**REPUBLIC OF AZERBAIJAN**

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# ABSTRACT

of the dissertation for the degree of Doctor of Science

## INVESTIGATION OF THE SUSTAINABLE DEVELOPMENT OF THE REGIONAL ECONOMIC-ECOLOGICAL FUNCTIONAL STRUCTURE OF THE REPUBLIC OF AZERBAIJAN

Speciality: 5401.01 – Economic geography

Field of science: Geography

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## GENERAL CHARACTERISTIC OF THE INVESTIGATION

**Actuality and investigation level of the topic.** The concept of regional economic and environmental policy is an important part of sustainable development implemented by the state. In this regard, the state policy in the field of ensuring the sustainability of economic development, along with other sciences, creates the need for economic, geographical and environmental research. The urgency of the problem is also explained by the fact that it is important to systematize the methods of economic-geographical and environmental research in the policy of sustainable development in the country. The integration of economic and geographical research with the ecological balance in a complex form stems from the need for new research.

The "National Program for Environmentally Sustainable Socioeconomic Development" approved in 2003 has further expanded the environmental policy and created new opportunities for its implementation. The methodology of studying the optimal organization of regional sustainable development on economic and socio-geographical bases arising from the national program determines the relevance of the dissertation.

In economic and social geography, the analysis of the sustainable development of the economic and ecological functional structure of the regions and the determination of the direction of development are of scientific and theoretical importance. The analysis of the interaction of economic and environmental processes in modern economic-geographical research stems from modern requirements.

The research was approached from a new perspective, using methods for the analysis of the theoretical and methodological bases of the regional economic-ecological functional structure. Insufficient scientific research has been conducted on the economic-geographical bases of the typological structure of the regional economic-ecological system.

In addition to taking into account the requirements of modern socio-economic development in traditional research, it also requires the use of territorial-production structural models. Based on the

scope of Azerbaijan's “Vision to future” concept, a comprehensive approach to economic and environmental problems is necessary to ensure sustainable development.

It is important to form a sustainable development of the regional economic and ecological functional structure in Azerbaijan and to determine the changes that will take place in the future, to determine its effective use. Ways to study and solve these problems ensure the relevance of the dissertation topic.

**Research area**: The research area is the regions of the Republic of Azerbaijan and various types of economic and ecological functional structures. The study of sustainable development of the economic and ecological functional structure of the regions should ensure the reduction of inconsistencies between the capital and the regions from the socio-economic development, management of the urbanization process, the involvement of local natural resources in the economy.

**Purpose and objectives of the research.** The main ***purpose*** of the research is to study the formation of sustainable development of economic and ecological functional structures of the regions, their impact on the modern socio-economic development of the republic. In this regard, the following ***objectives*** were set in the research process:

- Theoretical and methodological analysis of the regional economic and ecological functional structure, determination of their economic and geographical structure;
- Study of forms of diversification of typological functions of the regional economic-ecological structure;
- Identification of scientific and practical bases of global economic and ecological processes in modern economic-geographical researches;
- Substantiation of the directions of its management using the resource potential of each region, along with the territorial organization of competitive areas that ensure sustainable economic development;
- Substantiation of the correct implementation of regional environmental policy in the sustainable development of the country;

- Identification of ways to effectively use the results obtained, based on the scientific and theoretical provisions of economic and social geography in the analysis of the concept of sustainable development of the regional economic and environmental functional structure.

**Research methods.** System-structural analysis, field research, comparative statistical, economic-mathematical models, indexing, cartographic and forecasting methods were used in the dissertation work. The analysis was carried out on the basis of application of GIS technologies, various methodical materials and norms. Economic and environmental problems in Azerbaijan, which is developing in a market economy, have a global character, and regional, economic and socio-geographical scientific research that is important for the country should be aimed at solving them.

**The main provisions of the defense:**

- Identification of problems of territorial organization of sustainable development of regional economic-ecological functional structure of the Republic of Azerbaijan;
- Economic and socio-geographical substantiation of regional economic-ecological structures;
- Assessment of regional ecological threat and economic-ecological conditions, development of methodology for calculating the damage to the environment as a result of production activities;
- Creation of ecologically sustainable territorial-production complexes creating conditions for balanced economic development in the regions and determination of improvement of the system of use of natural resources;
- Study of strategic directions providing complex development on the basis of socio-economic base of the regions, creation of a safe economic-ecological network;
- Selection of optimal options for sustainable development of economic-ecological functional structure in the process of economic activity and analysis.

**Scientific novelty of the research:**

- For the first time in the dissertation the concept of complex sustainable development of economic-ecological functional structure of regions was studied;
- Scientific and theoretical provisions of economic and social geography have been developed and improved while analyzing the concept of sustainable development of economic-ecological functional structure based on the principles of complexity;
- Ways to use the natural and economic potential of the country relevant to the regional socio-economic development of the economic-ecological functional structure were studied and proposals and recommendations were prepared to achieve sustainable economic growth and strategic progress;
- Study of optimal options of economic-ecological functional structural models occurring in the socio-economic development of the country, analysis of resource, production, social and political factors of the regions of the country;
- Proposals were made to reduce the costs of eliminating the damage caused by environmental pollution in connection with the development of production in the economic and ecological system of the regions;
- For the first time at the regional level, the typology of industries was determined, the territorial organization of the economic-ecological functional structure was mapped;
- Scientific-practical analysis of ecological problems related to increasing the efficiency of territorial organization of sustainable development of regional economic-ecological functional structure and ways of their solution were identified;
- The issues of differential approach in forecasting the sustainable development of the economic-ecological functional structure of the country have been identified in the economic-geographical context.

**Theoretical and practical significance of the research.** The materials of the dissertation can be used to determine the development of the country's economy, the development of various environmental programs, the efficient use of natural resources, the territorial organization of reproduction and environmental protection

and other issues. Compiled maps can be a key tool in the preparation of proposals for the restoration of water resources, atmosphere, forests and shrubs, degraded lands of the studied areas.

The obtained scientific results of the dissertation are important in the development of state programs for socio-economic development of the regions, the development of projects to improve economic and ecological systems in the future, spatial planning and forecasting. The results of the research are also an important source in the teaching of economic and social geography, nature management, nature protection in universities.

**Approbation and application.** The main provisions of the dissertation and the obtained results were reported in scientific seminars organized at the faculty of history and geography of Azerbaijan State Pedagogical Universitiy in Baku, and at International Conferences in Elista (2013), Makhachkala (2014), Almaty (2014), Ganja (2014) and St. Petersburg (2015, 2016). The main results were reported at the following congresses and conferences: V-VI Congresses on the Azerbaijan Geographical Society (Baku, 1985, 1990); Scientific Conferences of ASPU (Baku, 1990, 1998, 2005); the conference devoted to the "tourism year" in Azerbaijan (Baku, 2011); International Scientific-Practical Conference on the topic of "Globalisation and Geography" (Baku, 2012); Republic Scientific Conference on the topic of "The development of geography in the independecy years" (Baku, 2013); IV Scientific-Practical Conference on the topic of "XXI century: Innovations in the field of Geodesy and Cartography" (Baku, 2012); Republical Scientific Conference devoted to the 90th anniversasry of H.A.Aliyev (Baku, 2013); Scientific-Practical Conference on the topic of "The application directions of modern geography" (Baku, 2014); International Symposium in the topic of "the policy and problems of teacher training" (Baku, 2013); Republic Scientific Conference on the topic of "Haydar Aliyev and the development of Geography" (Baku, 2013); Republic Scientific Conference on the topic of "Ecological problems and ecological education" (Baku, 2013); VIII traditional International Conference on the topic of "Ecology and protection of life activity" devoted to the "Industry

year" (Baku, 2014); Republic Scientific-Practical Conference on the topic of "Socioeconomic development of regions: reality and perspectives" (Baku, 2015); International Conference on the topic of "Role of tourism in providing of the sustainable development" devoted to the 100th anniversary of Baku State University (Baku, 2019). Totally, 1 monography and more that 50 scientific articles, teses, textbook related to the dissertation topic were published by writer.

**Implementation of dissertation.** The dissertation was carried out in the "Political and economic geography of Azerbaijan" department of the Institute of Geography named after academician H.A.Aliyev of Azerbaijan National Academy of Sciences.

**The structure and the volume of the dissertation.** The volume of dissertation is 301 pages, including introduction 6 pages, I chapter 43 pages, II chapter 48 pages, III chapter 49 pages, IV chapter 40 pages, V chapter 45 pages, VI chapter 38 pages, result 3 pages, references 25 pages. There are 41 figures (maps and schemes), 29 tables and 311 references in the dissertation. It consists of 58213 signs without table, graph, figure and refenrence.

## PRIMARY CONTENT OF THE DISSERTATION

**The introduction** gives brief information about the actuality, the aim and objetive, scientific–theoratical and practical significance of the topic, the defenced provisions, the volume and structure of the dissertation and others.

The first chapter of dissertation was named **"The theoratical–methodological bases of the investigation".** In this chapter, the concept of "economic–ecological" approach, its economic and socio–geographical essence, dialectical approach to regional "economic–ecological" sustainable development and scientific–practical and methodological directions of "economic–ecological functional structure" are defined, and the economic–geographical bases of regional development strategy was studied. In addition to this, the natural resources and the directions of use of the nature which is the

primary element of economic–ecological system in terms of economic–geographical direction was analysed.

In researching the concept of "economic–ecological system" and regional "economic–ecological functional structure", economic and socio–geographical research was preferred. The analysis indicates that the economic–ecological system itself acts as a special type of regional geographical system. In regional economic–ecological systems, we accept the relationship as an economic–ecological functional structure, which reflects the relevant processes arising from the interaction and impact of production conditions with the environment.

The "economic–ecological" approach in the dissertation analysis of issues related to the problem of new content in economic and socio–geographical areas – definition and economic–geographical substantiation of stressed areas, innovation and economic–ecological approach, human and environment, regional sustainable development and other areas conducted.

In the dissertation, along with structural changes in the economic and ecological sphere in terms of future development of the regions, the principles of achieving the application of the form of "sustainable development" on a scientific basis, which is now an important problem in the world, have become the object of research. The notions and ideas of foreign and Azerbaijani scientists who have conducted research in this area are analyzed in detail. In this respect, both foreign researchers (V.Ayzard, Ch.Cumberland, V.Bityukova, S.Buzmakov, V.Leontiyev, H.Reymars, A.Gaponenko, Ş.Aizenshtat, I.Kvasnin, Y. Puzachenko, T.Subbotina, etc.) and Azerbaijani scholars (A.M.Hajizade, Sh.Y.Goychayli, N.A.Babakhanov, Sh.B.Khalilov, N.A.Nabiyev, A.A.Gurbanzade, Ch.N.Ismayilov. T.G.Hasanov, Z.N.Eminov, N.A.Pashayev, A.Kh.Nuriyev, B.M.Azizov, T.A.Khalilov, Sh.I.Mammadov and others) play a pivotal role in the researches in the direction of general geography and ecnomic–ecological study.

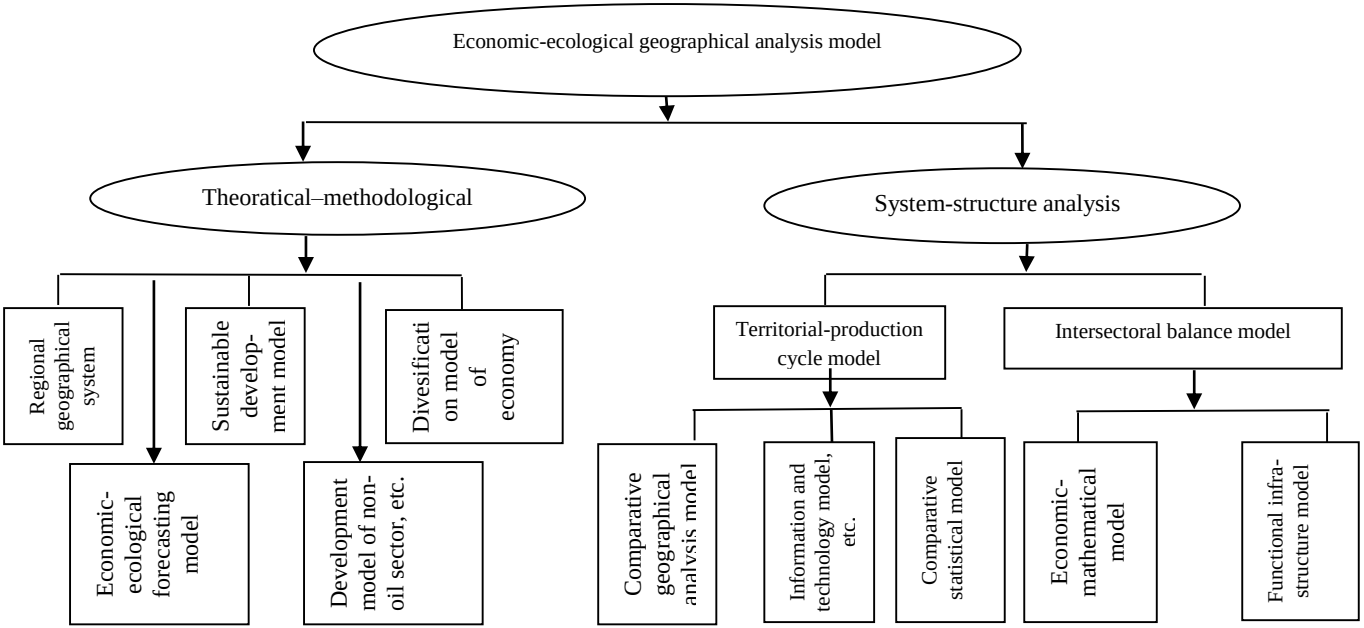


**Figure 1. Schemes of economic–ecological model groups**

Moreover, in the dissertation, the results of scientific considerations in physical geography, economic and social geography, economics and ecology were accepted as the basis for the study of ways to address economic and ecological problems. During the research, the principles of constructive approach of the methodology of the territorial–production complex (cycles) to the territorial organization of the economic–ecological functional structure were used. This allows the discovery of complex and multifunctional objects and natural potential in the area.

It is more effective to study the spatial–temporal relations of the components of the economic–ecological geographical system, the study of the impact of negative factors on it and sustainable territorial processes through the study of economic–geographical models (Figure 1).

Given the lack of a single concept based on the multifunctional "economic development – environmental environment", economic–geographical research was preferred in a comprehensive approach to the issue. Along with several research models in the formation of the economic–eco–geographical system, the method of geographical system–structural approach opens up the possibility of optimizing the interaction between society and nature. The role of system–structural analysis in the creation of new scientific concepts from the data collected in the territorial organization of the economic–ecological functional structure is great. They allow the discovery of complex and multifunctional objects and natural potential in the area.

On the basis of system–structural analysis, it was determined that "sustainable development" is a combination of three structures with natural, economic and social functions. However, in order to fully ensure "sustainable development", all its elements should be approached in a balanced and diversified manner. Therefore, the economic and geographical aspects of the interaction of these three functional structures are analyzed. It was determined that the form of "sustainable development" of the economic–ecological functional structure covers the areas of balancing the territorial–production structures of the regions. The solution to the diversification of the

national economy complements the transition to a "sustainable development" model.

From our perspectives, only a comprehensive and systematic approach to the study of sustainable economic and environmental processes can give the necessary results. The analysis of the dialectical approach to regional "economic–ecological" sustainable development indicates that nature and the social system have a dynamic nature, a novel environment has emerged and developed into an economic–ecological system during the first productive activity of human society.

Research analyzes the prevalence of environmental pollution in developed countries due to the existence of ideas that characterize the economic and environmental conditions. As in other countries of the world, in Azerbaijan, normative bases regulating the maximum permissible limit (MPL) of concentrates released into the atmosphere and released into water bodies have been developed, approved and equipped with commissioned facilities. However, only 56 out of 78 urban settlements have treatment facilities. The total volume of domestic wastewater in Baku is 1.2 million $m^3$ per day, and only about 50% of this water is treated. According to the Amelioration and Water Management OJSC, an average of 218 million $m^3$ of industrial and domestic wastewater from 4.8 billion $m^3$ of wastewater discharged across the country is discharged into untreated water sources [1], including the Caspian Sea. However, in recent years, several new treatment plants have been built at many enterprises. In order to strengthen control over the ecological condition of the environment, the State Ecological Expertise Department was established under the Ministry of Ecology and Natural Resources. Work is underway to properly assess the level of environmental hazards, to create technology for the efficient use of low–waste and natural resources.

As the economic potential of the republic grows, special attention is paid to addressing environmental problems. The issues of development and improvement of nature protection activities are

[1] Environment in Azerbaijan – Baku: State Statistical Committee– 2020 – 139 p., (In Azerbaijani).

more clearly stated in the "National Program on ecologically sustainable socio–economic development in the Republic of Azerbaijan" adopted in 2003. Estimates show that expenditures on environmental protection and restoration account for 2–2.8% of the country's budget.

According to the analysis, the regional development strategy should be studied within the economic–geographical regions, and perspective socio–economic planning should be based on the long–term sustainable development of the natural resource factor. From the point of view of sustainable development and management of the economic–ecological functional structure, it is more expedient to consider the region as an internal territorial unit of the country. The region represents the whole territory with mixed components, presents itself as a special economic–geographical space where natural and labour resources, production and social spheres are concentrated.

The essential goal of state–of–the–art regional policy and governance is to ensure the implementation of the goals and objectives of the socio–economic development policy pursued in the country on a regional scale. The "country–region–economic region" trinity, based on the sustainable development of the social, economic and ecological functional structure, is included in the economic–geographical research. Thus, on the basis of a comprehensive analysis of socio–economic processes, the factors limiting development in the regions are identified. The primary components determining the socio–economic opportunities were assessed and the target period of 16–25 years was selected on the basis of strategically important plans. Therefore, as a key condition for the development of a new strategy, special attention was paid to the economic and geographical assessment of administrative–territorial structures, natural and economic potential, production areas.

The dissertation pays special attention to the study of the main elements of the economic and ecological system – natural resources and factors affecting the environment. Natural resources are valued as a set of elements that directly affect the development and location of production. From a practical point of view, the use of various

natural resources, protection, etc. In connection with the activities carried out, we consider it expedient to use this or that group for the purpose of their management and planning. The analysis shows that in the grouping of natural resources, the economic–geographical category is determined by the main directions of their use in human activity:

- direct human livelihoods and their reproduction;
- sources of material means of production and the most important factors of its development.

The grouping of nature use directions is scientifically and practically important in identifying different sources of environmental stress. Due to the use of modern nature to meet the needs of the population, to further increase the efficiency of production, a complex impact on the environment has been achieved:

- meeting the growing demand of society for natural resources;
- increasing the productivity of the natural environment and creating conditions for reproduction;
- efficient and economical use of non–renewable resources.

In recent years, regional economic and ecological functional structures have been established in the country and their activities have been adapted to the requirements of sustainable development. As in the leading countries of the world, the process of improving the use of nature is taking place in Azerbaijan. These improvements are grouped in the following areas: 1) resource consumption; 2) reconstruction at a constructive pace; 3) reproduction of natural resources; 4) protection of natural resources and environment; 5) management and monitoring of natural resources and natural environment.

Studies show that nature conservation is closely linked to reproduction. The impact of environmental protection measures is owing to the most comprehensive approach. It is known that along with other economic complexes, there is a complex protection of the environment. Analyzes show that environmental protection can be achieved through the organization of scientifically based monitoring.

The second chapter of the dissertation is dedicated to **"Generation of the regional multifunctional economic and**

**ecological structure of Azerbaijan".** It examines the development of Azerbaijan's regional multifunctional economic and ecological structure at the macro–regional level, factoring in socio–economic and natural–geographical differences on the basis of territorial–regional approach, economic–geographical analysis of factors affecting the development of economic–ecological functional structure and other problems.

The dissertation is devoted to the generation of regional multifunctional economic and ecological structure of Azerbaijan ("generation", – in Greek – "genos" – derivative; means the economic–ecological structures formed under the influence of), and the priority of the problem is determined. Four regions identified by previous researchers, accepted and justified by us – the Greater Caucasus, the Lesser Caucasus, the Kura–Araz and Lankaran – have economic and environmental problems. Each of these is interrelated with the development of productive forces. They are conventionally divided into three groups:

- inter–regional economic and environmental problems are related to the need to balance territorial–production structures through the implementation of macro–regional (mountainous regions of the country) or large–scale socio–economic development programs in the country;
- complex economic–ecological problems – are connected with the structures requiring improvement (or reconstruction) of the economic region or large territorial–production complex;
- local economic and ecological problems – are related to the measures taken at the level of meso or micro–district (local area–production complex).

According to the results of the study, the efficient use of natural resources and the assessment of natural conditions for the modern socio–economic development of the regions is a mixed process, creating conditions for the development of many areas of production. Without studying them, it is impossible to achieve a sustainable territorial organization of the regional economic and environmental structure.

The dissertation analyzes the economic and geographical features of the multifunctional structure of the Greater Caucasus region. It was determined that the territorial harmonization of natural factors led to the development of industry and agriculture. The region accounts for 34.5% of the country's total area. The main feature of its activity as an economic–ecological system is related to the huge intensive anthropogenic "burden" on the natural environment. Taking into account the population density and concentration of production funds, this is about 3 times higher than the national average. The study of economic and environmental problems in the environment of the region, in terms of a complex economic and geographical context in accordance with the modern socio–economic development of the regions, creates the need to address the following issues:

- increasing the integrated use of mineral resources and forest resources;
- the need to create environmentally friendly production in large industrial cities and junctions (Baku, Sumgait, Ganja, Shaki, Shirvan, Khachmaz);
- measures to combat water management problems and to combat the deterioration of the quality of water resources;
- intensification of land use and involvement of improved lands in agricultural turnover.

The Greater Caucasus natural and economic complex differs in its resource potential in the economic and social development of Azerbaijan. Increasing the degree of complexity in the use of mineral resources and forest resources is very important for the economic and geographical regions of the region. In connection with the protection of the natural environment in the Sheki–Zagatala economic region, the use and complex development of natural resources, especially the part where the Filizchay polymetallic deposits are located, is of great importance. Up to 80% of the country's copper reserves and 90% of sulfur pyrites are concentrated here. There are also various non–metallic minerals, the Khalkhal hot mineral spring is of great therapeutic value. However, the complexity of the orthographic conditions of the area makes them difficult to master.

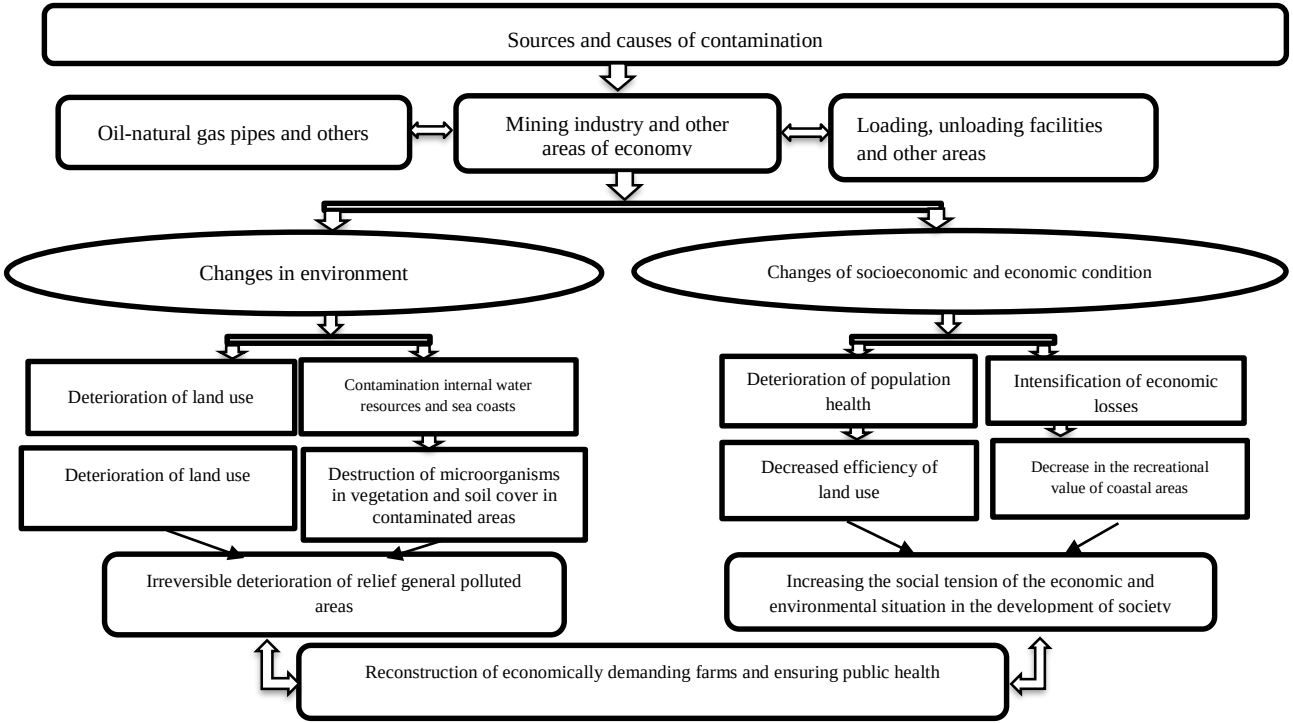


**Figure 2. Scheme of the impact of the mining industry and other sectors of the economy on the economic and ecological functional structures**

Rich oil, natural gas, various construction materials, mineral water resources in the Absheron economic region differ from other regions of the country in terms of quality. Environmental problems on the Absheron Peninsula caused by the exploration, exploration and exploitation of oil and gas fields have not been resolved for more than 160 years. Because of this matter, all natural components of the region have been damaged, only up to 20,000 hectares of land have been contaminated with oil and oil products (Figure 2).

The great tension in the environment of cities in the Greater Caucasus, such as Baku, Sumgait and Shaki, makes it necessary to take measures for ecological balance. High concentration of the population, production funds, requires the implementation of various measures to limit the harmful effects of previously applied technology. In order to further improve the condition of the urban environment in the future, the production of sanitary toxins requires the removal of cities and the replacement of technological equipment.

The Lesser Caucasus region is a part of Azerbaijan with promising economic and ecological differentiation in terms of natural resources, with an area of 31.6 thousand $km^2$. The Lesser Caucasus accounts for 85% of metal ore resources and almost 1/3 of forest resources.[2] Exploitation and processing of the country's metal ore deposits are of strategic importance for the future development of Azerbaijan. The rich natural resources of the Lesser Caucasus region, such as iron ore, alunite, copper–molybdenum, lead, gold, silver, bentonite clay (gilabi), various building materials – travertine, marble, cement raw materials and many therapeutic mineral water deposits are of industrial importance. The extraction of these natural resources affects the economic and ecological conditions of the area – soil, water, atmosphere and vegetation.

Analysis of the soil resources of the Lesser Caucasus indicates that although soil types differ in their fertility and use, they are also exposed to pollution as a result of human activities and natural

[2] Environment in Azerbaijan – Baku: State Statistical Committee– 2020 – 139 p., (In Azerbaijani).

factors. As a result, certain economic and environmental problems have arisen:

- firstly, the location of industrial enterprises, settlements, transport systems, reservoirs and canals in the region has led to quantitative and qualitative changes in soils in some areas;
- secondly, lands are polluted by wastes from mining, processing industries, agricultural enterprises, cities and utilities;
- thirdly, soils in the region are also subject to natural pollution. Rehabilitation of contaminated soils and measures against erosion are relatively lower.

Environmental problems of the mining industry in the region stem from the intensive use of mineral resources. The mining industry created in Ganja, Dashkasan, Gadabay, Gazakh on the basis of mineral resources has a significant impact on the environment. Tons of waste are collected in fertile soils around mines and industrial enterprises. Such a process has led to a certain disruption of the unity between production and nature. Wastes generated during mining and processing of raw materials increase soil pollution.

In the process of open–pit mining of iron ore in the mines of Dashkasan, 960 hectares of the area, including 500 hectares, were polluted with unusable rock waste. Areas contaminated with waste from 300 hectares of alunite, 25 hectares of cobalt, 150 hectares of copper mines in Gadabay create unfavorable conditions for the development of farms. As a result of Dashkasan marble production, enterprises emit large amounts of solids into the atmosphere. An average of 2,400 tons of pollutants are released into the atmosphere from stationary sources every year[3]. In the process of refining iron ore, up to 50–55% of waste is generated. The economic and ecological system of the Armenian–occupied territory of Karabakh has been severely damaged for 30 years. In all areas where destructive weapons and heavy equipment are used, the ground cover has been negatively affected. Flora and fauna were severely damaged in the area of 100,000 hectares.

[3] Environment in Azerbaijan – Baku, State Statistical Committee– 2020 – 139 p., (In Azerbaijani).

By analyzing the location and development features of production in the Nakhchivan economic region with rich natural potential in the Lesser Caucasus region, it was determined that its future development is associated with a number of economic and environmental problems: 1) the need for integrated use of mineral resources; 2) protection of land resources and water sources from pollution; 3) protection of the air basin in industrial centers; 4) regulation of man–made impact on landscape structures.

The analysis depicts that these economic and environmental problems have a specific character in different parts of the region. These are primarily due to the zonal features of the economic development of the area.

In the dissertation, the economic–ecological differences and development directions of the Kura–Araz region were analyzed and it was determined that intensive development of the territory and formation of industrial hubs are taking place in the region on the basis of rich natural resource potential. The area of the region located in the Kura–Araz lowland is 21.43 thousand $km^2$. The current economic and ecological situation in the Kura–Araz region, which makes up 24,7% of the country's territory, is characterized by the development and specialization of various sectors of the economy, rich oil and gas and mineral resources, as well as water shortages. 47% of agricultural land is cultivated under irrigation. Improper compliance with technological rules in the process of using land and water resources has led to lower yields than expected, as well as the violation of economic and environmental balance.

Untreated wastewater from utilities in Mingachevir, Shirvan and other cities pollutes water sources in the region. In the Mugan and Salyan plains, as a result of periodic failure to clean drainage collectors, groundwater levels rise, increasing soil salinization in the surrounding areas. The formation of new swamps along the Upper Karabakh and Upper Shirvan main canals has led to an increase in economic and environmental tensions in the area.

The activity of the extractive industry in the Aran region has led to large–scale soil pollution. This was mainly due to the extraction of oil and gas and construction materials. Due to oil and gas production,

more than 150 hectares and 220,2 hectares of useful lands were polluted due to oil and gas production in the region. It is possible to improve the ecological condition of the area by recultivating these lands.

Problems of interaction of the economy with the natural environment in the Lankaran region are associated with the production of intensive agricultural products and high population density, formed on the basis of the temperate–hot climate, fertile soils and water resources characteristic of the region. The area of the region is 6.08 thousand $km^2$ and covers 7% of the country's territory and 9.5% of the population. Intensive use of agricultural lands in the region has led to the deterioration of soil and vegetation, as well as an increase in economic and environmental tensions, which has a detrimental effect on water bodies and the air basin. Only 102,6 thousand hectares of the total land fund is sown with agricultural crops.

One of the important natural resources of the Lankaran region is the part of the Caspian Sea in the region. There are fish farms in the Caspian coast of the region. This also plays an important role in increasing the food supply of the population. Fine sandy beaches allow to create recreation complexes here. However, the level of the Caspian Sea rose in 1978–1995 and flooded 35660 hectares of Lankaran and 1050 hectares of Astara. As a result, it caused significant damage to farms located in the coastal zone of the economic region and led to an increase in environmental tensions. In some areas, the drying of excessively moist soils, strict control over the allocation of arable land for industrial and construction projects, and the restoration of lands damaged by landslides and floods are among the urgent issues. In the Lankaran region, which has a unique nature, densely populated, lack of suitable land resources in the country, it is expedient to develop industries with low metal content and requiring qualified personnel.

The third chapter of the dissertation is devoted to **"Analysis of environmental factors against the background of sustainable socio–economic development of Azerbaijan".** It analyzes the resource provision of the territorial organization of the functional

structure, the assessment of economic and environmental factors against the background of sustainable development of production, the relationship between production and the environment in the integrated development of cities in Azerbaijan, ways to effectively use industrial urban areas.

One of the most important approaches in the socio–economic development of the regions is the solution of environmental problems, both in the country and in individual areas. Provides integrated use of natural resources, environmentalization of production and effective organization of optimal living conditions for the population. For this purpose, the main ***ecological factors and conditions*** manifested at different levels of planning of socio–economic development of the regions (by production areas) are substantiated: 1) land use; 2) use of water; 3) ensuring the protection of the atmosphere; 4) ensuring affordable water quality; 5) protection of landscapes of recreational and aesthetic value; 6) protection of lands.

The dissertation examines specific types of environmental factors (resource provision) and their socio–economic features in the placement of effective options for the production structure. It is noted that land supply is one of the important environmental factors in the process of production placement. Analysis of the use of arable land shows that in some regions of the country, especially in densely populated areas, limited land resources are a major factor affecting land. In many regions, a lot of land is required for the construction of industrial, road and other non–agricultural facilities. Depending on the type and capacity of production, an enterprise needs 1 ha to 1000 ha or more of land. One of the most land–intensive industries is the hydropower industry. Several 1000 $km^2$ of usable land remains under hydropower plants. The area of underwater lands is 394,6 thousand hectares, which is equal to 4,8% of the country's territory. According to estimates, the area of industrial, road and other non–agricultural lands in the country is 341,7 thousand hectares[4]. The average size of non–agricultural land is 1,9%, and it is distributed unequally by

[4] Environment in Azerbaijan – Baku: State Statistical Committee– 2020 – 139 p., (In Azerbaijani).

region of the country. In the Absheron economic region, the density of non–agricultural lands is higher, accounting for 39% of the total land area of the region.

Despite the limited water resources in the country, they are not used efficiently, piped water provides 50% of the population, and in some regions there is a shortage of drinking water. In 2019, the use of household resources and drinking water in Azerbaijan will be only 312,3 million $m^3$, 31,2 $m^3$ per capita. By regions, these figures are 170,6 million $m^3$ in Baku, 74,6 million $m^3$ per capita and 21,9 million $m^3$ in Sumgait, 63,7 $m^3$ per capita, 32,5 million $m^3$ in Aran economic region, 19,7 $m^3$ per capita.

In the dissertation, the potential for the country's transition to a model of sustainable development is associated with the assessment of environmental factors of production, the justification of the location of individual production facilities ***is justified at the following levels (stages):*** 1) macroregion (country); 2) at the level of economic regions (inter–districts); 3) at the level of meso–district (administrative districts, Territorial–Production Complex (TPC)); 4) at the level of micro–district (selection of local areas for construction of production facilities).

At each stage, the specific features of environmental factors were taken into account in the placement of production and the directions of their use were analyzed. Calculations illustrate that in some regions of the country, especially in areas with maximum concentration of production, restrictions on the location of production facilities (in some cases incentives) require stricter measures than in the whole country. In addition, environmental factors should be further increased as a constraint on the location of production in areas where productive forces are developed in the regions.

While researching the field model of placement in the dissertation, the methodology for assessing environmental factors in the placement of production by field was clarified. However, the main issue is to obtain comprehensive data for cross–sectoral calculations that allow to assess the economic effect on the location of production. In this sense, in order to solve the problem, we

consider it expedient to link the development of production and the location of nature protection facilities in the regions of the republic and the Territorial Production Complex as a targeted function. The result of the study is to minimize the amount of damage caused by environmental pollution. At the same time, the size of capital investment in the development of production and production, as well as environmental protection was used as an environmental constraint. The minimum total cost of eliminating the damage caused by environmental pollution as a result of production was estimated at 241285,1 manat.

In the context of the interaction of "population–production–environment", "the pressure of the population and production on the area", the amount of various substances polluting the environment, their changes were studied. The analysis shows that with the development of scientific and technical progress, the process of urban development has become more universal, affecting all aspects of public life. In 1913, only 23,8% of the population lived in the cities of the republic, in 1970, this figure was 51,1%, in 2000, 51,1%, in 2015, 53,1% and 52,8% (2020). According to forecasts, in 2025–2030, 52–52,5% of the country's population will populate in cities. The process of urban development creates a crisis in the relationship between society and nature, turning cities into more intense ecological areas.

Urban development and related intensification of production not only increase people's impact on the natural environment, but also create the necessary conditions to prevent the deterioration of its nature in large cities. It has been established that nature can be preserved only in the conditions of urbanization. Because, when cities are built, the restoration of the natural environment is resolved positively, a number of its shortcomings are eliminated, and the environment is improved.

Much work has been done in recent years to make efficient use of local resources to improve the quality of the country's urban environment. The quality of the atmosphere in the cities of the republic has improved. Impacts on water bodies of Guba, Khachmaz, Shaki, Zagatala, Gazakh and other cities have decreased. A number

of studies suggest planting greenery in and around Baku in accordance with the norm (up to 50% of the area) – on 10–11 thousand hectares. However, the analysis of the data shows that in the early 2000s, the area of greenery in Baku increased to 2750 hectares, and now to 3885 hectares. If we take into account that the area of Baku is 22,5 thousand hectares, then this figure is relatively lower. A survey conducted in Baku found that more than 90% of the city's population wants to spend their short vacations in forest parks and on the beach. The analysis depicts that the amount of harmful gases in the settlements of Baku is still high[5] (Table 1).

During the study, analyzes were conducted on household waste, which is a factor that disrupts environmental stability in cities and settlements of the country. It was determined that 5 million $m^3$ of solid waste is generated annually in these settlements. 50% of it is collected in Baku and Sumgait and surrounding settlements. 20–40% of this waste is paper and cardboard, 4–5% is wood, 5–6% is glass, 2–4% is ferrous and non–ferrous metals, more than 6% is polymers, and the rest is food and other wastes. About half of this waste is dumped in landfills, 2–3% is incinerated and 2% is recycled.

**Table 1.**

**Emission of pollutants from stationary sources into the atmosphere in major cities of the country, (thousand tonnes)**

| № | Name / Years | 2005 | 2010 | 2015 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|
| 1 | Baku | 464,6 | 164,6 | 128,2 | 137,1 | 144,9 | 151,3 |
| 2 | Sumgait | 27,1 | 2,2 | 1,9 | 1,8 | 1,4 | 1,8 |
| 3 | Ganja | 4,3 | 0,4 | 0,2 | 0,2 | 0,1 | 0,1 |
| 4 | Mungachevir | 14,5 | 1,6 | 4,2 | 6,6 | 1,9 | 1,9 |
| 5 | Shirvan | 17,5 | 8,4 | 6,5 | 5,2 | 3,4 | 3,4 |
| 6 | Nakhchivan | 0,3 | 19,3 | 18,0 | 61,2 | 1,5 | 81,5 |
| By the Republic of Azerbaijan | | 567,9 | 214,8 | 170,0 | 184,1 | 170,9 | 177,1 |

**Source**: ***Environment in Azerbaijan. SSC. Baku–2019.***

[5] Environment in Azerbaijan – Baku: State Statistical Committee– 2020 – 139 p., (In Azerbaijani).

The study also analyzed quantitative indicators of environmental impact factors among the country's major cities and identified significant differences between them. Vehicles, especially cars, account for 70–80% of air pollution in Baku. 55–60% of these wastes are carbon dioxide, 17–20% are nitrogen oxides and other compounds. In the cities of Mingachevir and Shirvan, about 80% of the toxic gases polluting the air are thermal power plants, the main part of which is nitrogen oxides. 10–18% of the gas emitted into cities falls on motor vehicles.

The dissertation studies in detail the ways of efficient use of industrial urban areas. One of the most important environmental aspects is the future development of urban settlements, directly related to the efficient use of territorial (land) resources. The overgrowth of urban settlements makes their normal operation very difficult. An analysis of land use in the country's cities shows that it is extremely intensive. It is dominated by non–residential areas, which account for more than half of the total urban area. Their development is often determined by random factors, and in contrast to the areas allocated for construction, its methods and standards are not sufficiently developed. The analysis ilustrates that about 7 hectares of land have recently been invested in industrial construction in the country with an average investment of 1 million manat. Sometimes departments and designers often unreasonably require large areas of 400–500 hectares, but later it turns out that the exact demand is 100–200 hectares. Approximate calculations depict that in all urban areas of the country in non–residential areas, the area allocated for the organization of the necessary activities may be reduced by 20–30%.

The fourth chapter of the dissertation is dedicated to **"The greening of production in Azerbaijan and the directions of regional economic and environmental forecasting".** It investigates the methodological bases of the greening of the production structure, the concept of sustainable development and forecasting of the country, the development of economic and environmental forecasting standards for regional development of Azerbaijan, forecast balance models of territorial resources and other problems.

The study found that modern greening of the production is not only a low–capacity or waste–free technology, but also the proper reconstruction of the entire planning system and private farms. The solution of economic and environmental problems within the production system is primarily related to the improvement of two areas:

the first is the economical and complex use of natural resources – mineral resources and water.

the second is to limit or eliminate the negative impact on the environment in the production process.

At the same time, the relationship between the complex use of natural resources and the level of production efficiency has been clarified. Increasing the production, processing, complexity of mineral resources, eliminating and refining the negative impact increases the efficiency of modern production and allows to increase its stock yield. In the Absheron economic region, the cement industry is distinguished by the advanced growth of dusters compared to all production funds. This is the most dusty industry. The cost of building a dusting plant is 10–12% of the total capital investment. The stock yield of pulverizing plants at the cement plant is almost 1.5 times higher than the stock yield of all major production assets of the industry. In a number of other areas of the processing industry, up to 20–25% of the total capital investment has been set for the establishment of treatment plants.

One of the most important steps in the solution of the methods used to achieve the maximum cost–effectiveness of environmentally friendly equipment is to assess the amount of pollution as a whole. In this regard, many indicators were used: 1) the amount of pollution resulting from the use of one technique during the year; 2) the number of available equipment used in the country's economy; 3) projected service life of new equipment; 4) indicators such as the magnitude of the possible amount of pollution during the use of new equipment were calculated. As a result, it was determined that environmental repair in the country should be $P_{n.tech}<P_{old\cdot tech}$ (exceptions $P_{n.tech}=P_{old\cdot tech}$) in the replacement of new technology with old technology in order to eliminate the possible deterioration of

the environmental situation in the process of its growth. When these requirements are not met, existing models need to be improved.

In order to form a model of sustainable development of Azerbaijan in contemporary times, it is necessary to rely on effective forms of governance that regulate the activities of the territorial–production structure in the regions. The development of the regional economic and ecological functional structure of the country is of great importance in the development of concrete plans, forecasting in the implementation of the most important necessary functions.

The results obtained in an effective management process should be linked to forecasts. During the study, an analysis of "economic and environmental forecasting" was conducted to ensure the sustainability of the economic and environmental functional structure. Although its interpretation is ambiguous, the term "environmental forecasting" has been well studied in the scientific literature in the concept of sustainable development. The assessment of the factors determining the economic and ecological situation, the identification of their development trends, plays a basic role in the study of economic and environmental processes in the regions. Dimensions of anthropogenic impact on the natural environment in the future and determination of the consequences of this impact are the main directions of economic and environmental forecasting. In this regard, during the development of the economic–ecological forecast model, attention was paid to the interaction of the environment with the economic activity of the population: 1) the condition and level of development of the components of the environment; 2) the degree of impact on it as a result of economic activity; 3) collection of normative bases; 4) statistical data were collected, selected and systematized. As a result, a priority (priority) table of the environmental problem was established for the analysis of the regional economic and ecological situation. This allows for the identification of priority issues for crisis alert in specific regions (Table 2).

The stress rate in the table was calculated by an expert assessment of 5 points. This table identifies priority issues for

warning of the crisis situation created by the types of tensions in the territorial units of the Absheron economic region.

**Table 2**

**Priority schedule of environmental problems (stress level, score)**

| Teritorial units – city, town, district, etc. | Gərginlik növləri | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Weather | | Water | | Solid waste | | Noise | |
| | Sulfuric anhydride | Carbon dioxide | Oxygen content | Phosphorus content | Regular garbage transportation | Garbage disposal | The noise of industry | The noise of traffic |
| | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Baku | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 5 |
| Sumgait | 5 | 5 | 2 | 1 | 3 | 1 | 1 | 4 |
| Binagadi | 4 | 1 | 4 | 2 | 5 | 1 | 3 | 3 |
| Ramana | 2 | 2 | 3 | 1 | 2 | 2 | 4 | 3 |

**Source**: ***Compiled as a result of the author's calculations.***

The forecast of territorial resources (land use) is very important for regions with limited land resources and urbanized areas. The analysis indicates that various methodological difficulties prevent the detection of demand in non–agricultural areas of production purpose. This is owing to the lack of specific standards for a number of categories of land use. The study clarifies the identification of optimal structures for land use. In this regard, the indicators of the special territorial land capacity are: 1) the area of non–agricultural areas of production purpose; 2) size of capital investment for construction; 3) soil capacity coefficient was estimated. In the future, the calculation of the demand for various types of land use (full coefficients for construction, estimated at 1 million manat per 1 hectare of capital investment) will reduce the number of special land–based production facilities for most new facilities.

The analysis demostrates that the most effective inter–sectoral and inter–regional optimal area model is used to forecast the demand

for natural resources and to determine the amount of pollutants. The study clarifies the concepts of application of inter–sectoral balance model and their definition in the analysis of the impact of economic activities on the environment. The scale, composition and environmental pollution of economic activities depend not only on environmental protection measures, but also on the effective use of various models.

The model is usually based on specific data that reflect the resource costs required for production and the pollutants released into the environment during the release of the product. Its application is considered as a mandatory effect of production and consumption processes. The level of production and pollution, together with the emissions of pollutants, were calculated using special statistics. All sources of information related to intersectoral relations are presented sequentially in the following block model (Figure 3).

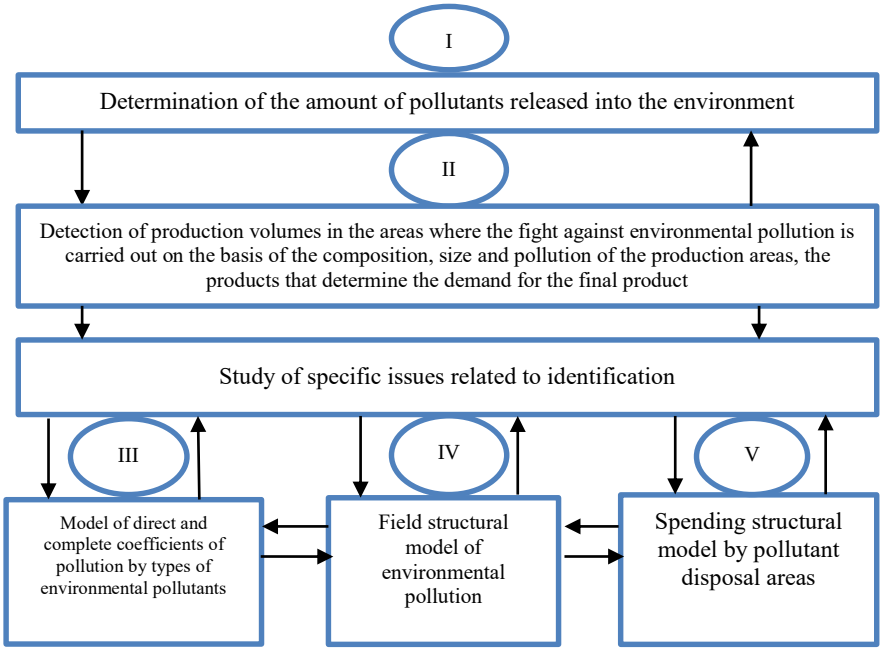


**Figure 3. Block–model of information sources of economic–ecological forecasting of "economy–environment".**

Data on the level of production and pollution, the amount of final consumer goods, the cost ratio and the emissions of pollutants were analyzed in detail in the study. The data obtained indicate the volume of different types of waste disposal, the ratio corresponding to the size of 1 ton of waste in waste disposal plants.

Based on the data collected during the study, direct and then complete waste ratios were determined. By applying them to atmospheric emissions, the total coefficients of pollutants were calculated at 1 million manat per 1,000 tonnes of waste. The main types of atmospheric emissions are solid particles emitted during the production of the final products of each field – sulfur oxide, carbon monoxide, nitrogen oxide and others. Calculations, depending on the type of environmental protection, were implemented through the main pollutants – solid particles – 0,068; sulfur oxide – 0,15; carbon monoxide – 1,0; nitrogen oxide – 0,05 and other coefficients.

The analysis shows that the amount of total waste per unit of output is very large in the country. The sulfur content of fuel oil in thermal power plants operating on natural gas and fuel oil in the country is 2%, 700–1000 tonnes of sulfur and nitrogen oxides enter the atmosphere from burned fuel oil per day. In 2019, a total of 177,1 thousand tonnes of pollutants emitted into the atmosphere from stationary sources in the country, including 7,4 thousand tonnes of solids, 169,7 thousand tonnes of gas–like and liquid substances. Of them, sulfur dioxide ($SO_2$) had been 0.7 thousand tonnes, carbon monoxide (CO) – 16,2 thousand tonnes, nitrogen oxide ($NO_2$) – 22.3 thousand tonnes, hydrocarbons – 116,8 thousand tonnes[6].

According to estimates, air pollutants and sources of pollution are unevenly distributed throughout the country. The main pollution centers are located in Absheron, Ganja–Gazakh and Aran economic regions. On average, more than 1,500,000 tonnes of various wastes are released into the atmosphere every year. The amount of complete waste per 1 million manat product unit was set at 7,1 thousand tonnes in oil refining, 8 million manat from the production of 1 million manat construction materials and iron ore. Intersectoral relations

[6] Environment in Azerbaijan – Baku: State Statistical Committee– 2020 – 139 p., (In Azerbaijani).

facilitate the development of a gradual increase in waste from any field. In the food industry, direct waste is 2,000 tonnes, and indirect waste is 4,000 tonnes. It not only compares the level of environmental pollution with the level of production development in the studied regions, but also determines the impact of the level of production development on the environment from the point of view of optimality, the ratio of production and environmental protection costs.

The advantage of the analysis methodology is, first of all, that the regional model of intersectoral balance allows the development of a forecast model of intersectoral relations to calculate the environmental impact of the region's economy. In general, the model consists of a price system. The collected prices are multiplied by the volume of products produced in the region, plus the prices of the final product and the prices of the last pollutants generated in non–production areas. The results obtained allow to calculate the total amount of all types of pollutants produced in the region and determine the ratio of environmental costs. The calculation of emissions in the model applied to the cities of Baku and Sumgayit shows that the processing of wastes into harmless substances will account for 92% of all emissions into the environment by 2030. Also, the chances of maintaining the "profit–expenditure" ratio until 2030 will not be less than 1,5: 1,2.

The fifth chapter of the dissertation examines **“The concept of regional economic and ecological territorial differentiation and development of the functional structure of Azerbaijan”.** This chapter examines the methodology for taking into account the damage caused to the environment by production, the assessment of regional environmental threats and economic–ecological conditions, the taxonomy of economic–ecological territorial differentiation, economic–ecological problems of territorial differentiation.

In the dissertation, the damage caused by environmental damage as a result of the impact of production activities was taken into account when studying the sustainable development of the regional economic–ecological functional structure. It has been determined that the condition of air, water and soil changes depending on the

level of use of various production areas and minerals, and as a result of partial or complete loss of use, the country's economy suffers great damage. When determining the damage caused by production activities, its economic, social and environmental aspects were assessed.

The calculation of regional damage during the research was carried out on the basis of the analysis of the methods and proposals given in the dissertation, systematization of damage caused by pollution of air, water and land resources. When substantiating the solution of the complex nature of the economy, the main criterion for the economic efficiency of additional capital investment in environmental protection is the minimum economic costs incurred. They were evaluated by the following formula (Formula 1).

$$K_{ie} = \sum_{i=i}^{n} C_i + E_n K_i + Z_i \rightarrow min \qquad (1)$$

There

$K_i$ – capital investment for each option;

En – normative coefficient of economic efficiency of capital investment;

$C_i$ – current expenses on those options;

$Z_i$ – expression of the value of the damage under the option;

i =1 and this represents damage to the atmosphere, water, and soil from 1 to n.

Calculations demostrate that the economic damage caused by water and air pollution in the country in 2015–2017 amounted to 1069991,3 manat, the damage to the economy per hectare per year in different regions as a result of soil pollution (unused) of the main components of the natural environment is about from 354,5 manats to 650,0 manats. Our calculation is accurate for about 55–60% of the damage, which is very important for its size. Even an approximate calculation shows that the damage is relatively higher.

Natural and anthropogenic (man–made) indicators were selected to reveal the economic and ecological situation in the regions where the mining industry and production areas are developed. Geomorphological processes that determine the current state of landscapes, their forms and landscapes have been studied mainly

from natural components. Socio–economic groups used indicators of land and water resources that form the resource base of the economy. Also taken into account is the state of social conditions that form the economic and environmental situation as a result of social tensions and the level of economic development. Based on the above criteria, the overall comparative assessment of the regional economic and environmental situation in the country was assessed with 5 points: satisfactory (1 point); favourable (2 points); very favourable (3 points); scary (4 points); critical (5 points). At each level, key measures to improve the economic and environmental situation are proposed.

Analyzes show that natural disasters or environmental threats are of an emergency nature, disrupt people's normal living conditions and are an important source of damage to property. Natural environmental hazards in the lithosphere within the country – landslides, erosion, earthquakes, as well as anthropogenic (man–made) environmental hazards – deflation, salinization, swamping, soil pollution and others. In the study, the coefficients of environmental hazards were grouped according to a 5–degree system and their relationship was determined as follows: 1) hazard within the natural background – not more than 1,0; 2) weak threat – from 0,75 to 1,0; 3) moderate danger – from 0,55 to 0,75; 4) significant danger – from 0,40 to 0,55; 5) alarming danger – less than 0,40. The results obtained from the assessment of economic and environmental conditions in the regions of Azerbaijan, the degree of environmental threat and their spatial position are reflected in the map–scheme of environmental risk assessment and economic and environmental conditions compiled by us (Figure 4).

For the first time in the dissertation work, the concept of sustainable development of regional economic–ecological territorial differentiation and functional structure of Azerbaijan has been tried to become the object of research of economic and social geography.


GEORGIA
RUSSIA
ARMENIA
IRAN
Caspian sea
Balakan
Zagatala
Gakh
Shaki
Oguz
Gabala
Gusar
Khachmaz
Guba
Shabran
Siazan
Khizi
Ismailli
Agstafa
Gazakh
Tovuz
Shamkir
Samukh
Mingachevir
Goychay
Agdash
Yevlakh
Goranboy
Naftalan
Ucar
Barda
Tartar
Dashkasan
Gadabay
Kalbajar
Zardab
Kurdamir
Shamakhi
Agsu
Gobustan
Sumgait
BAKI
Aghjabadi
Agdam
Khojali
Khankendi
Khojavend
Beylagan
Sabirabad
Hajigabul
Shirvan
Imishli
Saatli
Sharur
Shahbuz
Babek
Nakhchivan
Julfa
Ordubad
Susa
Lachin
Fuzuli
Jabrail
Gubadli
Zangilan
Bilasuvar
Salyan
Neftchala
Jalilabad
Masalli
Yardimli
Lerik
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Astara
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50°
42°
40°
N
W
E
S

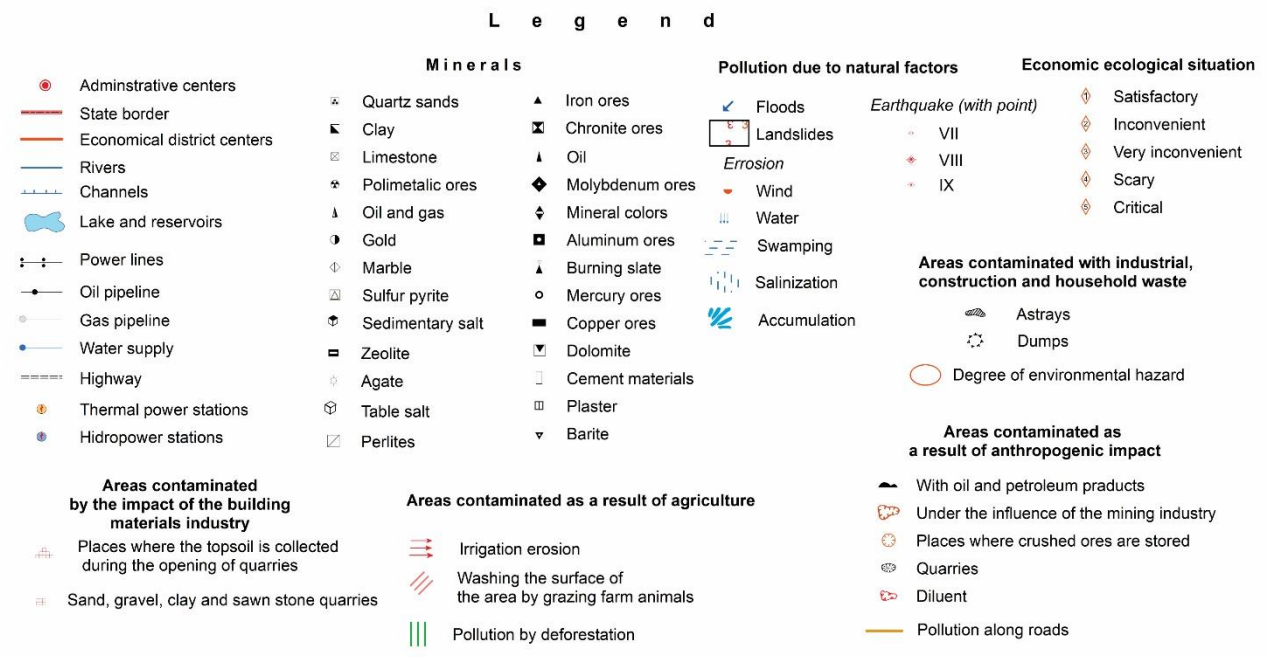


**Figure 4. Map of assessment of regional environmental threat and economic-ecological situation in Azerbaijan (compiled by: M.Mammadov)**

The study provides a comprehensive approach to the relationship of economic and ecological functional structures of economic–ecological territorial differentiation and substantiates each economic–ecological tension as a territorial unit that differs according to economic and ecological structures in the separation of areas.

During the research, the factors that make up the economic–ecological territorial differentiation and its taxonomic unit are: 1) natural–resource potential; 2) production traditions of the population; 3) structural level of economic development; 4) complex directions of territorial–production structure are analyzed. It was determined that economic and ecological reconstruction of farms in Azerbaijan should be given priority.

The analysis indicates that the functional purpose of territorial differentiation is relevant because the future development of diversified production in Azerbaijan depends on the solution of this issue on a scientific basis. Taking this into account, the functional structural potential of the regions was assessed from the economic and geographical point of view, and on the basis of which technology, which production diversification was connected with the solution of the development was diversified. Significant proposals on economic and ecological territorial differentiation have been developed in the research work. Taking into account the dependence of the geographical space of Azerbaijan on multifunctional factors, when classifying the areas of complex economic and ecological tension on the basis of taxonomic analysis of the differentiation of the territory: 1) economic and ecological usefulness; 2) production funds; 3) capital investment; 4) differences and proportions of technical structures between different regions are defined.

We take into account the area of economic and environmental tension as part of the economic and geographical region. The area of economic and environmental stress is the area or territory where components with similar properties are spread, and the size of the interdependence between the components within it is the same. We consider the area of economic and ecological tension as a single unit

of the natural complex, a unit of taxonomic classification that to some extent reflects the ecological functions.

It is a scientific novelty of the research to determine the structure of differential functional areas of the area in the dissertation work in economic and geographical terms. We consider the territorial differentiation of habitats as a local territorial unit formed in the internal network of separate integrated regions and distinguished by its dynamics. The methodological issues of their determination have been studied and scientifically substantiated by the method of structural balance – indexation, geographic information system and cartographic realities. For this purpose, the appropriate indexation methodology of territorial differentiation on the scale of future development of the country has been substantiated. In determining the index of the area of economic and ecological tension: 1) the volume of products produced by regions; 2) density of ecological stress per unit area; 3) taken as a forecast–oriented basis. It was found that the comparative index approaching "0" (zero) reflects the distribution of tension in the country. If the indicators of the economic sectors of the region coincide with the basic indicators, then the differences between the economic and environmental tensions will be "0≥" (inequality).

The research was implemented in connection with the typology and methodology of separation of areas of economic and ecological tension, research on the typology of industrial hubs in the country. On the example of different economic regions of Azerbaijan industrial zones: I–functional features; II – for size (according to the volume of production) according to the degree of development; A map–scheme of the typology was compiled according to the factors creating conditions for the formation of III–industrial nodes. This allows the study of environmental processes occurring in different levels of territorial–industrial complexes of the country for different purposes and options.

Substantiation of the separation of areas of economic and ecological tension was carried out in stages. ***Firstly,*** according to the nature of the impact of socio–economic subsystems on the environment, typological grouping of areas was developed according

to the level of economic development of the area and methods of use during the typological grouping at the mesodistrict (territorial–production complexes, industrial hubs, industrial centers). To measure the level of land use (in terms of 1 $km^2$); the size of the value of production funds; population; Indicators collected from various sources were calculated according to the value of the gross product. The main indicators characterizing the complex stress in the environment are: 1) the degree of territorial decontamination of production assets; 2) population density; 3) specific weight of the city population; 4) density of transport roads; 5) level of territorial decontamination of mineral–raw material production. All indicators of economic and environmental tensions for each meso–unities were compared with the national average and the relevant indices were calculated: a) with the highest comparative advantage index and specialized in very large industries – Greater Baku 0,290, Ganja–Dashkasan 0,320, Sumgait 0,350 areas of economic and ecological tension; b) Siyazan–Khachmaz 0,481, Nakhchivan foothills 0,455, Mingachevir–Yevlakh 0,530, Shirvan 0,586, Salyan–Neftchala 0,628, Gazakh–Gadabay 0,680 areas of economic and ecological tension on the most narrowly specialized production areas with high comparative advantage index; c) the remaining areas of economic and environmental stress, specializing in the comparative advantage index and the relatively average performance of production areas.

Areas of regional economic and ecological tension have been separated by a combination of mesovahids belonging to ***the second*** same group. In this case – the generality of the "ecological community" – the integrity of the natural background or the similarity of zonal features was preferred. Based on the results of the study, a block–model (Figure 5) and a mapped model (Figure 6) of 15 regional economic and environmental stress areas in the country were developed.

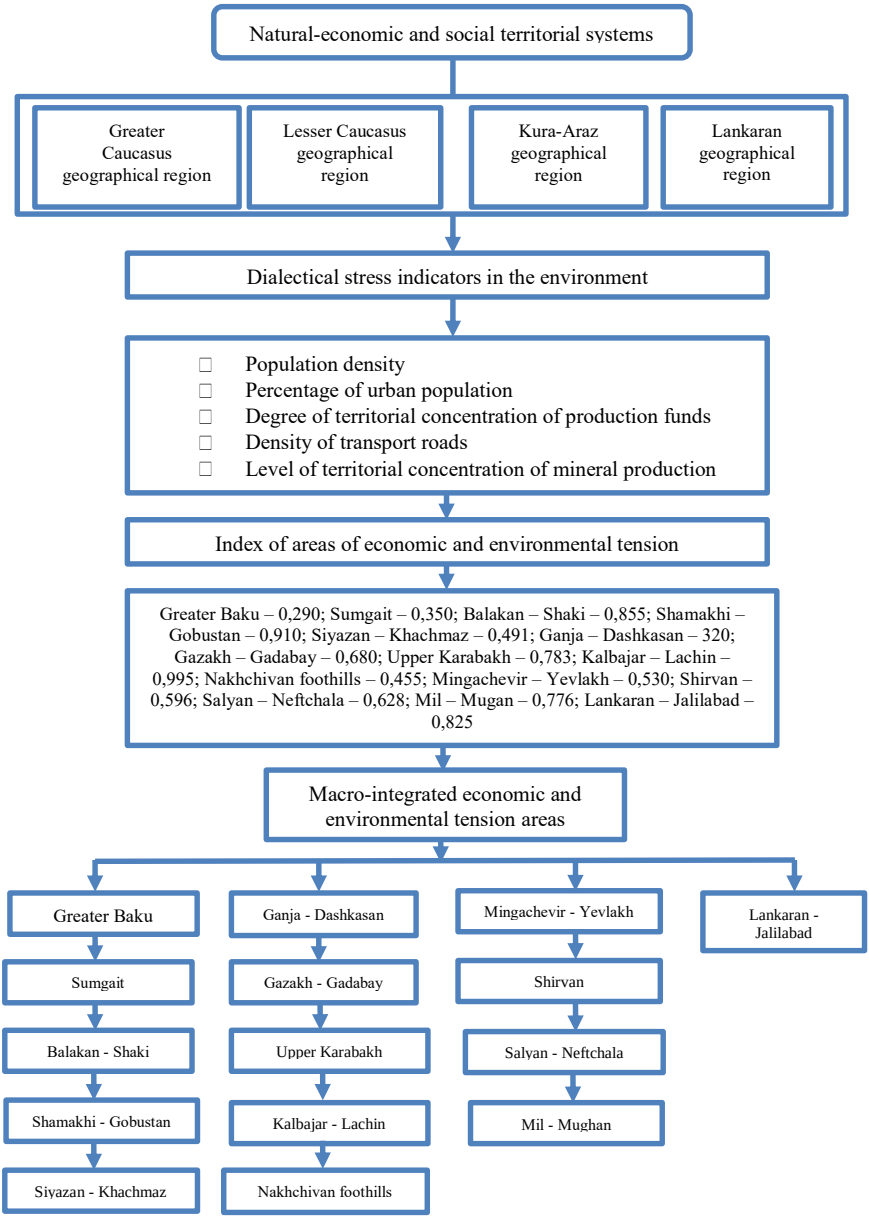


**Figure 5. Azerbaijan block–model of separation of Azerbaijan regional economic and ecological tension area**


GEORGİA
RUSSİA
ARMENİA
İRAN
Caspian Sea
BAKİ
Balaken
Zegatala
Gakh
Khachmaz
Gusar
Agstafa
Gazakh
Tovuz
Samukh
Shaki
Oguz
Gabala
Guba
Shabran
Siazan
Shamkir
Mingachevir
Yevlakh
Ismayilli
Ganja
Gadabay
Goygol
Goranboy
Naftalan
Dashkasan
Agdash
Goychay
Ujar
Shamakhi
Agsu
Khizi
Sumgait
Gobustan
Absheron
Tartar
Barda
Zardab
Kurdamir
Hajigabul
Kalbajar
Agdam
Aghjabadi
Imishli
Sabirabad
Shirvan
Saatli
Salyan
Saderek
Sharur
Khojali
Khankendi
Lachin
Shusha
Khocavend
Beylagan
Bilasuvar
Shahbuz
Khengerli
Fuzuli
Gubadi
Jabrail
Nahchivan
Babek
Julfa
Ordubad
Zengilan
Neftchala
Jalilabad
Masalli
Lankaran
Yardimli
Lerik
Astara
I
II
III
IV
V
VI
VII
VIII
IX
X
1
2
3
4
80
40
0
80
Km
N
W
E
S
46°
48°
50°
42°
41°
40°
39°

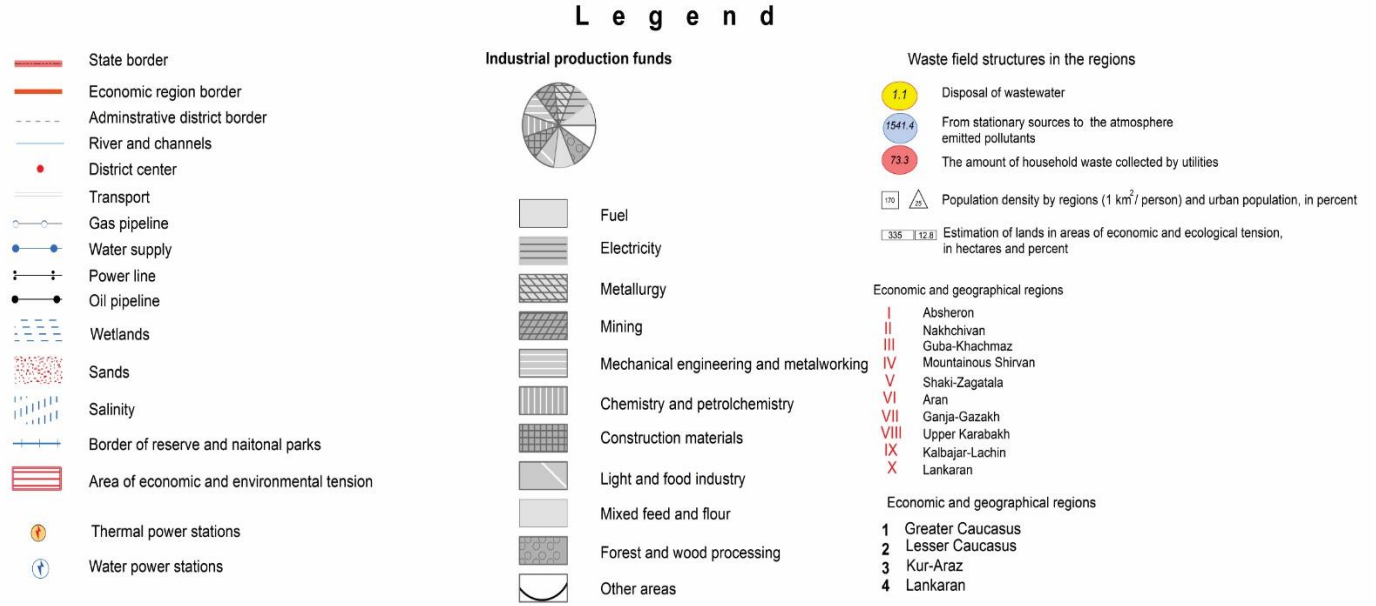


**Figure. 6 Map of regional economic and ecological tension areas (compiled by: M.Mammadov)**

The list of areas of economic and ecological tension allocated by us by regions is the first approach, and the overlap of a number of economic and ecological areas with economic and geographical regions (Upper Karabakh, Eastern Zangazur) or their convergence can be controversial. This is due to the fact that the two are closely related. Analysis depicts that, unlike integrated zoning, areas of economic and environmental tension are characterized by a large number of different related economic and environmental processes, consisting of areas with specific complex environmental problems between the environment and the socio–economic system. Areas of economic and ecological tension are more connected to the network of main economic and geographical regions than to physical and geographical zoning, form a link in the system of economic zoning of the country, participate in the completion of its economic and social unity. Existing research can be used in long–term plans for socio–economic development of the regions.

The sixth chapter of the dissertation is devoted to **"Determination of optimal options for sustainable development of the regional economic and ecological functional structure of Azerbaijan".** It clarifies the definition of optimal options for regional development and environmental interactions, the level parameters of economic and environmental development, management systems of economic and environmental structural construction and the identification of products with comparative economic and environmental advantages, its economic and geographical nature.

It was determined that the regional development and functional activities of the country necessitate the implementation of modeling projects in the first place. The theoretical sustainability of this need is to some extent related to the functioning of multifunctional structures. The analysis shows that economic and environmental indicators are given in scientific sources and planning work on regional development. However, the use of natural resources and the level of effectiveness of environmental protection in the studied regions are not sufficiently characterized. In our opinion, it is

important to determine their economic and environmental effectiveness for socio–economic planning. It was determined that the intensification of the use of local natural resources in the regions as a result of the application of modern progressive technological processes – the creation of a quality environment for sustainable organization of individual sectors of the economy, or reducing its negative impact on its economic and environmental efficiency.

A common feature of the optimal (best) options of economic and ecological structures in the regions of Azerbaijan – in accordance with the requirements of a market economy – the criterion of optimality – the territorial organization of the structure with economic and ecological function on the basis of new technology. In this case, the maximum effect is obtained from the organized areas at minimal cost to the work done. The indicators reflected in the model were used as we developed the $\mathbf{D_{ovs}}$ specific form of selection of sustainable optimal options of this economic–ecological structure (Formula 2).

$$\boldsymbol{D_{ovs} = \sum_{i=1}^{n} R_{drts} \cdot R_{isme} \cdot T - X \rightarrow min} \qquad (2)$$

There

$\mathbf{R_{drts}}$ – in territorial organization of sustainable competitive economic sectors of the economic and ecological functional structure of the regions;

$\mathbf{R_{isme}}$ – maximum effect to be obtained from i–variant fields organized in that direction in the regions;

T – lack of competitiveness of the economy, as well as demand for recreation and sanitary hygiene;

X – the ratio of the economic–ecological structure to the compensation of the areas obtained at the minimum cost of the organization of sustainable territory;

i=1 represents the optimal variants of the economic–ecological functional structure from 1 to n.

During the assessment, the selection of the optimal options for the economic–ecological functional structure was based on the minimum costs incurred, the comparison of several options and the

efficiency ratios of the compared options, or the payback period of the additional capital investment. In research, the normative coefficients of capital investment efficiency determine the lower limit of efficiency in terms of meaning, the repayment period is 8 years. The choice of optimal options for the economic–ecological functional structure depends on their economic–efficiency indicators. The calculations show that the indicators of the size of the average annual effect obtained when using different options of economic–ecological functional structure in the regions vary between 326,1 manats and 1454,5 manats per year. The calculated assessment of the economic–ecological functional structure between the costs of sustainable territorial organization and the effect obtained determines the payback period of economic–ecological efficiency from 1 to 15 years. It was found that most of the possible variants of the economic–ecological functional structure correspond to the geographical conditions of each region. It should be noted that the determination of optimal options for economic and environmental functional structure based on the analysis of geographical factors in the regions creates ample opportunities for their sustainable territorial organization. This shows that the analysis of geographical factors is theoretically appropriate and practically effective.

Despite the incompleteness of the calculations made in determining the optimal options for the economic–ecological functional structure, they are effective for the specific conditions of each region. From the optimal options selected by the assessment of economic and environmental efficiency: 1) mining and processing industry; 2) agriculture (vegetable growing, fruit growing, viticulture, cotton growing); 3) forestry; 4) water economy; 5) recreation; 6) optimal sanitary–hygienic options are more effective.

The analysis shows that in an economic–ecological system based on a dynamic general model, the efficiency of the optimal level of territorial–production structures arises in the sustainable growth of production areas and "moves" the sustainable development of regional economies.

It was determined that the optimal level of oil and gas resource potential in the sustainable development of Azerbaijan is

comparatively higher. The construction of economic and ecological structures is reflected in the interaction with the use of oil and gas opportunities. The production and processing of oil and gas resources in Azerbaijan have the greatest impact on the environment.

In 2019, the country produced 37,5 million tons of offshore oil, 1,6 million tons of oil and 24,5 billion $m^3$ of onshore gas[7]. Garadagh Gas Production Industry produces an average of 4,2–4,7 billion cubic meters of gas a year. This figure is 30% less than its projected production capacity (annual capacity is 6,5 billion $m^3$). In the dissertation, oil and gas resources as a key component in the formation of territorial–production structures that ensure the sustainable development of the country in the future, as well as in the economic system are analyzed in detail. The study of the sustainable development of the economic and ecological functional structure of the oil and gas resource potential of Azerbaijan combines the following as a result:

- In the construction of economic and ecological functional structure, the oil and gas industry complex as a whole will differ for many years due to its sustainability in the socio–economic development of the country;
- In the economic–ecological functional structure, the potential of the resource base of the fuel and energy industry operates on a large scale. In this regard, comparative analyzes were conducted on the basis of relevant research.
- The industry structure of the mining and metallurgy is effective in the construction of economic and ecological functional structure of Azerbaijan. The economic and environmental impact of the mining and metallurgical industry is measured by the fact that it has a sustainable development as a strategic structure in the macroeconomic environment of the country. Effective use of Dashkasan iron ore concentrate, Khoshbulag flux lime, Dash Salahli bentonite clay, scrap metal creates an opportunity for it.

A comprehensive study of the sustainable development of the mining functional structure of the republic from the economic and

[7] Environment in Azerbaijan – Baku: State Statistical Committee– 2020 – 139 p., (In Azerbaijani).

geographical point of view creates conditions for solving the following issues: 1) Development of non–oil industries and increasing export opportunities on the basis of mineral resource potential; 2) Reduction of environmental tensions through the application of new technologies in the mineral and metallurgical industries.

According to research, ore and non–ore deposits formed in the country have formed areas in accordance with natural and genetic regularity in Balakan–Zagatala, Gadabay, Ordubad regions. The thickness of the layers in the Zeylik alunite deposit varies from 2 to 54 meters, the area of the area is 3 $km^2$. The length of seven alunitized horizons in the Seyfali alunite deposit is 500–700 meters. Identification of mineral resources discovered and to be discovered in the future in the socio–economic development of the regions of the republic will create conditions for the sustainability of the economic and ecological functional structure.

As noted in the research process, wastes generated by the interaction of the environment with the extraction and processing of minerals in the country have caused tensions in the air, water, soil and other areas. As a result, the level of economic and environmental tensions in the regions is growing. In general, the extraction and processing of minerals in the country, the economic and environmental functional construction and management of the industry is justified as the optimal option for sustainable development.

The strategy of sustainable development of the future economic and ecological functional structure of Azerbaijan is based on the optimal territorial organization of agriculture and the important position of economic construction. The analysis shows that the sustainability of the economic and ecological functional structure of agriculture in the context of globalization is formed by increasing the production of products in the country and the creation of new competitive and export–oriented structures: – regulates the competitiveness of the market; changes the nature of the economic structure and optimizes environmental management.

In order to ensure the sustainable development of the regional economic and ecological functional structure, the country has justified the production of products with comparative advantage in terms of competitive production of the non–oil sector and diversification of exports in other areas. Comparative Advantage Index (CMI) were used in the study. Analyzing the foreign trade data of many countries, Azerbaijan's products with comparative advantage were identified. Especially, the competitiveness of some products, which are belons to the non–oil sector, was determined based on the CMI, thus, this index for fruits is 6,78; for cucumber–domato is 6,12; for potato is 4,21; for canned fruit 4,2; for canned cucumbers and tomatoes are 4,01; for tea and aromatic flavours are 4,2.

## RESULTS

1. Measures of important socio–economic development and nature protection in the regions of Azerbaijan have been identified, and ways to implement them have been indicated. For this purpose, the principles of complexity, application of system–structural analysis methods have been identified [47].

2. The study identified the importance of a comprehensive approach in the methodology of regional economic and environmental analysis and forecasting. The characteristics of the natural environment and the nature of the impact of economic sectors on the environment have been identified as a set of interrelated elements of a complex economic–ecological functional structure [43].

3. A comprehensive approach to the development of a regional economic and ecological functional structure allows to determine the measures for the use of nature in the environment. Improving the quality of the environment allows to increase the efficiency of the use of natural resources. Consistent application of the system and other legislative decisions in the process of modern technology and management has been possible by substantiating the processes that create the conditions for this [44].

4. One of the primary problems in achieving sustainable development of economic and ecological functional structure in Azerbaijan is the integrated use of natural resources, giving preference to optimal options of regional production structures and territorial organization, achieving the application of sustainable economic development on a scientific basis [14].

5. The application of models that determine the theoretical and methodological basis of economic and environmental problems of the republic determines their economic and geographical structure and forms the basis of future development. They regulate the dynamic function of the economic and environmental structure. The dissertation analyzes the practical basis for determining the optimal options for sustainable development [39].

6. As a consequence of the lack of proper regional policy in Azerbaijan, there has been inequality in the territorial organization of the country's industrial potential and infrastructure. The main territorial–production complexes were established in the Absheron region, and in this regard, the idea of regional policy was to balance the "population pressure" in the regions, the deep socio–economic mismatch between the capital and the regions, the management of the urbanization process, the involvement of new natural resources [12].

7. The occurrence of natural and anthropogenic impacts in the studied areas depended on the geological structure, geomorphological nature of the area, mineral extraction and scale. In Absheron, Dashkasan, Nakhchivan and other regions of the country where the mining industry is developed, the ratio of negative processes caused by natural and anthropogenic impacts was taken as a criterion to determine the degree of environmental threat. Comparative scoring of negative processes caused by natural and anthropogenic activity was carried out on the morphogenetic distribution of relief and reflected in the mapped model [46].

8. On the basis of modern economic, social and ecological analysis of Azerbaijan, their analysis was carried out with step–by–step surveys of complex economic and ecological stress areas. First, according to the nature of the impact of socio–economic subsystems on the environment, the typological grouping of areas was developed

according to the level of economic development of the area and methods of use during the typological grouping at the mesoraion level (territorial production complexes, industrial junctions) [36].

9. From the point of view of the requirements of the perspective development concept of Azerbaijan, competitive export–oriented products with potential of the non–oil sector were analyzed in accordance with the sustainable territorial–organizational methodology of the regional economic–ecological functional structure. Quantitative indicators of the competitive advantage index of a number of products related to the non–oil sector in Azerbaijan have been identified [23].

10. Factoring in the demand for potable and technical water, as well as opportunities to treat polluted water at production sites, owing to the nature of sanitary and hygienic conditions, the specificity of local conditions, namely wind speed and direction, humidity, the number of sunny days during the year and others being the important factors related to the placement of new industrial enterprises in the regions of the country are the essential indicators in preserving the ecological balance [38].

**The following scientific works were published in accordance with the topic of the dissertation:**

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