REPUBLIC OF AZERBAIJAN

On the rights of the manuscript

ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

MODELING AND OPTIMIZATION OF THE DEVELOPMENT DYNAMICS OF URBANIZED LANDSCAPES IN AZERBAIJAN (IN THE EXAMPLE OF GANJA AND MINGACHEVIR CITIES)

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

Field of science: Geography

Applicant: **Khumar Khanim Dadash Dadashova**

Baku – 2024

The work was performed in the departament of "Physical Geography" of "Geography" faculty at Baku State University.

Scientific supervisor: Philosophy Doctor in Geography, Associate Professor **Mirnuh Javad İsmailov**

Official opponents: Doctor of Geographic Science, Associate Professor **Mahmud Yusif Khalilov**

Ph.D. in Geography, Associate Professor **Afgan Talib Talibov**

Ph.D. in Geography, Associate Professor **Latifa Arif Kazimova**

Dissertation council FD 2.51 of Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at Baku State University in Geography faculty.

Chairman of the Dissertation council: Doctor of Geographic Science, Professor **Chingiz Niyazi Ismailov**

Scientific secretary of the Dissertation council: Ph.D. in Geography, Associate Professor **Allahverdiyeva Sahila Abish**

Chairman of the scientific seminar: Doctor of Geographic Sciences, Associate Professor **Stara Abulfaz Tarikhazer**

Azərbaycan Respublikasının Elm və Təhsil Nazirliyi BAKI DÖVLƏT UNİVERSİTETİ
Ministry of Science and Education of the Republic of Azerbaijan Baku State University
SCIENTIFIC SECRETARY
İmzalı edirəm
"18" 12 2024

GENERAL CHARACTERISTICS OF THE WORK

Relevance of the topic and degree of development. The process of urban planning is the improvement of city planning and the formation of its structure in accordance with the modern requirements of scientific and technical development. On the one hand, this process reflects the historical development of settlements, reflecting their long-term spatial planning, construction and improvement. On the other hand, city planning requires a material outcome, the current state and future development of construction and development, that is, a synthesis of old urban planning traditions and innovation.

The cities of Ganja and Mingachevir, which are the research area, are different cities in terms of historical settlement. However, increasing anthropogenic impacts in modern times have led to the degradation of sensitive ecosystems and the creation of secondary complexes in both cities. In a period of intensifying anthropogenic influences, complex assessment of landscapes, study of ecogeographic situation, analysis of anthropogenic modifications, modeling and optimization of development dynamics of urbanized landscapes are indispensable.

Urban development, demographic and ecological problems of cities are currently one of the most urgent problems of the world, and scientists of many countries of the world (I. Milkov, A. Isachenko, A. Kurbatova and E. Kovalyeva, T. Anderson, L. Hauzen, S. Mark and others had reflected in their studies. Among Azerbaijani scientists, the works of R. Mammadov, M. Ismayilov, Y. Garibov on landscapes and their optimization, and the works of Sh.Mammadov, I.Khalilov and T. Bakhshalizade are of great importance from the point of view of ecological and environmental protection of the area.

The object and subject of the research. The object of the study is the two most important cities of Azerbaijan and their urban landscapes. Urban landscapes and the physical geographical basis of their formation, including the analysis of the ecological situation, constitute the object of research. The subject of the study reflects the

special approach to the research and study of the research object, so that as a result, the investigated cities are more comprehensively studied from a geographical point of view.

The purpose and tasks of the study. The main goal of the research is to analyze and generalize the processes of regional placement, city creation and urban development at the level of living environment in the Republic of Azerbaijan, and to determine the main regularities of the formation of this environment, taking into account the processes of innovation and tradition.

For this purpose, the following are the main objectives of the work:

- Study of the main regularities of the factors influencing the differentiation of modern geosystems;
- Study of the main problems and directions of the dynamics of urban landscapes;
- Studying the structural and functional aspects of modern natural geosystems spread in the research area, the levels of anthropogenic loading and assimilation;
- Research of ways of environmental analysis and optimization of urban landscapes.

Research methods. During the research, statistical analysis, comparison, mapping, historical-geographical and systematic approach, field research, etc. has been used.

Clauses defended:

1. Researching the historical-geographic features of the formation of urban landscapes;
2. Determination of the role of natural-geographical and anthropogenic factors in the development of urban landscapes;
3. Modeling the grouping and development of urban landscapes according to their structural and functional characteristics
4. Determination of landscape-ecological problems and risk zones of Ganja and Mingachevir cities;
5. Determination of ways to optimize urban landscapes.

Scientific innovations of the research work.

1) For the first time, the laws of differentiation and transformation of landscapes under the influence of human economic activity were systematically analyzed and mapped in research objects.

2) For the first time, a new field-expedition, cartographic, geomorphological, landscape, etc. on the basis of research materials, the borders were clarified, the areas were calculated, and the modern development directions of the natural-anthropogenic landscapes were determined.
3) The degree of anthropogenic degradation of the territory was determined, and a map-scheme of the ecogeographic assessment of landscape complexes was drawn up.
4) Research of anthropogenic changes of natural landscapes and quantitative assessment of anthropogenic impact based on digital electronic map fragments was carried out.
5) In the ArcGIS program, maps were drawn up at a scale of 1:20.000, taking into account the ecogeographical situation and risk zones of modern urban landscapes, identifying ways to optimize urban landscapes.

Theoretical and practical significance of research. The results of the research can be used in the practical work conducted in the Ministry of Ecology and Natural Resources, Architecture and Urban Planning Committee of the Republic of Azerbaijan. The obtained scientific results will make it possible to meet the relevant requirements and optimize the landscapes in the future development dynamics of urban landscapes.

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: "Mountain ecosystems of Azerbaijan: Problems and prospects" scientific and practical conference - Baku, 2017; "Eurasian space in world civilization" international scientific and practical conference - Nur-Sultan, 2021; "Comprehensive study of ecosystems of mountain territories" Materials of the VI Caucasian International Ecological Forum Grozny, 2023.

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

The results of the research can be used in the work carried out in the Ministry of Ecology and Natural Resources of the Republic of Azerbaijan, as well as in the implementation of state plans and

programs.

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

The scope and structure of the dissertation. Dissertation work consists of introduction, 4 chapters, conclusion, bibliography and appendices. The total volume of the work is 167 pages. Chapter I - 25 pages, Chapter II - 28 pages, Chapter III - 34 pages, Chapter IV - 47 pages, the conclusions 2 pages, and proposals 1 page. 38 figures, 26 tables, 16 graphs and a bibliography with 157 names were used in the research work. The mark volume of the dissertation is 202202.

THE MAIN CONTENT OF THE RESEARCH

The introduction provides information on the relevance and level of study of the topic, the object and subject of the research, goals and objectives, research methods, main propositions defended, scientific innovation, theoretical and practical importance, volume and structure.

The first chapter of the dissertation deals with the historical-geographical analysis of the formation of urban landscapes in Azerbaijan. Accordingly, the main stages of urban landscape development dynamics and modern trends in urban landscape development dynamics were grouped and classified chronologically.

The research area was Ganja and Mingachevir urban landscapes with a total area of 240 km^2, which is 0.28% of the territory of the Republic of Azerbaijan. 110 km^2 of the total area (0.13% of the territory of the entire republic) belongs to the city of Ganja, and 130 km^2 (0.15% of the territory of the entire republic) belongs to the city of Mingachevir.

In terms of its economic strength, the city of Ganja lags behind only the capital city of Baku, and the city of Mingachevir lags behind the cities of Baku, Ganja and Sumgait. The population of

Ganja is 313 thousand people, and the population of Mingachevir is 150 thousand people. The population density in Ganja was 2845.5 people per 1 km^2, and in Mingachevir it was 1153.8 people. This indicator is 2 times higher in Ganja than in Baku, and approximately the same in Mingachevir. Ganja is surrounded by Samukh from the north and Goygol from the south. Mingachevir city is surrounded by the Mingachevir reservoir from the north, Yevlakh administrative district from the east, south and west. The geographical coordinates of the city of Ganja are $40^o40/58//$ km. latitude, $46^o21/38//$ sh. longitude circle, and the geographical coordinates of the city of Mingachevir are $40^o46/12//$ km. latitude, $47^o02/56//$ sh. length corresponds to the circle. The city of Ganja stretches 15 km from north to south and 7.2 km from west to east along the Ganja river, and the city of Mingachevir stretches 12.5 km from west to east and 9.5 km from north to south.

Due to the fact that the history of settlement in Azerbaijan is quite old and the settlements, including rural and then urban types of living, were formed, it is possible to distinguish the stages of ancient, medieval and modern eras according to the level of appropriation of the country's territory. However, the process of urbanization, urban planning traditions and the formation of urban landscapes took on a wider scale in the 20th century, and in this regard, the urban planning tradition in the Republic of Azerbaijan in the 20th century reflects a 3-stage trend:

1) the stage until the 1940s;

2) the tradition of the 1940s-1970s;

3) The trend of urban planning from the 1970s to the present day.

Due to the fact that the factors affecting urban settlement manifest themselves at different levels, urban settlement types and areas that differ significantly from each other due to the level of development and multi-functionality have emerged in the territory of the country. The intensity of existing relations in residential areas depends on the number of people living in their territory, transport and geographical position, etc. It really depends on the factors.

The analysis of modern urban infrastructure and the characteristics of the formation of unique systems of settlements prove that in the modern settlement system created in the Republic of Azerbaijan, individual settlements, as well as inter-village cultural and household services, perform the role of different characteristic centers depending on their functions[1].

The historical-geographic features of the formation of the studied cities were investigated and the established geographical regularities were reflected in the dissertation. Thus, it has been determined that the construction and settlement of urban areas, as well as the expansion of areas and the implementation of greening works, are based on the characteristics of the geographical distribution of important geographical-ecological conditions and geographical components such as relief, climate, soil and vegetation.

In the second chapter, all geographical factors that shape urban landscapes are analyzed, their roles in the formation of urban landscapes are determined, and large-scale (1:20000) maps with relevant content are drawn up. In this chapter, the role and influence of geological-geomorphological, hydroclimatic factors are defined. The natural landscapes of the studied areas and the characteristics of antopogenic transformation of natural landscapes were investigated and large-scale (1:20000) maps with relevant content were drawn up.

In both research cities, the geological structure has a significant role in the formation of the urban area and urban landscapes. Territories belonging to the Upper Jurassic and Upper Cretaceous periods cover 7% of the city, i.e. 7.7 km^2, 11% (12.1 km^2) Upper Quaternary alluvial-proluvial sediments (cone of bringing mountain plains), 28% (30, 8 km^2) lower Quaternary alluvial-proluvial sediments (cone of bringing mountain plains) and the largest part i.e. 54%

[1] Dadashova Kh.D. Natural-anthropogenic bases of the formation of urban landscapes and ecological framework model (in the case of Ganja and Mingachevir cities) // News of Baku State University, ISSN 1609-0586, Series of Natural Sciences, No. 4, - Baku- 2018, p. 111-116

(59.4 km^2) is the area of modern and upper Quaternary delluvial-proluvial sediments. 91% of the territory of Ganja city, i.e. 100.1 km^2, is occupied by sloping, undulating alluvial-proluvial plains, 9%, i.e. 9.9 km^2, by denuded alluvial-proluvial plains. 0.1% (0.13 km^2) of Mingachevir city is the territory of the Middle Quaternary and Lower Quaternary alluvial-proluvial cone sediments. 20% (26 km^2) of Pliocene, Absheron stage areas, 38% (49.4 km^2) of modern and Upper Quaternary sediments, and 41% (54.47 km^2) of modern and Upper Quaternary subasar sediments. . 48% of the territory of Mingachevir city, i.e. 62.4 km^2, are anticlinal and monoclinal low mountain ridges, ridges and heights, 24%, i.e. 31.2 km^2, are sloping, undulating alluvial-proluvial plains, 22%, i.e. 28, 6 km^2 are alluvial plains.

Another important factor that shapes landscapes is the climatic conditions of the area. The geographical location of the cities selected as research areas is one of the most important aspects that shape their climate types. Since each of the research cities has a semi-desert and dry desert climate with dry and mild winters, the number of sunny hours in the area is 2250-2450 hours/year. Annual solar radiation is 125-135 kcal/cm^2 in Ganja and 125-135 kcal/cm^2 in Mingachevir. The absolute minimum temperature is -14-22 ^oC in Ganja, -18-26 ^oC in Mingachevir, and the absolute maximum temperature is 30-37 ^oC, 37-40 ^oC, respectively. The total of temperatures above +5 oC during the year is 3500-5000 ^oC in Ganja and Mingachevir. The total of temperatures above +10 ^oC during the year is 3800-4400 ^oC in Ganja and more than 4400 ^oC in Mingachevir. In April-September, the amount of precipitation is 100-150 mm in Ganja and 100-200 mm in Mingachevir. The amount of precipitation in October-March is 100-150 mm in Ganja and Mingachevir. During the year, the number of days with precipitation exceeding 0.1 mm is 70-90 days in Ganja and Mingachevir, the number of days with lightning is 25-35 days in Ganja, and 5-15 days

in Mingachevir[2]. The number of days with snow cover during the year is less than 10 days in Ganja and 10-20 days in Mingachevir, and the average thickness of snow cover is less than 10 cm in Ganja and Mingachevir. Relative humidity is 20-50% in Ganja and 20-30% in Mingachevir. Here, the average temperature of the hottest month is 25-26.5^{o} C, the average annual temperature of the coldest month is 1.1-3.8^{o} C, the maximum is 37.1-39.8^{o} C, and the minimum is 15.1-17.1^{o} C. The small differences recorded in the climate indicators for the study areas are related to the existing relief conditions of the cities and its influence on the climate.

Natural landscapes of the city of Ganja: 4% (4.4 km^2) of landscapes consisting of blackthorn, agot and wormwood in the chestnut soils of the poorly fragmented sloping plain, 18% (19.8 km^2) of the moderately fragmented sloping undulating plain with open chestnut and wormwood in the late soils, various herbs , ephemeral landscape, 78% (85.8 km^2) of the weakly fragmented sloping-undulating plain has chestnut and late-season soils of wormwood, wormwood, various grass ephemeral landscapes. 8% (10.4 km^2) of the natural landscapes of the city of Mingachevir are sagebrush, wormwood-ephemeral-sagewort landscapes on the steep, severely fragmented slopes of low mountains (badland), heavily washed light-gray soils and sandy clay rock outcrops, 11% (14.8 km^2) mountain-open chestnut and gray-brown soils of split lowlands and slopes with wormwood-ephemeral and wormwood-salarygrass landscapes, 13% (16.9 km^2) of flat, wavy-striped plain gray, gray-meadow, saline Wormwood, wormwood-ephemeral, saltwort landscape, 17% (22.1 km^2) of low-humus gray-meadow and medium-humus grass-gray soils of the wavy-striped plain, shrub-grass and saltwort landscape, 20% (26 km^2) landscape of sagebrush, wormwood and ephemerals in the gray-grass ordinary and chal-saline soils of the flat plains, 31% (40.3 km^2) of tugay forests in the

[2] Aliyev F.G. The anthropogenic impact on surface water resources in Azerbaijan / F.G.Aliyev, H.Kh.Khalilova // Energy and Environment. 2014. Vol. 25. № 2. P. 343-356

gray-grass and tugay forest soils of the convex, dashed-axamzli and delta plains, forest-shrubs and bushes belong to the landscape.

During field studies, it is known that dark-chestnut, chestnut, light chestnut, gray, gray-brown, grass and grass-tugai soils are distributed in the cities with the research area. In these soils, the thickness of the humus horizon is about 100-130 cm, and due to its mechanical composition, it is clayey, rarely heavy granular. The amount of humus is about 2.5-3.5%, and it decreases towards the depth. In the territory of the city of Ganja, the sloping plain covers a wider strip than the other areas within the complex, and its upper border has been determined to be at an altitude of about 300-500 m.

It is known that the amount of annual precipitation is 350-400 mm on average for both research cities, of which about 250 mm occurs during the vegetation period. The soils of Ganja city are steppe-type chestnut soils, and gray-chestnut soils are formed in the northeastern part of Ganja.

It is known that the dry steppe landscape complex is dominated by various herbaceous plants of stonewort, wormwood, limpet wormwood, wormwood. In some places, bushes and xerophytes have formed[3]. Shrubs and xerophytes of this type are present along the slopes of the Bozdag range in Mingachevir city from the study area. The areas where the desert landscapes of the territory of Azerbaijan are spread are mainly suitable for sorghum farming and including viticulture farms. It is known that Ganja-Dashkasan economic geographical region is one of the most important grape-growing regions of the country. Although the city of Ganja, which is part of that economic geographical region, also has a great potential for grape cultivation, which is considered the most important source of raw materials as a winemaking center, a large part of the city area is specialized in industrial and winemaking zones, so not enough attention has been paid to the establishment and development of agro-landscapes.

In the third chapter, the modeling of the development dynamics of the urban landscapes of Ganja and Mingachevir was

[3] Museibov M.A. Landscapes of Azerbaijan Republic / - Baku. - 2011

determined for the first time and their development models were proposed. Each city has its own characteristics of development and expansion. The main structural-functional elements of the city landscapes of Ganja and Mingachevir, as well as the landscape-architectural features of the cities' landscapes were comparatively analyzed and large-scale (1:20000) maps with relevant content were drawn up for the cities.

The picture shows the territories of Ganja city in 2005 and 2015, respectively. The indicators of the structural and functional areas of landscapes in the city of Ganja are as follows: the area occupied by industrial areas - 18 km^2 (17%), the area of greenery - 1.4 km^2 (1%), the private residential zone - 82 km^2 (80%), the area of multi-storey buildings in the city -44 km^2 (43%) (Figure 1).

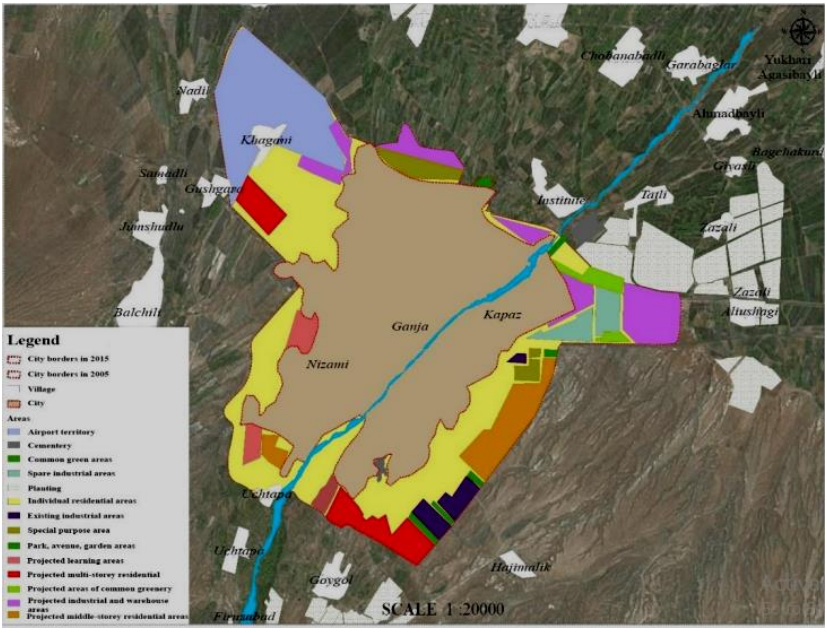


Figure 1. Development maps of Ganja city for the years 2005-2015

In the city of Mingachevir, the indicators of the structural and functional areas have somewhat different characteristics. The area of arable land is 553 ha (4%), the area of meadows is 5378 ha (44%), the main urban area is 23.6 km^2 (19%), the area of rural area is 3 km^2 (2%), the recreational strip zone is 16 km^2 (13 %) (Figure 2).

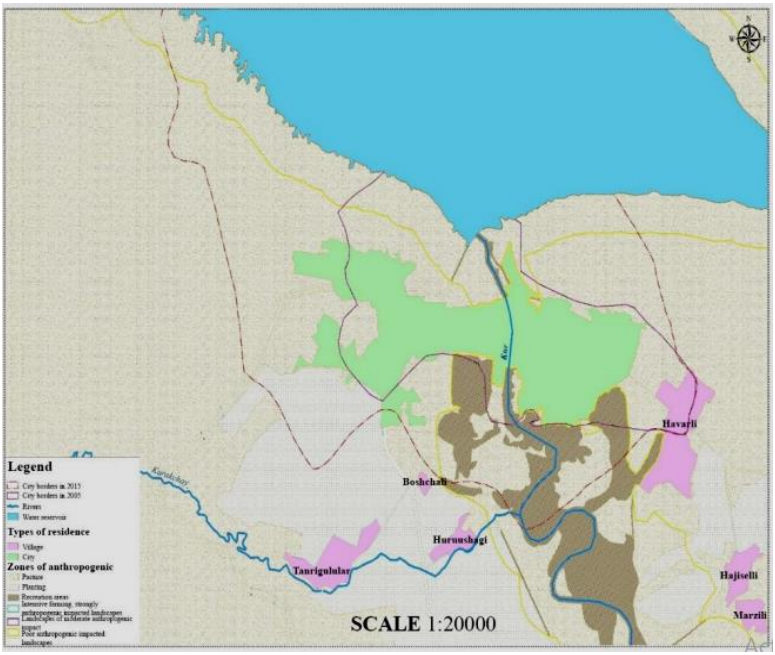


Figure 2. Development maps of Mingachevir city
for the years 2005-2015

The landscape-ecological basis of the formation of structural and functional elements of Ganja and Mingachevir city landscapes was studied. The geological, geomorphological basis, climate, and natural systems of the formation of urban landscapes related to the landscape ecological basis have been extensively analyzed. For the first time, in Ganja and Mingachevir urban landscapes, structural elements differing according to their functional characteristics were separated: 1) the main city, 2) the central part, 3) suburbs.

Although each of the existing cities in the territory of the Republic of Azerbaijan has opportunities to widely use resort-recreational resources, in this regard, the resort-recreational resources in the cities of Ganja and Mingachevir have a richer area and potential indicators. Taking into account these indicators, it should be noted that the factors that create a wide opportunity for this in each of the two cities have different characteristics. Thus, it is possible to turn these cities into resort-recreation centers of our Republic by widely using the possibilities of the existing climate potential in the city of Ganja, and the climate potential in the city of Mingachevir, as well as the abundance of thalassotherapy opportunities along the shores of the Mingachevir reservoir.

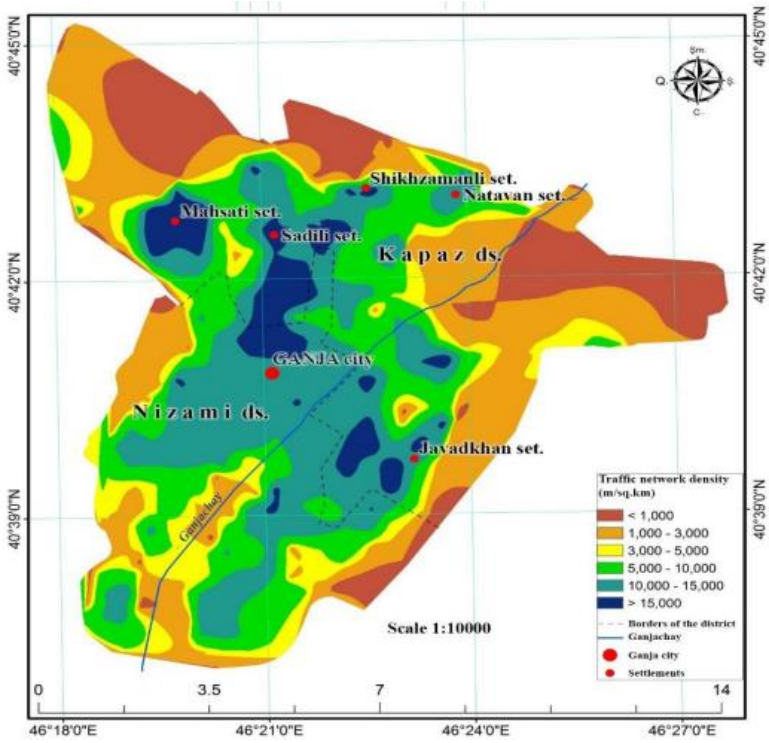


Figure 3. Traffic density in Ganja city

It is known that road landscapes are one of the most important factors in the formation and connection of urban infrastructure. For this reason, we paid more attention to this type of anthropogenic landscapes, grouped them as a special landscape type and mapped them (Figures 3 and 4).

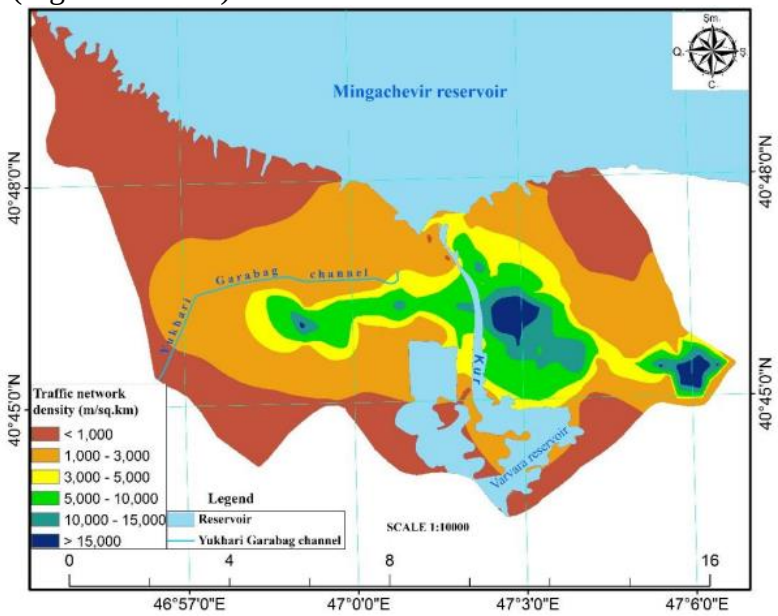


Figure 4. Traffic density in Mingachevir city

Table 1.

Traffic density in Ganja and Mingachevir cities

Density (m/sq.km)	**in Ganja (ha)**	**in Mingachevir (ha)**
< 1,000	1528,2	3603,7
1,000 - 3,000	2673,2	3386,3
3,000 - 5,000	1227,1	793,2
5,000 - 10,000	2290,2	859,9
10,000 - 15,000	2623,3	328,3
> 15,000	624,7	133,9
Total	**10966,7**	**9105,3**

Table 1 shows the traffic density of the cities. As can be seen from the analysis of the table, the density of the street-road network in the central parts of both urban landscapes is more than 4-5 km/km^2. In the outer parts of the urban landscape, the density decreases to 2-2.5 km/km^2. The greater density of roads in the city of Ganja and the fact that it has a more complex character than the city of Mingachevir is explained not only by its strong infrastructure and industrial city, but also by the fact that it has an older history as a city.

Table 2.

Functional characteristics of roads in Ganja urban landscape

No	Designation of roads	Length with m and, %	Intensity, unit/hour	Calculated intensity, units/hour	Number of lanes	Estimated speed, km/h
1.	A city-wide main street	27943m-20,3%	715-2910	1000-2000	2-5	100
2.	Important main street in a district	86300m-62,3%	102-3062	300-1500	2-6	80
3.	Locally important	23981m-17,4%	288-980	100-200	1-2	≤60
4.	Total	138224 m-100%	-	-	-	-

As can be seen from Table 2, the roads of Ganja city are divided into 3 groups: city-wide, regional and local. The total length of roads in Ganja urban landscape is 138224 m. The length of city-wide highways is 27943 m (20.3%), the length of regional highways is 86300m (62.3%), and the length of local highways is 23981m (17.4%). Intensity is 715 for pedestrians, 2910 for cars on city-wide highways, 102 for pedestrians, 3062 for cars on regional highways, 288 for pedestrians, 980 for cars on local roads. Calculated intensity is approximate for road categories. The number of lanes is 2-5 on city-wide highways, 2-6 on regional highways, and 1-2 on local highways. The estimated speed is 100 km/h on city-wide highways, 80 km/h on regional highways, and ≤60 km/h on local highways.

In the landscape of Mingachevir city, national highways pass from the east and south: Mingachevir-Bahramtepe highway to the south, Khaldan-Mingachevir highway to the east. This road connects the city of Mingachevir with the national border highway Yevlakh-Zagatala-Georgia. Transporters can access the Baku-Shamakhi-Yevlakh and Baku-Tbilisi roads from the indicated roads. In addition to the important national roads, there is also the Varvara-Mingachevir road connecting the city with Varvara settlement[4]. The total length of the street-road network in the city territory is 406.9 km, including the length of the main streets and roads of the city, 88.9 km, and the length of locally important roads is 318.0 km. The density of the street-road network in the built-up part of the city is 2.0 km/km².

As a result of deciphering the space images of the city of Ganja for the relevant years, it was determined that the share of industrial enterprises in the development of the city increased significantly. The indicator of settlement and appropriation of the urban area has also increased. Rapid assimilation of urban landscapes by the population has led to serious landscape transformation and severe anthropogenic loading of urban landscapes.

As a result of deciphering the space images of the city of Mingachevir for the relevant years, it was determined that the share of industrial enterprises in the development of the city increased significantly. The indicator of settlement and appropriation of the urban area has also increased. Rapid assimilation of urban landscapes by the population has led to serious landscape transformation and severe anthropogenic loading of urban landscapes. Specific areas are reserved for different types of activities. So, as the city grows, the sectors expand towards the edges. It has been determined that the development principles and characteristics of the cities of the

[4] Dadashova Kh.D. The main principles of the formation, development and management of urban-road landscape in urbanized areas (on the example of the cities of Ganja and Mingachevir) // Azerbaijan Geographical Society ANAS acad. Institute of Geography named after H.A. Aliyev, Works of the Azerbaijan Geographical Society Volume XIX Mountain Geosystems of Azerbaijan: Problems and Perspectives - Baku-2017, p. 138-142

Republic of Azerbaijan are more in line with the sectoral development model.

Modeling is the part of geography that is subjected to more mathematical operations and is the mathematicalization of many geographic components and processes. Modeling is a very broad concept. Modeling is the functional dependence between the quantities governing any process[5]. Optimization is a process in which a control function is selected among certain criteria, and this process results in obtaining minimum or maximum values. Cities have different governance models. Modeling of cities is a process that determines the optimization of management and development of cities. The increase in the area and population of research cities, including the number, causes problems such as energy consumption, the creation of heat island areas, the reduction of greenery and biodiversity, and the reduction of agricultural land. The advantage of the conducted research is the extensive use of materials based on satellite images, landscape images and ArcGIS software. Using these methods, various optimization models were investigated and proposed for application in both cities of the research area.

By applying this model to any region and city area within the Republic, optimization conditions and optimization level can be increased. Scientific results of quite serious importance have been obtained by carrying out researches based on different criteria in the country and the world. During urban planning, it is quite important to correctly assess the land in the urban area and even apply ecological models correctly. Modeling of road transport infrastructure also has an important role for proper development of urban infrastructure. Hierarchical systems reflecting the interaction of man and nature are built based on these criteria. Therefore, city models are formed by reflecting geographic, economic, sociological and statistical aspects. Initial city models were investigated starting from the 50s of the 20th

[5] Dadashova Kh.D. Study of the landscape-ecological basis of the formation of urbanized areas in Azerbaijan with GIS technologies // Lankaran State University, Scientific News Natural Sciences Series, - Lankaran-2016, p. 152-157, Ismayilov M.C.

century and proposals with different contents were put forward. Models of cities can be considered as a single urban organism that connects different functional zones of cities. Each proposed city model provides conditions for transformation of the existing city on the basis of specific social and economic activities. That is, it is a process based on the appropriation of the territory due to economic and social factors based on the physical geographical components of the cities and radically changing it. Thus, the structure of urban models is formed.

Modeling and forecasting of urban landscapes is applied based on these principles, and all the research works conducted in the cities of Ganja and Mingachevir, which are the research area, were based on these principles and as a result, models were proposed. New scientific results obtained by applying the principles of modeling are considered as the results of the optimization process. In 1969, David Harvey, and in 1972, Alan Wilson identified 3 main factors in their theory of geographic information systems: 1) testing the internal and external compatibility of geographic components; 2) successful prediction of geographic phenomena: 3) measurement of geographic phenomena.

The components of their theory consist of elements, geographic components and the relationships between them. These three components should correspond to the content of any model, and of course, it is also true for the research cities of Ganja and Mingachevir. Thus, the sum of the relations between the geographical components, the geographical conditions created by those geographical components and the existing conditions created the current modern city model. The main feature of the models is the correct application of the construction. Models make it easier to predict trends, and overall simplify analysis. Worldwide models reflect approaches from a more socio-economic geographic perspective. The models have certain functions that allow us to understand the physical-geographical reality of the area in a more accurate way. Scientific interest in GIS and models increased at the end of the 20th century. There is a cause-and-effect relationship

between the elements within the models. For example, rainfall has an effect on soil erosion, but soil erosion has no effect on rainfall.

The heterogeneous structure of cities refers to the existence of different types of functional territorial units rather than to their single economic type. The internal structure of cities refers to the planning of inner-city location and functional zones. The concentric circles model is one of the first proposed models and was created by Ernest Burgis in 1924. This theory consists of circles expanding from the very center of the city to the outskirts. Different circles correspond to different zones within the city. It should be noted that different city models created in different periods include the socio-economic environment. The development of the social environment factor creates a unified city. The model of concentric circles is divided into central and peripheral zones. According to the morphological structure of the cities, Burgis proposed the correct arrangement of buildings, various purpose buildings, roads and infrastructures and based his model on them. However, in the city, reconstruction works should be carried out without stopping, and also optimization measures should be continued. The second model presented was proposed by Homer Hoyt in 1938. He observed this model in 34 American cities and observed that there are more expensive residential areas in several of their sectors. Urban modeling studies continued, and Hoyt conducted a survey in Washington in 1954. The city models proposed by Burgis Hoyut differ from each other not only in terms of their geometric structure, but also in terms of their economic efficiency. Thus, this feature is distributed from the center to the edges in the concentric circles model, and across sectors in the sector model. Each of these models has its own physical and economic geographic features, and these geographic features are more clearly reflected in the study cities. Among the research cities, the model of concentric circles fits the city of Ganja, and the model of sectors fits the city of Mingachevir.

According to sector model, it is known that industries are formed in sectors. It differs from the first two models in terms of handling features. Urban modeling has a symbolic role and approach for studying the structure of cities. Urban models are presented as a

formative tool for an ecological and functional approach. All models actually have the goal of normalizing the ecological situation of cities, so that the structure of cities is not only their economic-geographical importance, but also aims to preserve the stability of the nature of these cities. For this purpose, the dynamic models of the two most important cities of Azerbaijan, Ganja and Mingachevir, were investigated and the optimal dynamic models were investigated and ways of optimization were determined.

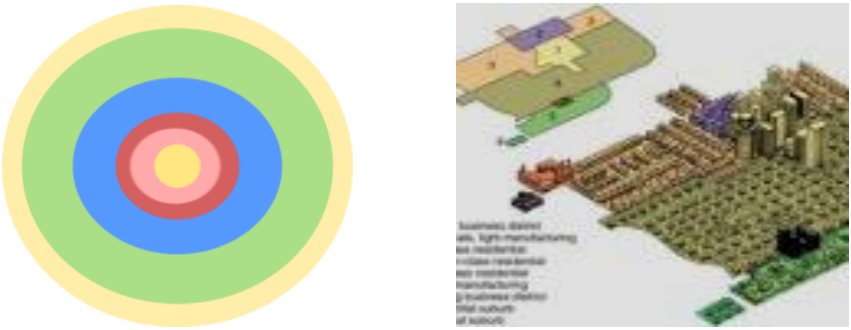
Urban models began to develop from the 1960s. The structure of the model is the factor of its formation within the geographical space. The selected geographical location should first of all serve the well-being of the city population, increase the economic efficiency under the condition of proper use of the area, and at the same time should allow the improvement of the ecological situation of the city. The models also differ according to the road network system. The grouping and formation of models according to the radial road network has an important role.

One of the prerequisites for the creation of a city is proximity to water bodies. The configuration of Ganja city was formed according to the direction of Ganjachay. The city is located along the right and left banks of Ganjachay. Although the ancient city of Ganja was separated from the modern city of Ganja, this geographical fact still showed its relevance.

Being one of the most important of the development models, it has also been compared with the development characteristics of the study cities. The mentioned urban modeling methods clearly reflect the development dynamics of the relevant regions within the country, and based on field studies, including territorial structure analyses, the urban modeling option was determined in both research cities, which is the concentric circle model in Ganja city, and the sectoral model in Mingachevir city accordingly. is a city model (Figure 5).

Preference is given to the expansion of service spheres and the creation of business clusters or pockets in the urban area. Taking into account the current development characteristics, the city of Ganja reflects the Concentric Circles model based on its development

aspects, while the development of Mingachevir reflects the Sectoral model.



A) Concentric model **B) Sectoral model**

Figure 5. Development models of cities

In the fourth chapter, environmental problems in the cities of Ganja and Mingachevir were investigated, their causes were analyzed, the tables were analyzed, pollution levels and ecological risk and danger zones and their number were determined. Large-scale (1:20000) maps of ecological risk zones of cities have been drawn up. The optimization characteristics of urbanized landscapes for the respective cities and the most favorable ways of optimization have been determined and proposed. Large-scale (1:20000) maps of cities have been prepared.

The polluting substances with the highest index in both cities are the gaseous ones according to their aggregate state, in Ganja this indicator is about 75% (2.83% of it is sulfur anhydride, 44.68% is carbon oxide, 14.18% nitrogen oxide compounds), in the city of Mingachevir it is 97.8% (0.38% of it is sulfur anhydride, 2.16% is carbon oxide, 96.78% is nitrogen oxides). Solid substances make up 25.17% of the total pollution in Ganja city and 0.19% in Mingachevir city.

Table 3.

Pollutants emitted from stationary sources into the atmospheric air of Ganja and Mingachevir cities in 2021 by chemical elements (tons)

Cities	The total amount of pollutants released into the atmosphere	O cümlədən:				
		Solids	Gaseous and liquid substances	From them:		
				Sulfuric anhydride	Carbon monoxide	Nitrogen oxides
Ganja	131,9	33,2	98,7	2,8	44,1	14,0
Mingachevir	1880,0	3,5	1876,5	7,2	40,5	1816,0

Source: The State Commitee of Statistics

An atmosphere with this characteristic composition is called compositional quality[6]. Since the economic development and industrial importance of both research cities are almost equal to each other, this is also reflected in the environmental conditions of the atmosphere of both cities.

Table 4.

Dynamics of ecological indicators of Kura river in Mingachevir city

Chemical elements	Unit	PHL	2012	2013	2014	2020	2021
Temperature of water	C°		15.5	16.76	14.97	14.55	12.9
Dependent substances	mg/l	0,75	9.35	-	114.2	52.08	17.4
Transparency	sm	-	23	28	24.25	15.5	22.75
pH		6,5-8,5	7.33	8.3	8.1	8.33	81
Dissolved O_2	mg/l	4-qış-6-yay	6.02	6.32	7.412	6.481	7.9
HCO_3	mg/l		170.9	103.8	176.9	162.3	169.5
SO_4	mg/l	100	106.6	169.3	99.97	110.8	81.6
Cl	mg/l	300	31.28	22.73	28	25.6	25.1
Ca	mg/l	180	61.1	57.3	71.8	54.9	69.8
Mg	mg/l	40	9.87	11.5	10.2	19.43	22.0
Phenol	mg/l	0.001	0,002	0,002	0,002	0.002	0.001
Common Fe	mg/l	0,4	-	0,21	0,02	167	-

***** Permissible Hardness Limit

Source: Annual bulletins of the Ecological Monitoring Department of the Ministry of Ecology and Natural Resources of the Republic of Azerbaijan

[6] Dadashova Kh.D. Development dynamics models of urban landscapes (on the example of the cities of Ganja and Mingachevir) // Academician of ANAS. YEAH. Aliyev Institute of Geography, Works of the Azerbaijan Geographical Society, Geography and natural resources magazine, No. 1, - Baku-2018, p. 35-41

Table 5.

Dynamics of environmental indicators of Ganjachay (Zurnabad) in Ganja city

Chemical elements	Unit	PHL	2012	2013	2014	2020	2021
Tempera-ture of water	C°		9.4	11.98	8.6	10.9	11.6
Dependent substances	mg/l	0,75	23.6	85.35	63.5	29.9	29
Transparency	sm		12	18.6	26	24	18.75
pH		6,5-8,5	7.6	8.1	7.7	7.8	7.7
Dissolved O_2	mg/l	4-qış-6-yay	5.28	6.19	8.1	6.8	7.1
HCO_3	mg/l	-	217	112	126.1	136.7	132.7
SO_4	mg/l	100	145	96.28	122.97	67.3	80.2
Cl	mg/l	300	27.8	14.85	18.6	8.4	17.9
Ca	mg/l	180	93.47	32.68	62.6	31.25	58.6
Mg	mg/l	40	22.07	22.4	9.8	11.6	11.4
Phenol	mg/l	0,001	0.002	0,003	0,001	0,002	0.002
Common Fe	mg/l	0,4	0.04	-	-	-	-

Source: Annual bulletins of the Ecological Monitoring Department of the Ministry of Ecology and Natural Resources of the Republic of Azerbaijan

According to the information of the Ministry of Ecology and Natural Resources, the Zn indicator in Ganja's soils has increased by about 2 times, lead has increased many times, Ni, Cr, copper and iron have increased significantly in the respective years. The pH in Ganjachay, Kura River and Mingachevir reservoir basins is normal. The amount of Ca, Mg is 3 times less than the norm in Ganja 2 in Mingachevir, suspended substances are 25 times more than the norm in Ganja and 10 times in Mingachevir. In both Ganja and Mingachevir, the amount of sulfate ion has increased, while the amount of nitrate ion has decreased, and the pH is within the norm. Although the average and maximum concentrations of dust, nitrogen 4 oxide, nitrogen 2 oxide, hydrogen sulfide, hydrogen fluoride in the atmosphere of Ganja city are relatively normal, the average and maximum concentration of sulfur gas is relatively higher compared to others. In the city of Mingachevir, the amount of dust, carbon

monoxide and phenol exceeds the norm. In Tables 4-5, as a result of the environmental monitoring conducted in each of the research cities and the indicators of environmental pollution obtained at the relevant stations reflect the risks of the general ecogeographical landscape for all natural components in both cities.

Correct placement of sanitary protection zones is also an important factor.

Environmental risk zones of urban landscapes are grouped according to the degree of danger. Five environmental risk categories were distinguished: 1) with a radius of 1000-2000 m; 2) with a radius of 1000-500 m; 3) radius 500-300 m; 4) with a radius of 300-100 m and 5) with a radius of less than 100 m. In the city of Ganja, there are four zones belonging to groups 1, 3, 4 and 5 of this group of risk zones. Optimization measures are carried out by laying sanitary protection and greening strips in that radius. This is possible due to the "green corridors" that connect the elements of the ecological framework that form the ecological framework (Figure 6).

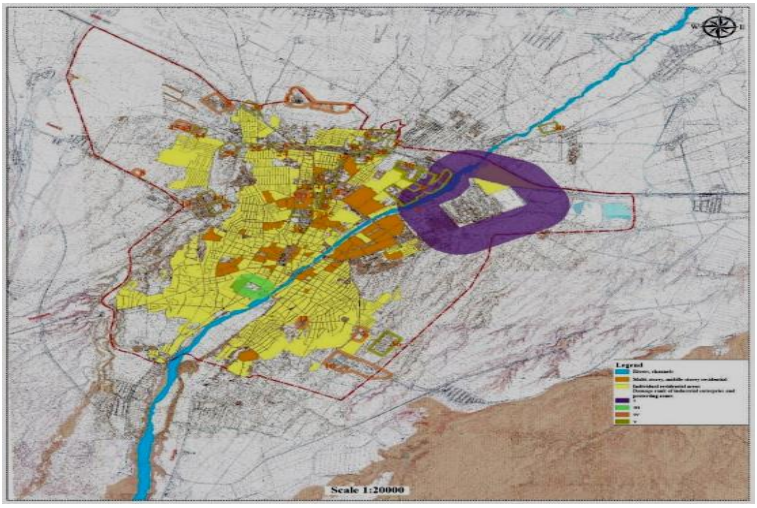


Figure 6. Ecological risk and optimization map-scheme of Ganja city

There are 4 zones of the ecological risk category series in Ganja, and 3 zones in Mingachevir. The reason it is more in Ganja is

because it is the largest industrial city in the country, which causes urban landscapes in Ganja to take up more space than in Mingachevir. (Here you need to add the exact figures. Depending on the industry). Such areas make up a very small percentage of the total area of the city.

On the contrary, it is 1.4/110, 6/130. In the city of Mingachevir, there are three zones belonging to groups 1, 2 and 4 of the ecological risk zone (Figure 7).

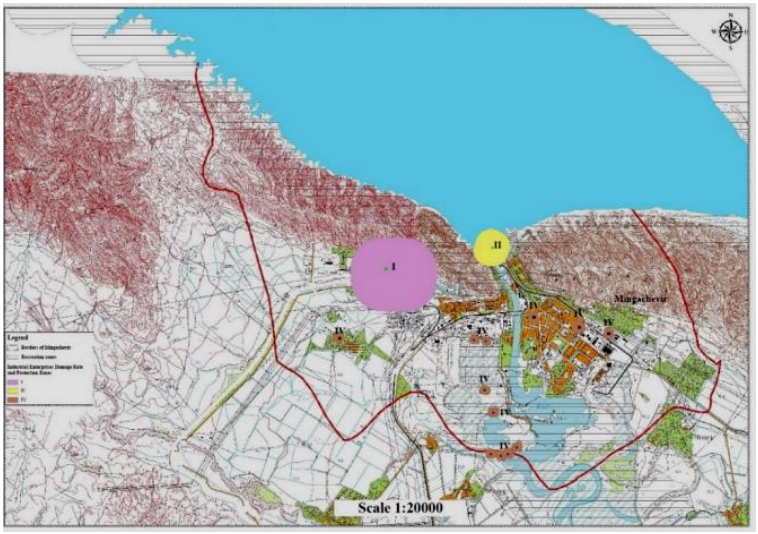
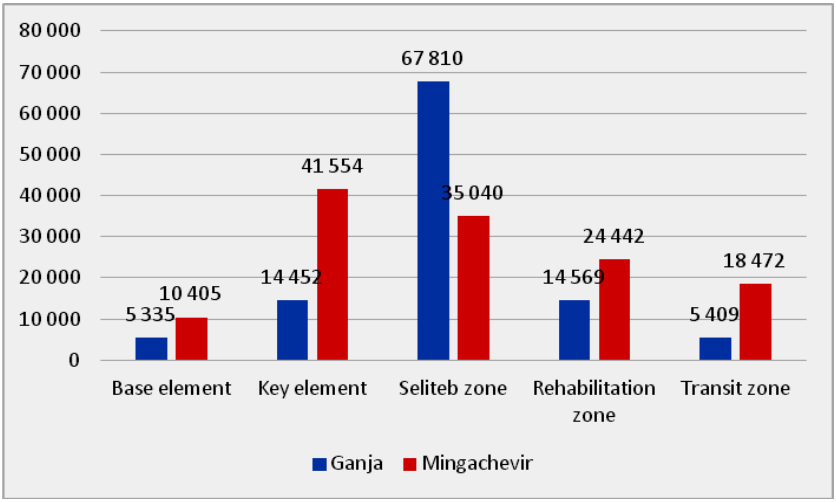


Figure 7. Ecological risk zones and optimization map of Mingachevir city

The landscapes of both cities, which are the study area, were divided into 5 very important elements, the area was determined for each of them, and the percentage indicators of the total urban area of those areas were calculated. Each element and its role, importance and function in the background of urban landscapes are explained. At the same time, all the elements for their purpose were compared for the area they occupied in the cities of the study area and these were also mentioned in the result. Elements with different field indicators were detected and corresponding analyzes were carried out for cities.

The areas of the elements of the ecological carcass were calculated with an accuracy of one thousandth, and their percentage indicators were calculated with an accuracy of one hundredth. The base element is a small part of the total area of both cities, 5,335 km^2 (4.85%) in Ganja and 10,405 km^2 (8.00%) in Mingachevir. The key element is 14,452 km^2 (13.14%) in Ganja and 41,554 km^2 (31.96%) in Mingachevir, which means that compared to cities, the key element in Mingachevir has a higher index. Seliteb zone is 67,810 km^2 (61.65%) in Ganja city, and 35,040 km^2 (26.95%) in Mingachevir. The Seliteb zone, in contrast to the previous comparison, has a higher indicator in Ganja, and is about 2.5 times more than the indicator in Mingachevir. The rehabilitation zone is 14,569 km^2 (13.24%) in the city of Ganja, and 24,442 km^2 (18.80%) in the city of Mingachevir. This indicator is almost the same for both mornings. The transit zone is 5,409 km^2 (4.92%) in Ganja and 18,472 km^2 (14.21%) in Mingachevir. Transit zone indicators are approximately 2.5 times higher in Mingachevir than in Ganja (graph 1).



Graph 1. Indicators of ecological frame model elements of Ganja and Mingachevir cities

Thus, taking into account the current conditions in Azerbaijan, the implementation of measures to optimize geosystems with scientific methods is the main way to achieve sustainable socio-economic and ecological conditions.

CONCLUSIONS

1. Based on the analysis of the historical-geographical and topographical maps of the space images of the research area, it was determined that the city of Ganja in Azerbaijan has a complex structure with modern functional elements, maintaining the ancient traditions of urban planning, and has a radial structure developed mainly in the meridional direction along the Ganjachay deposit. Mingachevir urban landscape is rich in modern functional elements and the role of spontaneous anthropogenic influences in its configuration and development is clearly distinguished.
2. Based on the analysis of the horizontal structure and functional characteristics of the studied urban landscapes based on space images, large-scale (1:25000) topographic maps and field research materials, it was found that the river of the same name and the roads passing through the area had the main influence in the formation of the spatial structure of the city of Ganja. The urban landscape of Mingachevir develops with the trend of moving away from the area along the river (in a parallel direction) under the influence of geotechnological systems (reservoirs, gravel quarries, etc.).
3. Urban landscapes were grouped according to their structural characteristics and their quantitative and qualitative indicators were analyzed based on digital maps by dividing them into zones. The development characteristics of the cities were studied and compared with the corresponding universal secular development models, and the suitable development models for both cities were proposed. It was determined that the development of the urban landscape in Ganja corresponds to the model of concentric circles, while Mingachevir corresponds to the sectoral development model.

4. Based on the degree of danger of industrial enterprises in Ganja and Mingachevir cities, 4 ecological risk zones were determined in Ganja city and 3 ecological risk zones in Mingachevir city based on those degrees of danger, and large-scale maps depicting the relevant sanitary protection zones for the optimization of those areas (M=1:20 000) was compiled. The primary and secondary elements of the ecological framework were separated for the first time for the urban landscapes of Ganja and Mingachevir.
5. The current and prospective positions of these elements in the urban landscape structure are analyzed and the creation of ecological "green corridors" is justified. Maps containing the elements of the ecological framework have been drawn up, optimization of the area was planned and proposed by us in accordance with those maps.

PROPOSALS

1. The high population density in the cities of Ganja and Mingachevir, which are the study cities, leads to high urban development and land expansion many times higher than the norm, and serious damage to the ecological balance. For this reason, we propose to use the territory of both cities and limited land resources more efficiently.
2. It is known that the very tense ecological situation of both cities has formed risk zones with different radii in the cities of Ganja and Mingachevir. It should be noted that, respectively, 4 risk zones have been identified in the city of Ganja and 3 in the city of Mingachevir, and the construction of green corridors (strips) around these identified zones is mandatory.
3. As a scientific result of the conducted studies, ecological risk zones of both study cities and maps of optimization of urban landscapes of both cities have been compiled. In this regard, we propose to correctly place the geographical components reflected

in the maps compiled in the process of planning and forming the urban landscapes of Ganja and Mingachevir.

4. Considering the complexity of the current situation in the city of Mingachevir, it is imperative to build a waste processing facility in the landfill area, and that facility should be built as soon as possible.

The following articles were published according to the content of the dissertation:

1. Dadashova X.D. The main features of using the GIS method in landscape planning in cities // Western University, materials of the scientific conference dedicated to the 92nd anniversary of the birth of national leader H. Aliyev, Baku-2015, pp. 16-18.
2. Dadashova Kh.D. Landscape-ecological foundations of the formation of urbanized areas in Azerbaijan and their dynamic development trends (on the example of the cities of Ganja and Mingachevir) // Azerbaijan Young Scientist, Postgraduate and Master's Society, Journal of the Works of Young Scientists No. 11, Baku-2015, p. 118-124
3. Dadashova X.D. Landscape-ecological foundations of the formation of urbanized areas in Azerbaijan and their dynamic development characteristics (on the example of the cities of Ganja and Mingachevir) // Azerbaijan Teachers' Institute, News scientific-methodical journal No. 3, Baku-2015, p. 120-125
4. Dadashova Kh.D. The study of the landscape-ecological basis of the formation of urbanized areas in Azerbaijan with GIS technologies (on the example of the cities of Ganja and Mingachevir) // Lankaran State University, Scientific News journal, Natural Sciences series No. 2 Lankaran-2016, p. 152-157 (co-author Ismayilov M.J.)
5. Dadashova X.D. The main principles of the formation, development and management of urban-road landscape in urbanized areas (on the example of the cities of Ganja and Mingachevir) // Academician of ANAS. Institute of Geography named after H. Aliyev, Works of the Azerbaijan Geographical

Society, Volume XIX Mountain Ecosystems of Azerbaijan: Problems and Prospects, c.e.d. prof. Materials of the conference to be held in connection with the 60th anniversary of E. Alizadeh, Baku-2017, p. 138-142
6. Dadashova Kh.D. Development dynamics models of urban landscapes (on the example of the cities of Ganja and Mingachevir) // Academician of ANAS. Institute of Geography named after H.A. Aliyev, Works of the Azerbaijan Geographical Society, Geography and natural resources magazine, No. 1, Baku-2018, p. 35-41
7. Dadashova X.D. Natural-anthropogenic bases of the formation of urban landscapes and the ecological framework model (on the example of the cities of Ganja and Mingachevir) // Baku University News, Baku-2019
8. Dadashova Kh.D. Landscape carcass model of urban landscape and methods of optimizing urban landscapes (on the patterns of Ganja and Mingachevir cities). , 2021 p. 7-12
9. Dadashova Kh.D. Impact of urban landscape pollution on human health. 39-45 (Hajiyeva G.N., Hajiyeva A.Z.)
10. Dadashova Kh.D. Study of urban landscapes of Azerbaijani cities // Universidad Y Sociedad Revista Científica de la Universidad de Cienfuegos 2023 №15(5) p. 93-103 (Amanova S.S., Hasanaliyeva L.H.)
11. Dadashova Kh.D. Methods of modeling the dynamics of the development of urban landscapes in Azerbaijan (on the example of the cities of Gyanji and Mingachevir) // Materials of the VI Caucasian International Ecological Forum Grozny, 2023 p. 113-119
12. Dadashova Kh.D. Methods of geographic analysis and restoration of transformed city landscapes (on the example of the cities of Ganja and Mingyachevir) // Ministry of Science and Higher Education of the Russian Federation Federal State Budget Educational Institution of Higher Education "Tula State University" ISSN 2218- 5194 Publications of the Tulsa State University of Earth sciences Issue 4 Tula Izdatesltvo TulGU, 2023 c. 51-62

13. Landscape-ecological carcass model of urban landscape and methods of optimizing urban landscapes (on the patterns of Ganja and Mingachevir cities) Ministry of Education and Science of Ukraine B. B. N. Karazina series "Geology. Geography. Ecology" Kharkiv 2023, No. 4

The defense of the dissertation work will be held on 24 January 2025 at 11:00 at the meeting of the Dissertation council FD 2.51 of Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at Baku State University in Geography faculty

Address: AZ 1148, Baku city, Academician Zahid Khalilov street 23, Baku State University. E-mail: bsu@edu.az.

Dissertation is accessable at the library of Baku State University.

Electronic version of the absract is available on the website of www.igaz.az.

Abstract was sent to the required addresses on 23 December in 2024.

Signed for print: 10.12.2024

Paper format: A5

Volume: 36068

Number of hard copies: 20