of the morphometric characteristics of the territory and for conducting scientifically based landscape analysis. On the slope inclination map, the territory is divided into 4 degrees of inclination, with low-slope slopes (<5°) mainly distributed in the plain and foothill zones located in the southeast of the region and near the Araz River valley. These areas are areas where soils are less exposed to erosion and are suitable for agriculture. Low-slope slopes cover 1.7 thousand $km^2$ of the total territory of the region, which corresponds to 22.9% of our study zone. Slopes with a slope ranging from 5 to 15º are widely distributed in the area and are observed in the foothills and mid-mountainous zones. In the Eastern Zangezur region, the largest area is covered by sloping slopes, which are spread over an area of 3.1 thousand $km^2$. These slopes occupy 41.1% of the area within the region. It is possible to develop agriculture in these areas, where the soils are moderately eroded, but proper agrotechnical measures are needed. Slopes with a medium slope (15–35°) are mainly more numerous in medium and high mountainous areas - in the central, western and northwestern parts of the region. Since the erosion process is more active in these areas, they are not suitable for agriculture and are mainly covered with natural pasture and shrub landscapes. Slopes with a medium slope cover 32.5% of the area, making up 2.4 thousand $km^2$. Steep slopes (>35°), which occupy a small area in the region, are located in mountainous areas, especially in high relief zones located on the border with Armenia. In these areas, the soil cover is poorly developed, the processes of erosion and rock disintegration are

strong. These are areas unsuitable for human activity and can be considered as natural protection zones. Steep slopes occupy 3.5% of the total area of the region, or 0.3 thousand km$^2$.

Unlike other regions of Azerbaijan, volcanic activity, which continued for a long geological period, played a major role in the formation of the territory of the Eastern Zangezur region. In the region, Jurassic, Cretaceous, Paleogene, Neogene and Anthropogenic (IV period) sediments belonging to the Mesozoic era, Cenozoic eras, volcanogenic-sedimentary and volcanic-intrusive rocks belonging to volcanic rocks are widespread. These areas were one of the first areas to be freed from sea waters during the Lesser Caucasus orogeny and Caspian regression[1].

Due to the diversity of geological rocks distributed in the area, the region is rich in gold (in the Aghduzdag and Zod deposits of the Kalbajar region, Vejnali deposits of the Zangilan region, as well as in the Tartarchay, Soyudluchay, Zarchay, Tutkhunchay areas), chromite (Goydare), tungsten (Dalidag), molybdenum (Dalidag), copper (Murovdag, Kechaldag, Delidag), mercury (Agyatag, Levchay, Shorbulag, Lachin-Bashlıbel), antimony (Levchay), silver (Agyatag), asbestos (Goydare, Levchay), nephritoid (Goycha-Karabakh tectonic zone), marble onyx (in many rivers located along the Tartar fault), irrigated obsidian (Kechaldag, Bazarchay), granite (Shorbulag, Goydare), mineral dyes (Agyatag), perlite (Kalbajar, Kechaldag), travertine (Istisu, Asrik), tuff (Kalbajar), geyser, sand, clay (left bank of Tartarchay) etc. natural resources are widespread[2].

The location of the Eastern Zangezur region on the southern and southeastern slopes of the Lesser Caucasus Mountains, the extension of mountain ranges and the fact that these mountains are

[1] Museyibov M.A., "Physical geography of Azerbaijan (general part)", Baku-Maarif-1998, 400 p.

[2] Abdurahmanov F.T., "Geological-geomorphological analysis of the territory of the Eastern Zangezur region", Materials of the XXV Republican Scientific Conference of Doctoral Students and Young Researchers (Volume 3), Baku-2023, p. 44-48, Naghiyev V.N., "Regularities of location of scattered gold deposits of the Lesser Caucasus", Baku-2007, 104 pp., Tahmazov M., "Kalbajar - encyclopedic terms", Baku-2012, 504 p.

over 3000 m high have led to a diverse climate. Thus, temperate and subtropical climate zones have been established in the region, which are divided into various subtypes depending on the relief conditions:[3]

1. Mountain-tundra climate type, which covers areas above 2800-3000 m, is considered the climate of subnival landscapes with cool and humid summers, harsh and cold winters and sometimes snow cover remains from year to year.

2. Cold climate subtype with dry winters, which is considered the climate of high mountain landscapes with cool and humid summers, cold and partly dry winters, sometimes with long-term snow cover and mountain-meadow (alpine and subalpine meadows) landscapes.

3. Temperate-warm climate subtype with dry winters, where mountain-forest and shrub landscapes of the middle mountain range are spread, with partly mild and humid summers and dry winters.

4. Temperate-warm climate subtype with dry summers, which is formed in steppe landscapes with dry and warm summers and partly mild and wet winters in sharply divided parts of the foothills.

5. A semi-desert and dry-steppe climate subtype with mild winters and dry summers, covering the plains and foothills, with warm and dry summers and mainly frost-free and mild winters and short-term snow cover, which is found in semi-desert and dry-steppe landscapes.

The annual amount of solar radiation within the Eastern Zangezur region, which has favourable agroclimatic conditions, continues to increase towards the high mountainous areas. Thus, it is known that this indicator increases from the Jabrayil district in the southeastern part to the north and north-west. As a result of the analysis of space photographs, it is known that the annual amount of solar radiation in the Eastern Zangezur region mainly varies between 120-140 kcal/cm$^2$ (Figure 3).

[3] Abdurahmanov F.T. Analysis of climatic indicators of the Eastern Zangezur region and assessment of the role of agroclimatic resources in the development of agricultural areas // Scientific works of Nakhchivan University No. 4, Baku-2023, p. 229-236.

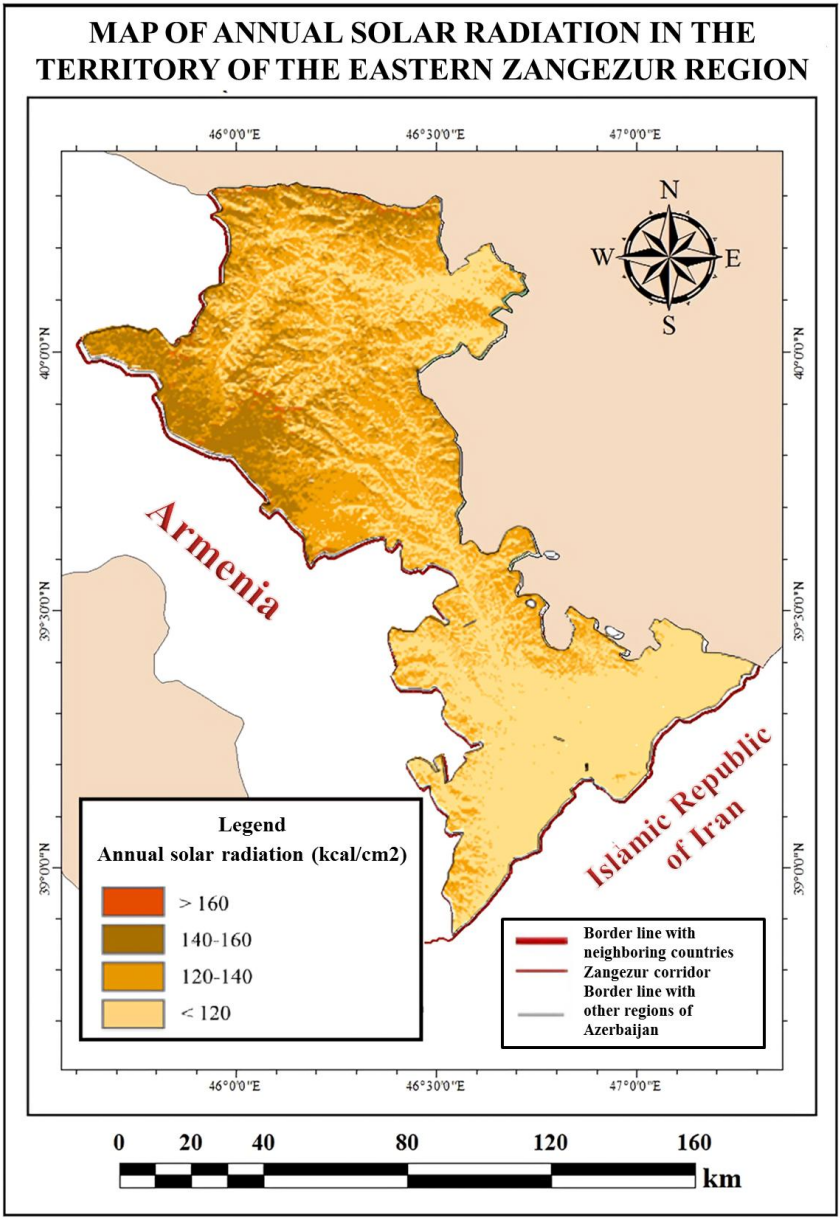


**Figure 3.** Annual solar radiation in the Eastern Zangezur region

According to the climatic data of A.M. Shikhlinski, in our research zone covering the southern and southeastern slopes of the Lesser Caucasus, the average annual air temperature was recorded as +7.4°C in the Kalbajar district, 10.0°C in Lachin, +13.1°C in Gubadli, +13.7°C in Zangilan and +12.7°C in Jabrayil. It should also be noted that A.M. Shikhlinski based his research on the climatic data of the Istisu settlement in the Kalbajar region, which is characterized by relatively high temperatures. However, when we calculated these indicators for the entire region during the research, the differences were reflected. In general, according to the climatic research conducted by A.M. Shikhlinski, the average monthly and average annual air temperatures in the region are shown in the table below (Table 1)[4]

**Table 1.**

**Average monthly and average annual weather indicators (Research by A.M. Shikhlinski)**

| Area | Average temperatures by month ($^0$C) | | | | | | | | | | | | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | |
| *Kalbajar* | -2.9 | -2.6 | -0.2 | 6.0 | 11.7 | 15.3 | 18.5 | 17.6 | 13.4 | 8.2 | 4.2 | 0.3 | 7.4 |
| *Lachin* | -0.9 | 0.3 | 3.9 | 8.6 | 13.9 | 18.0 | 20.8 | 20.8 | 16.2 | 11.3 | 5.9 | 1.6 | 10.0 |
| *Gubadli* | 0.5 | 2.4 | 6.7 | 12.0 | 17.4 | 22.4 | 25.2 | 24.7 | 20.2 | 14.3 | 8.5 | 3.4 | 13.1 |
| *Zangilan* | 0.7 | 3.5 | 8.0 | 12.1 | 18.8 | 23.4 | 29.9 | 25.0 | 20.4 | 14.2 | 8.7 | 3.7 | 13.7 |
| *Jabrayil* | 0.4 | 2.6 | 5.5 | 10.9 | 17.2 | 22.3 | 24.7 | 24.2 | 19.3 | 13.6 | 7.3 | 3.8 | 12.7 |

Unlike Table 1, as a result of the analysis of the last 30 years, the air temperature in this direction in the Eastern Zangezur region has become relatively favourable. Thus, the average annual air temperature was +4.5$^0$C in the Kalbajar region, +11.1$^0$C in Lachin, +13$^0$C in Gubadli, +14$^0$C in Zangilan and +15.8$^0$C in Jabrayil (Table 2).

Table 2 shows that the average annual temperature in Jabrayil district is high and the real reason for this is the influence of dry and warm air masses entering the area from the Iranian plateau, as well as the global warming problems that have occurred in the world.

[4] Guliyev H., "Regularities of vertical landscape belts in the Lesser Caucasus (within the territory of the Azerbaijani state)", Baku-2000, p. 25

**Table 2.**

**Average monthly and annual weather indicators**

| Area | Average temperatures by month ($^0$C) | | | | | | | | | | | | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | |
| *Kalbajar* | -5.9 | -5.0 | -1.3 | 3.7 | 8.1 | 12.0 | 14.0 | 14.4 | 10.9 | 5.8 | 0.4 | -3.2 | 4.5 |
| *Lachin* | 0.5 | 1.0 | 6.0 | 10.3 | 15.0 | 19.4 | 21.5 | 21.4 | 16.9 | 11.2 | 6.3 | 2.7 | 11.1 |
| *Gubadli* | 2.4 | 3.2 | 8.2 | 12.3 | 17.1 | 21.1 | 23.3 | 23.1 | 18.8 | 13.4 | 8.4 | 4.7 | 13.0 |
| *Zangilan* | 3.3 | 4.2 | 9.3 | 13.6 | 18.2 | 21.9 | 23.9 | 23.8 | 19.9 | 14.5 | 9.4 | 5.5 | 14.0 |
| *Jabrayil* | 4.9 | 5.4 | 10.7 | 14.6 | 20.0 | 24.9 | 27.4 | 27.0 | 21.5 | 15.3 | 10.4 | 6.9 | 15.8 |

The Eastern Zangezur district has good hydrological and hydrogeological conditions. There are many rivers, lakes, groundwater sources, reservoirs and other water bodies in its territory. The role of various sources in feeding the rivers flowing within the district is invaluable. Thus, in rivers flowing from high mountains, snow and glaciers play a major role, while in plains and foothills, rain and groundwater play a major role. In the Karabakh volcanic plateau located in the eastern Zangezur region, thick tuff-lava layers filter snow and rain water to the surface, causing the formation of underground streams, which in turn feeds the Tartarchay and Hakarichay rivers, which originate from this plateau. More than 60% of the Hakarichay River and more than 50% of the Toragaychay River, a tributary of the Tartarchay, fall into this basin.

The influence of soil-forming factors, the diversity of natural conditions and the development of ancient agricultural culture have led to the formation of a complex soil cover in the Eastern Zangezur region. In the Kalbajar region, there are mainly grassy mountain meadows and brown mountain forests, in the Lachin district, grassy mountain meadows, brown mountain forests and carbonate mountain forests, in the Gubadli district, there are mainly brown mountain forests and in the Jabrayil district, the soils of the Arazboyu plains are dark chestnut colour soils with high productivity.

Chapter III of the dissertation is devoted to **"Ecogeographical analysis of the landscape components of the Eastern Zangezur region based on aerospace images, study of their impact on the transformation and degradation of landscapes".** It should be noted that for the evaluation of land for agricultural purposes, only

its physical and chemical composition, granulometric indicators, etc. data is not enough. For this, it is also necessary to calculate the temperature of the surface of the soil.

It is known that space satellites, having high-quality optical cameras, are capable of taking accurate images of the Earth's surface from a distance of several hundred km from the ground. For this, it is necessary to obtain images at appropriate intervals from space satellites and perform a number of operations on them. When analyzing these images, it is important to take into account the characteristics of the selected satellite and the information from the acquired photographs.

As a result of the analysis of the space images obtained from the LANDSAT and AzerSky satellites using GIS technologies, the average annual soil temperature in the territory of the Eastern Zangezur region is depicted in the figure below (Figure 4).

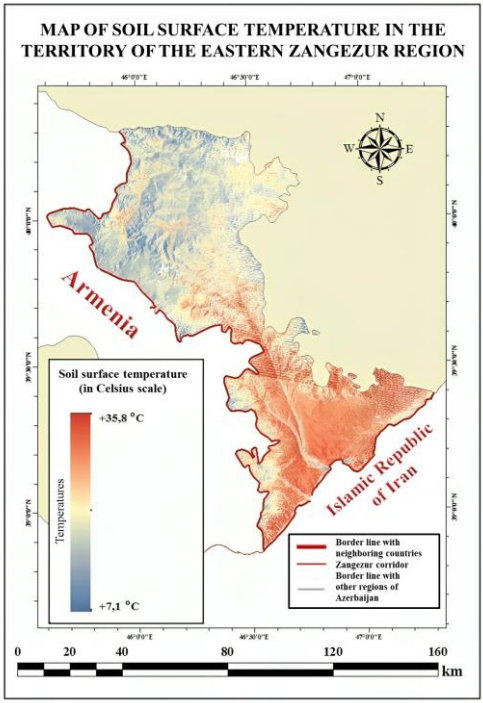


**Figure 4.** Soil temperature index of the Eastern Zangezur region

In general, we can conclude that the surface temperature of the soil in the territory of the Eastern Zangezur region varies between 7.1-35.8$^0$C, which creates conditions for the germination and development of many plant seeds. These include tomatoes, cucumbers, cabbage, beets, green crops, fruits and vegetables, etc. Examples can be given. Even the temperature above 30$^0$C opens up wide opportunities for such cultivation of dry subtropical plants. Taking into account the above information, it is possible to say that there are wide opportunities for the development of the plant-growing type of agriculture in the territory of the Eastern Zangezur district and the achievement of abundant productivity.[5]

The Lesser Caucasus Mountains, where the territory of the Eastern Zangezur district is located, are among the areas rich in forest resources. However, the occupation of the region after 1990 and its occupation for nearly 30 years led to a sharp decrease and destruction of forest areas within the region. This includes bombs used by enemies during the war, forest fires, illegal logging, etc. reasons. According to 2020 data, the total area of forests in the region was 178.1 thousand ha, of which the majority fell to Lachin (63.3 thousand ha) and Kalbajar (62.8 thousand ha). In other regions, Gubadli, Zangilan and Jabrayil, their share was 18.4 thousand ha, 19.6 thousand ha and 14 thousand ha, respectively.

Thus, based on the analysis of images obtained from AzerSky, LANDSAT-8, LANDSAT-9 and Sentinel space satellites for different periods, it was determined that in 1990 alone - before the occupation, the forest area of the Eastern Zangezur region was 227.8 thousand ha, but during the occupation years this indicator decreased. This means that as a result of illegal logging during the occupation period, as well as the burning of our forests by Armenians during the war and the violation of the ecological balance using white phosphorus bombs, about 50 thousand ha of forest area in our study zone were completely destroyed and wiped off the face

[5] Abdurahmanov F.T., "The research of the soils in the Eastern Zangezur region and the calculation of the soil temperature analysis using GIS technologies", Moscow Economic Journal, Том-9, №9, Russia-2024, p. 10-26

of the earth. After the liberation of the territorial lands from occupation, Azerbaijan launched construction and restoration works in order to restore the ecological balance in these areas and the area of our forests was estimated at 178.1 thousand ha. The areas where the most forests were destroyed mainly fell on the share of the Zangilan district. Currently, reforestation works are continuing (Figure 5).

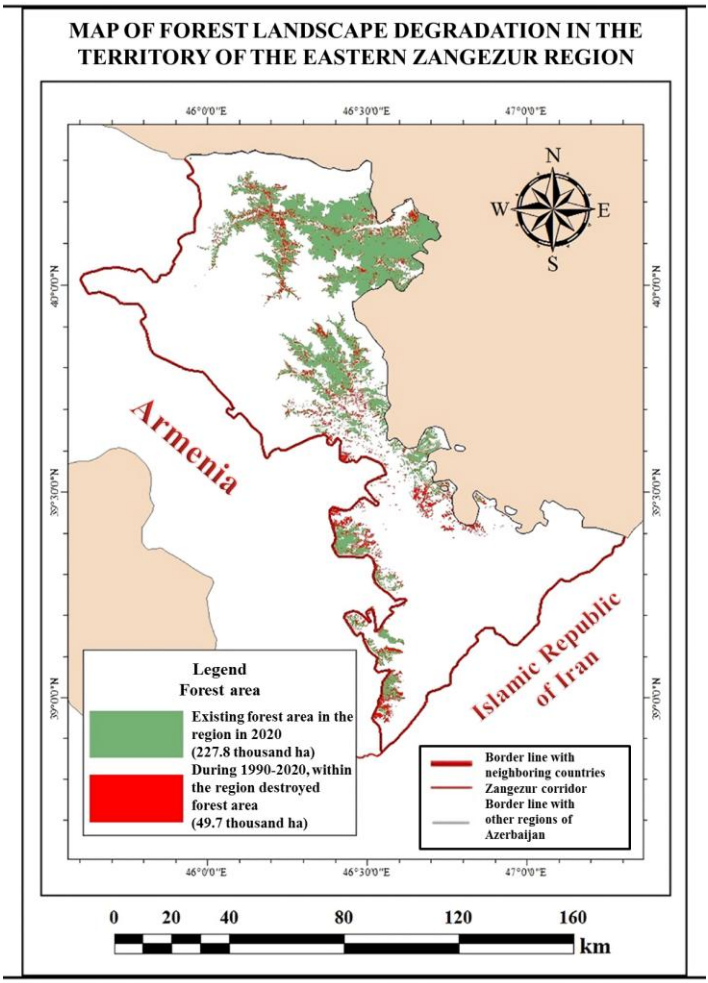


**Figure 5.** Ecological status of forests in the Eastern Zangezur region (1990-2020)

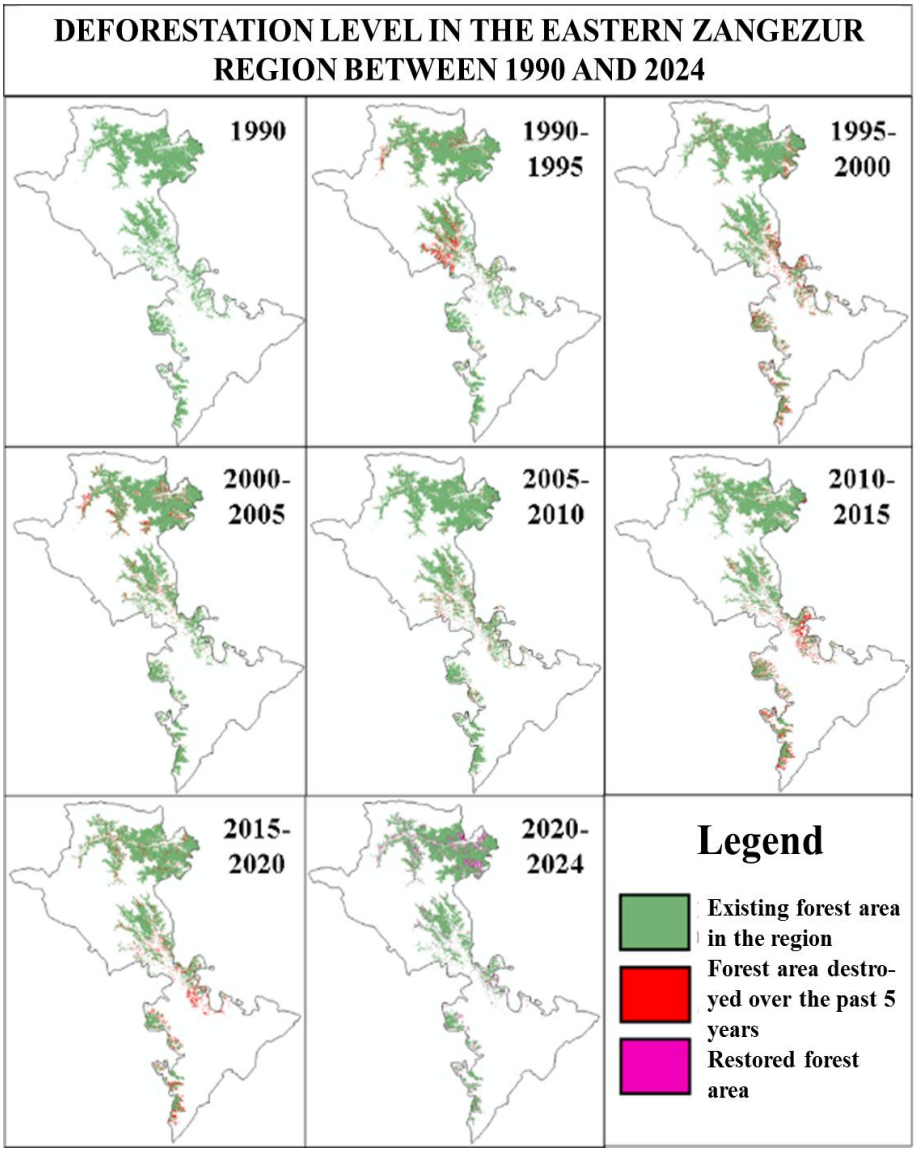


**Figure 6.** Dynamics of forest landscapes in the territory of the Eastern Zangezur region during 1990-2024

**Table 3.**

**The state of forests of the Eastern Zangezur region during the occupation period, forest cover, cleared forest area and deforestation rate (1990-2024)**

| Year | Forest area (thousand ha) | Forest cover ratio (%) | Deforested area (thousand ha) | Deforestation rate (%) |
|---|---|---|---|---|
| **1990** | 227,8 | 30,5 | - | - |
| **1995** | 219,0 | 29,3 | 8,8 | 3,9 |
| **2000** | 217,6 | 29,1 | 2,4 | 1,1 |
| **2005** | 213,5 | 28,6 | 4,1 | 1,9 |
| **2010** | 208,8 | 27,9 | 4,7 | 2,2 |
| **2015** | 190,4 | 25,5 | 18,4 | 8,8 |
| **2020** | 178,1 | 23,8 | 12,3 | 6,5 |
| **2024** | 185,4 | 24,8 | - | - |

Table 3 and Figure 6 show the forest area, afforestation and deforestation rates covering the years 1990-2024. Figure 6 shows the changes in forest cover in the Eastern Zangezur region between 1990 and 2024. The visual material is presented in 9 periods and in each period the existing forest areas (green), the forest areas that have been cut down in the last 5 years (red) and the restored forest areas (pink) are shown separately. Table 3 shows the existing and cut down forest areas (thousand ha), afforestation and deforestation rates (%) for those years.

It is clear from the table that the massive deforestation of the Eastern Zangezur region began in 2010. Thus, the existing forest area of 227.8 thousand ha in 1990 decreased to 219 thousand ha in 1995, which means the destruction of 8.8 thousand ha of forest area during the 5 years covering 1990-1995. The reason for this was the weapons and bombs used during the occupation, fires, etc. If the forest cover ratio in the region was 30.5% in 1990, this indicator decreased to 29.3% in 1995. If we distribute the destroyed forest area by years, this indicates the fact that approximately 1.8 thousand ha of forest area was destroyed per year. In 1995, the deforestation ratio was 3.9%. In the next 5 years, i.e. in 2000, our forest area was cut down

by an additional 2.4 thousand ha, decreasing to 217.6 thousand ha, which led to the deforestation rate in 2000 being 1.1% and the forest cover rate being 29.1%. As can be seen, our forest area suffered little damage during these years, which is probably due to the negotiations that covered those years. Because foreign countries were still reluctant to “covet” at the occupied lands. However, after 2000, the illegal appropriation of our regional resources, the deterioration of landscapes and the deforestation indicators began to increase. Already in 2005, it was estimated that there were 213.5 thousand ha of forest area in the Eastern Zangezur region, which indicates the deforestation of 4.1 thousand ha of forest area in 2000-2005. In 2005, the forest cover ratio decreased to 28.6%, while the deforestation ratio increased to 1.9%. According to the 2010 analysis, over the past 5 years, another 4.7 thousand ha of forest area were destroyed, reducing this figure to 208.8 thousand ha, which indicates a deforestation ratio of 2.2%. In 2010, the forest cover ratio in the area was 27.9%. Starting from this year, with the idea that our already occupied lands would not be returned, a ruthless "couch" was imposed on our forests and a massive reduction in our forest areas began. Foreign countries also played a large role in this. Because the wood materials cut from the area were annexed to foreign countries. Thus, according to 2015 estimates, 190.4 thousand hectares of forest area were registered within the region, which means the destruction of 18.4 thousand hectares of forest area between 2010 and 2015. It should also be noted that this indicator is the peak figure calculated during the occupation period. Already in 2015, the forest cover ratio decreased sharply to 25.5% and the deforestation ratio rose to a high level - 8.8%. After those years, the Azerbaijani side's appeals to the international community regarding Armenian vandalism became widespread. Since then, it has been clarified that the lands will be acquired not peacefully, but through war. Military preparations were continuing within the country for this. Already during the conflicts that occurred in 2015-2020 and the 2020 war, forest fires, the use of white phosphorus bombs, etc. Due to this, as well as as a result of deforestation works covering the years 2015-2020, the area of our forests decreased by another 12.3 thousand ha to 178.1 thousand ha.

This led to the deforestation rate being 6.5%. The forest rate in 2020 was 23.8%. From the general analysis, the damage caused by the enemy to our forest resources is once again evident. Thus, our forest area, which existed in 1990, from 227.8 thousand ha, decreased to 178.1 thousand ha in 2020, which means the destruction of 49.7 thousand ha of our forest area during the 30 years of occupation.[6] The deforestation rate in the territory of the Eastern Zangezur region over the entire 30 years was 21.8%. The fact that the area of forest landscapes within the Eastern Zangezur region has increased by 7.3 thousand ha to 185.4 thousand ha in 2024 allows us to say that the Azerbaijani side has successfully implemented the forest restoration policy, where the peaceful setting of forest landscapes in the area and the prevention of deforestation have led to the successful implementation of the policy.

In conclusion, deforestation between 1990–2015 was mainly acute and had a serious impact on ecosystems. During this period, uncontrolled human activity and weak state policy are the main reasons for the decline in forest cover. The start of forest restoration between 2020–2024 can be considered as an important progress. Although the scope of restoration areas is still limited, the sustainability and large-scale nature of this process is important for future ecological stability. The fact that deforestation is mainly in the southern and central parts of the region and the restoration process is in the north, can be explained by the different distribution of local climate, relief and human activity.

Eastern Zangezur region, which covers the western and southwestern borders of Azerbaijan, has various landscape units from low mountainous and plain areas to high mountainous areas (Figure 7).

[6] Abdurahmanov F.T., "The analysis of the transformation of forest landscapes in the Eastern Zangezur region of Azerbaijan based on satellite imagery", Moscow Economic Journal, Том-9, №8, Russia-2024, p. 83-99

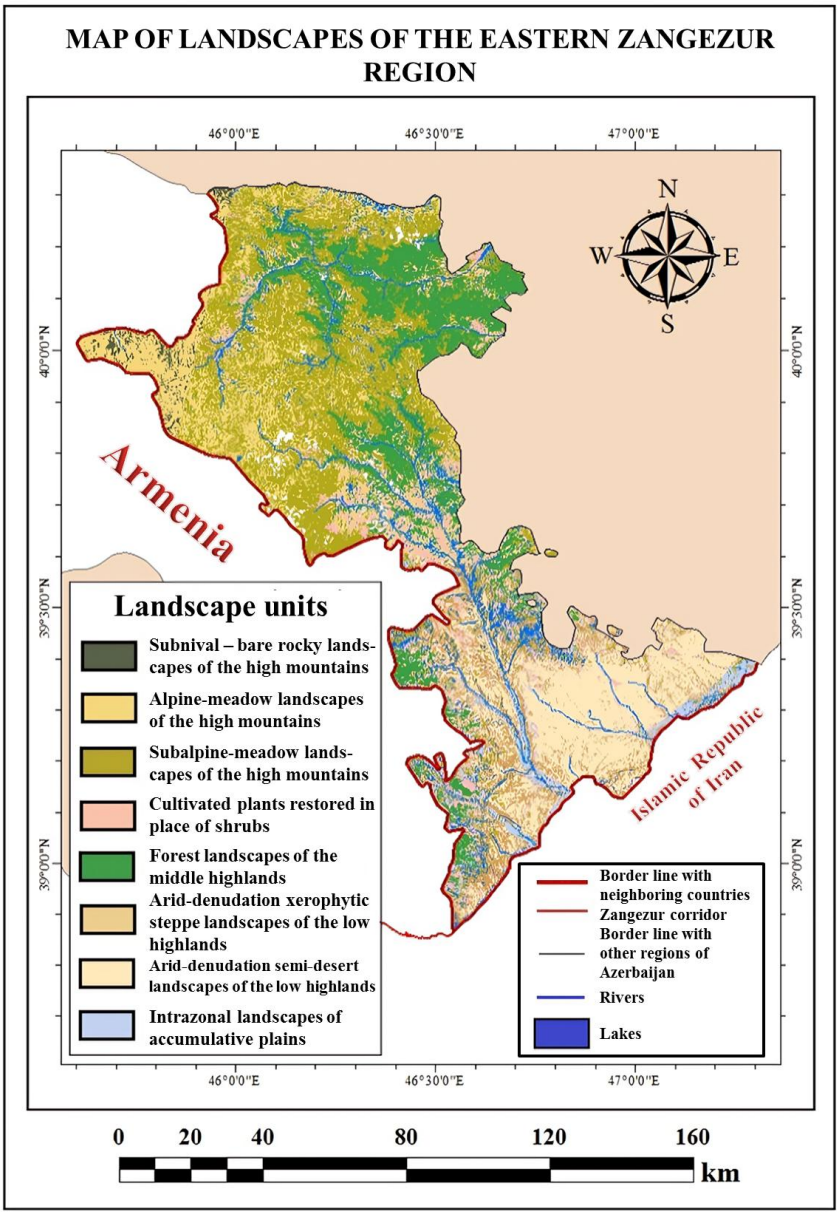


**Figure 7.** Landscape units existing in the territory of the Eastern Zangezur region

As can be seen from Figure 7, we can summarize the landscape units spread throughout the region and come to the following conclusions:

1. Subnival landscapes of the high mountains - these landscapes, which mainly cover the peaks of the Eastern Zangezur region above 3000 meters, are composed of bare rocks. Due to the formation of the territory with steep and high slopes, the annual amount of solar energy varies from 1800-1900 kW * s/m² to 2000-2200 kW * s/m², while the annual amount of solar radiation is equal to 160-170 kcal/cm². The subnival rocky landscapes of the highlands are completely devoid of soil cover due to cold weather, snow and glaciers throughout the year.

2. Mountain-meadow landscapes of the highlands – the mountain-meadow landscapes of the Lesser Caucasus Mountains, where the Eastern Zangezur region is located, mainly covering altitudes of 1,800-3,000 m, are divided into alpine and subalpine meadows based on differences in vegetation and soil cover. Alpine meadows, composed of low-growing grasses, cover the 2,200-3,000 m altitudes of the high mountains, while subalpine meadows, where tall grasses grow, cover the 1,800-2,200 m altitudes. During a nearly 30 year occupation period spanning 1990-2020, the impacts were reduced due to the difficulty of human occupation of these landscapes and as a result, the mountain-meadow landscapes restored their natural balance. However, due to the degradation of the forest landscapes below the mountain meadows, these landscapes have begun to expand their areas, lowering their lower borders even further. While the area of subalpine meadow landscapes calculated in 1990 within the region was 185.7 thousand ha, in 2020, subalpine meadows have spread to other areas, including deforested forests and increased their area to 236.9 thousand ha.

3. Mountain-forest landscapes of the Central Highlands, consisting mainly of oak, pistachio and alder trees - these landscapes cover altitudes of 800-1800 m in the territory of the Eastern Zangezur region and are composed of limestone, sandstone, volcanogenic-sedimentary rocks and clayey-clayey shales of the Jurassic and Cretaceous periods. Unfortunately, during the nearly 30

year occupation, Armenia has ruthlessly attacked our forests and due to the intensive destruction of our forests, many of them have been replaced by meadows and forests with a mixture of various grasses and shrubs.

4. Xerophytic landscapes of the Middle Highlands - this landscape unit is spread in the border zone of the Eastern Zangezur region in the Zangilan territories. In general, these xerophytic landscapes were formed under the influence of xerophytic formations brought to the region from Central Asia and Iran during the Tertiary period. The landscape once included the Basitchay State Reserve, which protected ancient Eastern plane forests. Unfortunately, over the course of nearly 30 years of occupation, the trees in the reserve have been cut down and destroyed and the landscapes have been transformed. As a result of the impact of Armenian vandals on the mountain-xerophytic landscapes, the wildlife has been forced to change its habitat.

5. Steppe and partially forest-steppe landscapes of the lowlands - this landscape unit covers the southern areas of the Eastern Zangezur region from 100-150 m to 1000 m and is formed from Cretaceous rocks. Since steppe landscapes do not correspond to the climatic conditions of the region, they are mainly considered derivative landscapes. These landscapes were formed mainly as a result of deforestation by humans.

6. Dry steppe landscapes of the plains - these landscape units were formed by the convergence of the lowlands and plains of the Karabakh Mountains with the southern parts. The territory is also used as winter pastures, like other landscapes.

Chapter IV of the dissertation is devoted to **"Landscape planning in the territory of the Eastern Zangezur region".**

It should be noted that the liberation of the territory from occupation and the development of the economy will primarily make a great contribution to the creation of new jobs and employment of the population, which will help to further reduce the unemployment rate in the country.

Our research area, the Eastern Zangezur region has all the necessary conditions for the development of the agricultural sector.

Its fertile soils, favourable climatic conditions and wide rivers have opened up vast opportunities for the establishment, development and expansion of crop and livestock farms. The relief conditions of the territory, highly productive and extensive mountain-meadow landscapes, pasture areas for animal husbandry, brown mountain-forest, mountain-black, etc. soils and agro-climatic reserves have created conditions for plant farming (Figure 8).

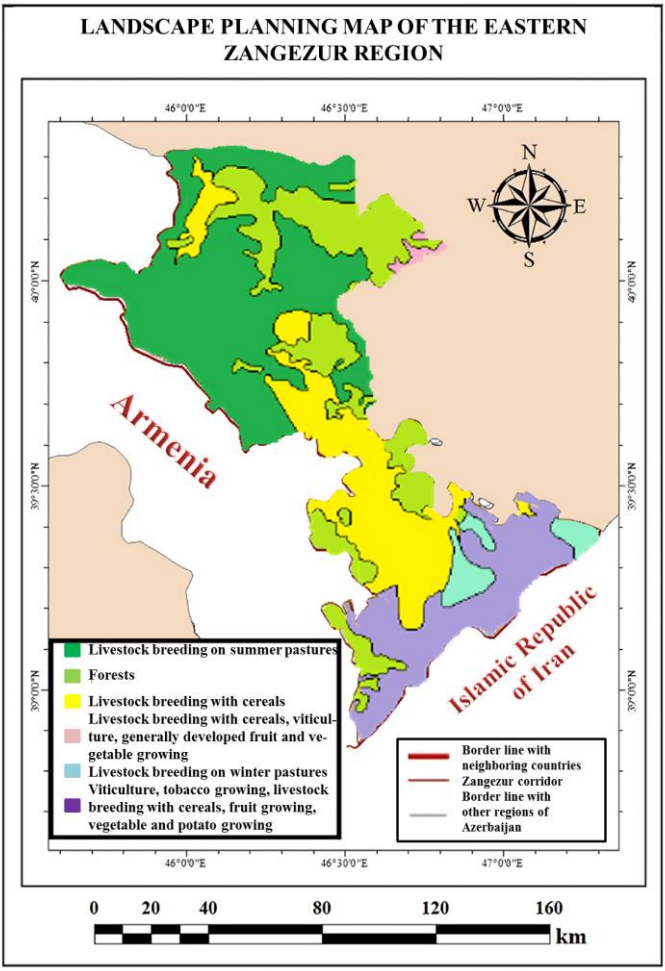


**Figure 8.** Landscape planning of the territory of the Eastern Zangezur region

As can be seen from Figure 8, the northern slopes of the Kalbajar and Lachin regions are mainly developed for summer pastures and cereal crops, which are also unsuitable for agricultural purposes since part of them is covered with forests. However, unlike these, Gubadli, Zangilan and Jabrayil regions covering the central and southern parts have a favourable position for the development of livestock and crop farming. Here, especially in the southern parts, it is possible to achieve abundant productivity by developing agricultural areas such as viticulture, fruit growing, vegetable growing and so on, which is directly related to the climate, soil and relief factors. In 2022, the area of wheat crops in the Eastern Zangezur region was 27,451 ha, barley crops were 12,629 ha and sorghum crops were 326 ha. It should also be noted that this indicator has caused a significant increase compared to the previous year, 2021. Of these, velami is planted only in the Zangilan (325 ha) and Jabrayil (1 ha) areas of the district, while the rest are planted in all parts of the district. A total of 27.95 tons of wheat, barley and velami were harvested from the total grain-growing economy, of which 18.9 thousand tons were wheat, 9 thousand tons were barley and 0.05 thousand tons were velami.

According to statistic informations, in 2022, a total of 6.1 thousand tons of meat were produced in the Eastern Zangezur region, of which 3.4 thousand tons were obtained from Kalbajar, 1.3 thousand tons from Lachin, 118 tons from Gubadli, 97 tons from Zangilan and 1.3 thousand tons from Jabrayil. As can be seen, this indicator was dominant in the Kalbajar and Lachin regions, which have large areas of pastures, as well as in the Jabrayil region, which has plains for wintering. The total volume of milk produced within the region was 50.7 thousand tons, with Kalbajar (20.2 thousand tons), Lachin (19.9 thousand tons) and Jabrayil regions (8.9 thousand tons) being the most prominent. The volume of milk obtained from the other Gubadli and Zangilan districts, respectively, amounted to 1.3 thousand tons and 486 tons. Let us also add that these meat and dairy products include products from cattle breeding, sheep breeding and poultry farming. According to statistical data, as of 2022, a total of 94.1 thousand head of cattle were registered in the district,

including 91.4 thousand cows and 2.7 thousand buffaloes. Of this, 37.9% is in Kalbajar (35.1 thousand cows and 0.6 thousand buffaloes out of a registered herd of 35.7 thousand cattle), 42.8% is in Lachin (38.2 thousand cows and 2.1 thousand buffaloes out of a registered herd of 40.3 thousand cattle), 2% is in Gubadli (all cows out of a registered herd of 1.9 thousand cattle), 5.6% is in Zangilan (5.3 thousand cattle). of the large cattle herd (all of which are cows) and 11.6% fell to the Jabrayil district (of the registered 10.9 thousand large cattle herd, almost all of which are cows). Although these figures are generally lower than those in the Soviet countries, it is predicted that these indicators will increase over time.[7]

In conclusion, it should be noted that the development of the region will create conditions for the full satisfaction of the population's needs for meat, milk and grain products and the provision of high-quality food. Therefore, special importance should be given to the agricultural development of the region, based on historical traditions. In this case, there will be a revival in the development of the agrarian sector of Azerbaijan and an increase in the share of the non-oil sector will be observed.

## CONCLUSION

The following results were obtained during the ecogeographical study of the landscapes of the Eastern Zangezur region based on aerospace images:

1. The Eastern Zangezur region covers the southern and southeastern slopes of the Lesser Caucasus Mountains and has a mainly mountainous relief. Due to the diversity of geological rocks distributed in the region, gold, chromite, tungsten, molybdenum, copper, mercury, antimony, silver, asbestos, nephritoid, marble onyx,

[7] Mammadova Sh.I., Abdurahmanov F.T., Humbatov M., “Main development directions of agricultural areas in the Eastern Zangezur region”, BIO Web of Conferences 151, France-2024, 13 pages

irrigated obsidian, granite, mineral paints, perlite, travertine, tuff, gneiss, sand, clay, etc. natural resources are widespread.

2. It was determined that the study area has rich agroclimatic resources for the development of agriculture. Thus, active temperatures in the Kalbajar and Lachin regions are only 1200-4000$^0$C, while other regions mainly correspond to the categories between 4000-8000$^0$C.

3. In the Eastern Zangezur region, it was determined that the soil surface temperature was higher in the southern part (Jabrail) and lower in the northern (Kalbajar) and western (Lachin) parts due to the prevailing cold weather.

4. We calculated the average surface temperature of the soil in the region and determined that the indicator varied between 7.1-35.8$^0$C. This also creates conditions for the growth of dry subtropical plants in the Eastern Zangezur region.

5. A comparative analysis of the forest landscapes of the Eastern Zangezur region between 1990 (total forest area 227.8 thousand ha) and 2020 (total forest area 178.1 thousand ha) was conducted and it was revealed that 49.7 thousand ha of forest landscapes were destroyed over 30 years. At the same time, it was shown that the deforestation rate in the Eastern Zangezur region over 30 years was 21.8%. In 2024, the area of forest landscapes within the study area increased by 7.5 thousand ha and reached 185.4 thousand ha.

6. Natural terrain complexes in the study area are distinguished by their diversity. Thus, the distribution of subnival landscapes of the highlands, alpine, subalpine and meadow-steppe landscapes, broad-leaved forests and meadow-shrub landscapes of the middle highlands, mountain-xerophyte landscapes, steppe and partial forest-steppe landscapes of the lowlands and dry-steppe landscapes of the plains has been determined here.

7. Maps of the landscapes of the Eastern Zangezur region have been compiled using aerospace research methods. The maps reflect the forests of 1990-2024, as well as the modern state of landscape units. At the same time, a map of the planning of the landscapes of the research area has been prepared.

## Proposals

1. By dividing the land according to its purpose, the process of its proper use can be implemented. At the same time, by carrying out phytoremediation (plant melioration) measures, it will be possible to return the land to its previous state more quickly.

2. Monitoring the harmful substances in river waters in the study region can provide effective results in the process of purifying water from pollutants.

3. In the process of forest restoration, it is appropriate to grow tree plants based on world experience. A number of tree species are capable of removing various heavy metals from the soil. As a result of a study conducted by Maria Greger and Tomi Landberg, they suggested that willow has significant potential for removing substances such as cadmium, zinc and copper from the soil. Subsequently, as a result of the research, it was revealed that it will play an effective role in removing arsenic from sunflower plants, cadmium, zinc and copper from willow trees, chromium from tomato plants, lead from poplar trees, sodium chloride (salt) from salt-tolerant barley or sugar beets, etc. from the soil.

4. It would be appropriate to carry out reforestation work to ensure the sustainability of regional landscapes.

**The following articles have been published in accordance with the content of the dissertation:**

1. Abdurahmanov F.T. The interaction of ecological problems and health problems // 1 Nation, 6 State, common media (media platform of Turkish-speaking countries) International Congress of Social and Human Sciences, Congress Book-1, Baku-2021, p. 184-189.

2. Mammadova Sh.I., Abdurahmanov F.T. Analysis of natural terrain complexes of the Eastern Zangezur region // The XXXII International scientific symposium “Turk`s victory: from Chanakkale to Karabakh”, Ankara-2022, p. 455-457.

3. Abdurahmanov F.T. Geological-geomorphological analysis

of the territory of the Eastern Zangezur region // Materials of the XXV Republican Scientific Conference of Doctoral Students and Young Researchers (Volume 3), Baku-2023, p. 44-48.

4. Mammadova Sh.I., Abdurahmanov F.T. Research of the rivers in the Eastern Zangezur region and their ecogeographical problems // Baku University News (Natural Sciences Series) No. 2, Baku-2023, p. 95-104.

5. Abdurahmanov F.T. Analysis of climatic indicators of the Eastern Zangezur region and assessment of the role of agroclimatic resources in the development of agricultural areas // Scientific Works of Nakhchivan University No. 4, Baku-2023, p. 229-236.

6. Abdurahmanov F.T. Assessment of the lands of the Eastern Zangezur region for the purpose of developing agriculture // News of the Pedagogical University (mathematics and natural sciences series), vol. 71, No. 4, Baku-2023, p. 145-155.

7. Mammadova Sh.I., Abdurahmanov F.T., Ganbarova N.I. Prospects for the development of agriculture in the Eastern Zangezur region // Materials of the Republican Scientific and Practical Conference on the topic "Heydar Aliyev's ideas: the whole of Azerbaijan and sustainable development", Baku-2023, p. 33-37.

8. Abdurahmanov F.T. The analysis of the transformation of forest landscapes in the Eastern Zangezur region of Azerbaijan based on satellite imagery // Moscow Economic Journal, Volume 9, No. 8, Russia-2024, p. 83-99.

9. Abdurahmanov F.T. The research of the soils in the Eastern Zangezur region and the calculation of the soil temperature analysis using GIS technologies // Moscow Economic Journal, Volume 9, No. 9, Russia-2024, p. 10-26.

10. Mammadova Sh.I., Abdurahmanov F.T. The necessity of implementing new districting in Azerbaijan and the importance of re-searching the landscapes in the Eastern Zangezur economic region // Baku State University Journal of Earth Sciences & Environment v 1 (3), Baku-2024, p. 39-44.

11. Abdurahmanov F.T. The necessity of implementing new districting in Azerbaijan and the importance of researching the landscapes of the Eastern Zangezur region // Special issue of the

republican scientific conference on scientific research of young scientists "Green Shusha - green world", Baku-2024, p. 136-141.

12. Mammadova Sh.I., Abdurahmanov F.T., Humbatov N. Main development directions of agricultural areas in the Eastern Zangezur region // BIO Web of Conferences 151, France-2024, p. 13.

The defense of the dissertation will be held on 24 October 2025 at 11$^{00}$ at the meeting of the Dissertation Council FD 2.51 operating under the Faculty of Geography of Baku State University, Ministry of Science and Education of the Republic of Azerbaijan.

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