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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

ECOLOGICAL AND ECONOMIC ASPECTS OF THE DEVELOPMENT OF THE OIL AND GAS EXTRACTION INDUSTRY

Speciality: 5312.01 – Field economy

Field of science: Economic sciences

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GENERAL CHARACTERISTICS OF THE RESEARCH

Relevance and degree of development of the topic. The oil and gas sector has historically been one of the priority areas in the Azerbaijani economy and has played a leading role in the country's economic development. This sector, especially having a significant share in the export structure, is considered one of the main sources of national income. Back in the Soviet Union, Azerbaijan was chosen for its oil and gas industry, and this direction developed as one of the leading pillars of the economy. However, along with the rapid development of the oil and gas sector, its impact on the environment has also been increasing. As a result of the expansion of industrial activity, especially the intensive activity of oil and gas production enterprises, environmental problems have begun to manifest themselves more prominently. In this regard, the Absheron Peninsula, which is distinguished by its high density of industrial facilities, requires special attention. The geographical features of the peninsula and the dense location of industrial enterprises have led to aggravation of the ecological situation.

That is why the impact of ecological and economic degradation and environmental pollution in the oil and gas production industry has become one of the main factors that most harm human health and other living beings. In order to eliminate or minimize such damage, ecologically, economically and socially effective measures must be constantly implemented. It is no coincidence that in order to achieve this, by the decree of the President of the country, in the National Priorities for Socio-Economic Development of Azerbaijan - 2030, issues such as "Green Economy", "Clean Environment" have been set as targets. Regular consultations on ecological and economic issues in the country, organization of international ecological exhibitions, improvement of ecological legislation, etc. are a clear example of the attention paid to the field of ecological activity. In this regard, National and State Programs have been approved and implemented to protect the environment and ensure ecological safety, and the requirements of up to 20 international conventions are being implemented.

By the Decree of the President of the Republic of Azerbaijan, Mr.

Ilham Aliyev dated 06.12.2016, an action plan for the period covering 2016-2020 and strategic road maps for sectors were approved, a long-term vision for the period until 2025 and development targets for the period after that year were determined. Based on these documents, strategic road maps were approved for the development of the oil and gas industry, production of consumer products at the small and medium-sized enterprise level, development of heavy and machine-building sectors of industry, tourism business, logistics and trade, and other such areas.

Azerbaijan aims to increase the share of renewable energy in electricity generation to 30 percent by 2030. This will not only reduce the negative impacts of climate change, but will also support the country's long-term ecological and economic development, and will allow our country to be recognized worldwide in the field of environmental sustainability and become an example for other countries. Hosting COP-29 in Azerbaijan in 2024 was an important step towards strengthening our country's position in global climate policy, as well as taking a more active role in protecting the local ecosystem and combating climate change. President Ilham Aliyev noted during his speech at the opening ceremony of the COP29 Leaders' Summit that today Azerbaijan accounts for 0.7 percent of global oil production and 0.9 percent of global gas production[1].

Currently, as the oil and gas industries enter a new stage of development, it is necessary to determine the environmental damage caused by oil and gas production departments, assess the ecological and economic state of the sector, and also reconsider the possibilities of increasing the efficiency of using the technical and technological potential of these enterprises.

Thus, in modern conditions, ensuring the ecological and economic sustainability of oil companies, environmental protection, waste minimization, and economic development of the sector based on innovation and digitalization, ensuring the ecological and economic security of the Absheron Peninsula, as well as the oil and gas industry of the country as a whole, is one of the urgent scientific and practical

[1] https://cop29.az/az/home

problems. For this reason, it has become necessary to formulate a unified ecological and economic policy for economic entities belonging to the oil and gas sector and enterprises and organizations providing services to the sector in the country, as well as to continue complex scientific research in order to ensure their ecological and economic sustainability. All this determines the relevance of the topic.

Considering the requirements for implementing large-scale social, economic, and ecological processes covering the global space, environmental problems have always remained in the focus of attention of world scientists.

Azerbaijani scientists H.A.Aliyev, B.A.Budagov, Z.A.Samadzade, U.I.Alekperov, I.H.Ibrahimov, N.A.Nabiyev, T.A.Ismayilov, S.A.Samadzade, G.Y.Goychayli, H.S.Baghirov, C.N.Ismayilov, F.G.Aliyev and others have devoted extensive space to the general and specific problems of environmental protection in their works. Azerbaijani scientists, geologists, and oil workers who lived in the past and are our contemporaries today have done valuable work to discover our natural resources, creating the basis for the present and future of the sustainable development of our independent country. In the context we mentioned, the geological, technical and technological problems of the oil and gas industry in our republic have been extensively studied in the scientific research of A. Alikhanov, A. Alizadeh, A. Amirov, M. Isgandarov, Sh. Mehdiyev, S. Orujov, M. Abbasov, G. Abbasov, A. Mirzajanzadeh, Kh. Yusifzadeh, F. Salmanov, Seyid-Rza Kerimoglu, A. Alizadeh, I. Guliyev, F. Gadirov and others.

The socio-economic and organizational aspects of the environmental problems of the oil and gas industry in Azerbaijan were studied by A.A.Agayeva, M.J.Atakishiyev, N.A.Aliyev, T.N.Aliyev, R.M.Aliyev, A.M.Asadov E.M.Hajizadeh, A.G.Huseynov, G.A.Safarov, S.M.Gasymov, M.A. Mammadov, B.A.Ahmedov, A.S.Isayev, V.T.Maharramova, T.A.Mustafayev, R.N.Nuraliyeva, A.S. Guliyev and other scientists.

Foreign scientists Y.A.Podavalov, A.K.Golichenkova, A.A.Golubova, M.V.Gluhoboy, N.V.Pakhomova, V.V.Vershinin, V.P.Voronin, T.A.Trifonova, A.P.Maskalinko, G.A.Betranol,

M.Grossman, A.Krueger, etc. studied the development of the oil and gas industry and the solutions to the problems of environmental protection and ecological and economic sustainability related to this process.

Without diminishing the theoretical, scientific and practical importance of the problems studied by scientists who have conducted research in this field, it should be noted that there is a need for constant improvement and research of the ecological and economic aspects of environmental protection and ensuring ecological safety in the oil and gas industry of our country within the framework of the requirements of the modern era. Therefore, there is a need to conduct a more in-depth and objective study of this field in the mentioned aspects, and all this made the choice of the topic of the dissertation relevant.

Object and subject of the study. The object of the study is the economic entities of the "Azneft" Production Association, which is part of the structure of SOCAR, engaged in oil and gas production. The subject of the study is the ecological and economic system of oil and gas production and the economic mechanisms for ensuring the ecological and economic balance of the sector.

The purpose and tasks of the study. The purpose of the study is to systematically analyze and assess the real situation of the damage caused by the oil and gas extraction sector of Azerbaijan to the environment and natural resources, as well as to develop the theoretical foundations of ecological-economic interactions in this area, improve existing economic mechanisms based on the circular economy model, and prepare practical proposals and recommendations to reduce environmental impacts.

To achieve the set goal, the following issues were identified and resolved:

- to study the theoretical and methodological foundations of environmental protection in oil and gas production, the balance and stability of the ecological and economic system in oil and gas production based on the study and generalization of the works of our republican and foreign scientists on the subject;
- to determine the characteristics of the ecological impact of the oil and gas production industry on the environment;

- to analyze and assess the current ecological and economic situation of the oil and gas industry of Azerbaijan and its component, oil and gas production, based on statistics, preliminary reports and data;
- to analyze the economic, ecological and social aspects of the activities of the oil and gas production industry;
- to assess potential pollution sources and the degree of ecological and economic safety;
- to identify ways to increase the efficiency of environmental protection measures in the oil and gas production industry;
- to improve the operation of oil and gas production facilities and improve management control over equipment in the context of "smart technologies";
- to identify directions for risk management in the oil and gas production industry, the formation and implementation of environmental risk insurance.

Research methods. In the process of completing the dissertation, methods and techniques of economic research such as grouping, analytical, generalization, economic-statistical analysis, systematic-purposeful approach and comparative analysis were used. Theoretical and practical considerations on the problem, as well as scientific works of Azerbaijani and foreign scientists, decrees and orders of the President, decisions of the Milli Majlis and the Cabinet of Ministers, recommendations of relevant ministries and scientific-practical conferences of republican importance, official collections of the State Statistical Committee, as well as data from the “Azneft Production Union” of SOCAR, were applied and processed.

The main provisions put forward for defense. The following provisions have been included in the defense:

- Systematic and sustainable development approaches are essential to ensure ecological and economic balance in the oil and gas industry;
- It is necessary to accurately determine the characteristics of the industry's impact on the environment;
- Statistical analysis of the current ecological and economic

situation shows that effective mechanisms are needed to reduce environmental loads in this area;

- Joint analysis of economic, ecological and social aspects of oil and gas extraction processes is important, because only in this case can sustainable development be ensured;
- Assessment of pollution sources and the level of environmental hazard is of great importance in terms of risk management;
- Increasing the effectiveness of environmental protection measures is necessary to ensure the ecological safety of the field;
- The application of smart technologies and the expansion of digital control systems are important to reduce environmental impacts in production processes;
- Risk management and the establishment of an insurance system are of great importance in terms of ensuring ecological and economic stability.

The scientific novelty of the study. The scientific novelty of the study includes the following:

- A conceptual model of joint management of the ecological-economic system of the oil and gas industry with the natural environment and economic activity has been formulated, and the mechanism of interaction of resource and waste flows in the production process has been systematized;
- The principles and methods of environmental protection and regulation of the ecological-economic system in the country's oil and gas industry have been summarized;
- A multifactor regression model has been developed based on the statistical data of the "Azneft PU" that determines the relationship between polluting factors and environmental payments;
- A step-by-step transformation block diagram has been developed, ensuring the transition from a linear economic model to a circular economic model, taking into account the technological features of the "Azneft PU";
- An integrative management strategy based on smart technologies has been developed to optimize environmental monitoring, ensuring the interaction of the ecological and socio-economic aspects of the sustainable development concept;

- A step-by-step management mechanism for the identification, assessment and concept of ecological and technogenic risks in oil and gas production has been developed, and the principles for the formation of an eco-risk fund have been substantiated.

Theoretical and practical significance of the research. The theoretical significance of the dissertation work is that the integrative-conceptual model developed for the ecological-economic aspects of the oil and gas industry will contribute to the expansion of scientific-theoretical research.

The practical significance of the research is that the main theoretical provisions, conclusions and proposals of the dissertation can allow for the assessment of the ecological-economic potential of oil and gas industry enterprises, ensuring stability, economic evaluation of projects, and the efficiency of equipment use.

Approval and application. The main scientific-theoretical provisions, conclusions and proposals of the dissertation were reflected in 8 articles (including three abroad) and 8 conference materials (including two abroad) published in reputable journals and conference materials recommended by the Higher Attestation Commission under the President of the Republic of Azerbaijan. Among the conference materials, the following theses can be cited: “Environmental policy as an integral part of socio-economic policy” (Baku, 2017), “Priority directions of environmental monitoring” (Baku, 2019), “Economic growth and the environment in Azerbaijan” (Dnipro, 2020), “The impact of the balance of the ecological-economic system on economic development” (Sumgayit, 2022), “Using Digital “Control” Technologies to Improve the Performance of Oil and Gas Extraction Facilities” (Istanbul, 2025). During the research, the author also wrote "Environmental risk management in oil and gas industry enterprises" (Baku, 2017), "Environmental measures used to protect the environment" (Moscow, 2020), "Sustainable development and its social, economic and ecological criteria" (Baku, 2020), "Socio-economic directions of the economy of the natural environment and resource" (Baku, 2024), "Efficiency of methods used in the analysis of financial planning in business entities" (Astana, 2026) was published.

Name of the organization where the dissertation was carried out. Azerbaijan State Oil and Industry University.

Total volume of the dissertation with a mark indicating the volume of the structural sections separately. The dissertation consists of an introduction, three chapters, a conclusion and a list of used literature. The total volume of the introduction (13212 characters), chapter I (87606 characters), chapter II (54913 characters), chapter III (103103 characters), conclusion (11854 characters) and list of used literature (20449 characters) is 302557 characters. The number of characters of the dissertation is 270688 characters, excluding tables, diagrams, graphs and list of used literature.

SUMMARY OF THE RESEARCH

The **introductory part** of the dissertation justifies the relevance of the topic, the degree of general development, the purpose and objectives of the research, the main provisions presented for defense, the scientific novelty of the work, theoretical and practical significance are reflected.

The first chapter of the dissertation is entitled "Theoretical and methodological issues of the ecological-economic system of the oil and gas industry". This chapter examines the theoretical problems of the balance and stability of the ecological-economic system, the features of the impact of the oil and gas industry on the environment, and the methods of regulating the natural environment in the conditions of the development of industrial sectors.

One of the main goals of the transition of society to a balanced development model is an objective assessment of the mutual relations between economic activity and the environment. This approach necessitates the consideration of environmental factors in the process of economic development and their systematic management.

At the same time, ensuring a dynamic balance between social and natural systems acts as one of the main conditions for sustainable economic growth. This balance not only shapes the sustainability of the ecological-economic system, but also serves to ensure long-term development prospects.

In general, the formation of the concept of balanced development is based on a system of ecological constraints associated with the depletion of natural resources, the slowdown in the rate of reproduction of renewable resources, and the limited assimilation capabilities of the environment. According to the approach of N.N. Lukyanchikov and I.M. Potravny, *"balanced development is a development model in which the needs of society are met within the framework of ecological constraints. This approach involves the efficient use of natural resources, their restoration, as well as the widespread involvement of industrial and consumer waste in economic turnover. At the same time, the mentioned model is aimed at ensuring the preservation of mutual relations between various natural-geographical systems and, as a result, maintaining a dynamic balance in the socio-natural system"*[2].

Many researchers use the concept of ecological balance, but there is no precise definition of this concept. Therefore, to introduce this concept, we will analyze the concepts of "balance" and "ecological balance" in Table 1.

Table 1

Classification of the concepts of balance and ecological equilibrium

Authors of the approach	Definition
1) Yatsenko N.E.	Ecological balance is the balance between the use and restoration of natural resources, the processes of disruption and restoration of normal ecological conditions.
2) Martynov A.S and others	The harmony of the spatial and biomass structure of plant species complexes.
3) Patrick K. Penfield	The application of sustainable production processes that can operate in an environmentally sustainable manner.
4) Akimova T.A., Kuzmin A.P., Haskin V.V.	It is a balanced combination of production and environmental processes to control production efficiency.

Source: table compiled by the author.

[2] Lukyanchikov, N.N., I.M. Potravny; Economics and organization of nature management: Monograph, Moscow: Unity-Dana, 2015. –688 p.

Environmental protection issues have become one of the priority areas on a global scale. As such, over the past decades, these problems have become more profound and have become increasingly international in nature. Environmental protection is carried out in the following ways (Figure 1):

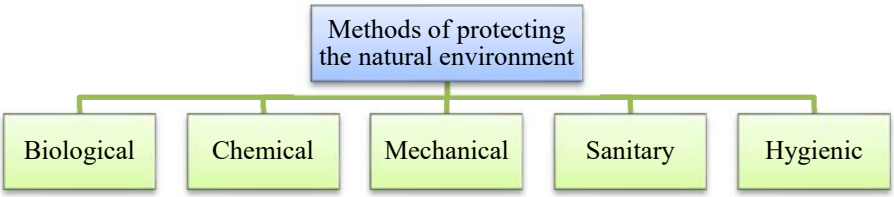
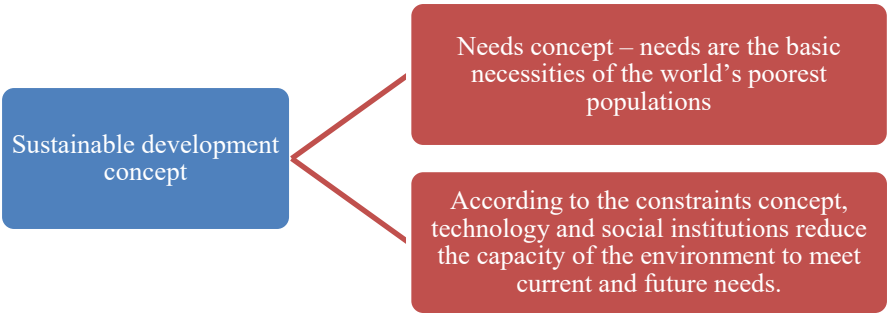


Figure 1. Classification of natural environment protection methods

The establishment of an effective management system for the protection of the natural environment is one of the most important foundations for ensuring the sustainable development of society. In recent years, changes in the structure of the economy, an increase in the accident rate of production and other factors have had a negative anthropogenic impact on the environment and natural resources.

In the last years of the 20th century, countries around the world included the principles of efficient use of natural resources, preservation and improvement of environmental quality in the "concept of sustainable development" as a direction of international activity. (scheme 1)



Scheme 1. Sustainable development concept

Source: Scheme compiled by the author.

The social component of sustainable development includes improving the standard and quality of life of people, stabilizing demographic and migration processes.

In his numerous scientific works, A.G. Huseynov extensively analyzes the issues of protecting the oil and gas industry from environmental threats, examines the environmental challenges faced by the oil and gas sector in the conditions of global economic integration and globalization of economic processes in the modern era, and at the same time justifies the strategy of sustainable economic development in this area, the mechanisms of its implementation, as well as criteria and indicators reflecting national economic interests.

Professor I. Ibrahimov notes in his book "Environmental Economics" that the concept of sustainable development combines the regulation of population growth, the formation of conscious consumer behavior and the development of ecological culture, taking into account the interrelation of ecological, economic and social problems. The unity of these components is reflected in the Sustainable Development Goals [3]

Although the methods applied in the field of environmental regulation are grouped according to various criteria, they are mainly classified into four areas: administrative-legal, economic, organizational-technical and social-informational methods.

Administrative-legal methods are based on the application of existing legislation, the preparation of regulatory documents and the application of appropriate sanctions for violation of environmental protection requirements.

Economic methods include financial instruments that stimulate environmental protection. These instruments include environmental taxes, various payments, subsidies and special environmental funds.

Technical methods involve the use of equipment in accordance with environmental standards and the development of environmentally safe production technologies in order to limit pollution from technological sources.

[3] Ibrahimov I.H. Environmental Economics, Baku, Business University Publishing House, 2015, 357 p.

Social and information-oriented methods are related to the involvement of the public in environmental issues, ensuring transparency and expanding environmental awareness.

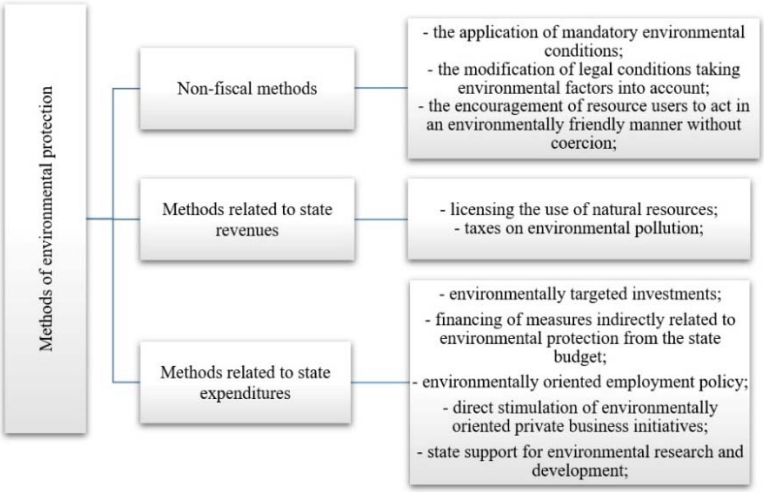
There is a need to apply each of these methods in the oil and gas industry. For example, it is important to increase the role of technical control systems as well as legal mechanisms in preventing oil spills. Cases such as associated gas emissions into the atmosphere should be resolved not only with fines, but also by applying alternative gas utilization technologies. Preventive control measures, assessment of ecological damage and improvement of related compensation mechanisms are required to eliminate cases of soil oiling and marine water pollution. At the same time, open disclosure of information on environmental impact to the public, strengthening public control mechanisms and increasing environmental accountability are requirements of modern management principles.

The study revealed that the effectiveness of regulatory methods is possible not only through their separate application, but also through their complementary and interrelated functioning. Although Azerbaijan has a legal framework for environmental protection, there are still certain gaps in the application of economic and technical incentives. In addition, limited public participation and poor development of information systems are also factors that hinder effective environmental management [4].

We believe that in terms of improving environmental regulation, it would be appropriate to introduce a differential payment mechanism based on environmental risk.

Since the end of the last century, various models of environmental protection activity management mechanisms have been developed in each of the Western countries. This mechanism is a diversified system that combines legal support, administrative and economic methods of environmental quality management. Environmental protection methods can be grouped as in scheme 2.

[4]https://www.researchgate.net/publication/341924085_Ecological_Challenges_and_the_Modern_Economic_Development



Scheme 2. Environmental protection methods

Source: compiled by the author.

These methods create conditions for environmental protection and sustainable economic development.

Prof. A.G. Huseynov in his monograph "Oil and ecological security: realities and prospects" notes that in principle, the country and its regions have every opportunity and resources to create a prototype of the future development model based on the principles of sustainability, adapted to production, consumption and a logical approach to the environment [5].

According to Academician Z. Samadzadeh, "...in a globalizing world, the efficient use of all resources is very important for every country. Special attention is paid to this issue in Azerbaijan. The economic reforms and work carried out in our country will further improve our economic indicators. We will achieve the Sustainable Development Goals faster than many countries. In this work, we, along with using international experience, also take into account our national interests [6].

[5] Huseynov A.G. "Oil and environmental security: realities and prospects", Baku, "Elm" publishing house, 2020, 428 p.

[6] https://www.yeniazerbaycan.com/SonXeber_e27567_az.html

In our opinion, environmental quality, economic development and social well-being are closely related to each other. International organizations, independent states, enterprises and societies should achieve sustainable ecological and economic development.

The second chapter of the dissertation is entitled “Analysis and assessment of the ecological and economic system in oil and gas production”. This chapter analyzes the current state of the oil and gas production industry, the economic, ecological and social aspects of its activities, potential sources of pollution and the assessment of the degree of ecological and economic safety.

The “Contract of the Century”, signed on September 20, 1994, thanks to the far-sighted foreign policy of Heydar Aliyev, found its political and economic solution. The agreement was signed between Azerbaijan and the world's leading oil companies - BP, Amoco, Exxon, Lukoil, Statoil and other partners. The agreement, which was prepared and signed as a result of the leadership and efforts of Heydar Aliyev, is considered one of the largest agreements concluded in the world both in terms of the amount of hydrocarbon reserves and the volume of investments.

As can be seen from Figure 1, production has been increasing sharply since 2005. In particular, production reached its maximum level (approximately 50 million tons) in 2008-2010. This increase is due to the full-scale development of the Azeri-Chirag-Gunashli (ACG) fields.

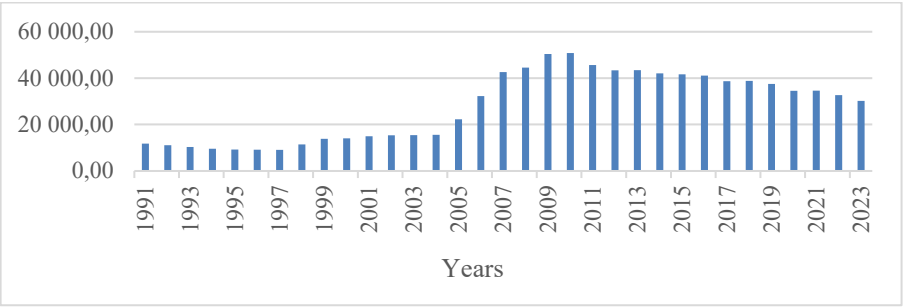


Diagram 1. Oil production during 1991-2023, thousand tons

Source: The diagram was compiled by the author based on data from the official website of the Constituent Assembly of Azerbaijan https://stat.gov.az/source/industry/

In subsequent years, the capacity of the Shah Deniz field was further increased, especially with the start of production within the framework of the Shah Deniz-2 phase in 2018, the country's gas production has maintained a steady growth trend. In 2023, natural gas production reached 48,497 million m³, the highest figure since independence (diagram 2).

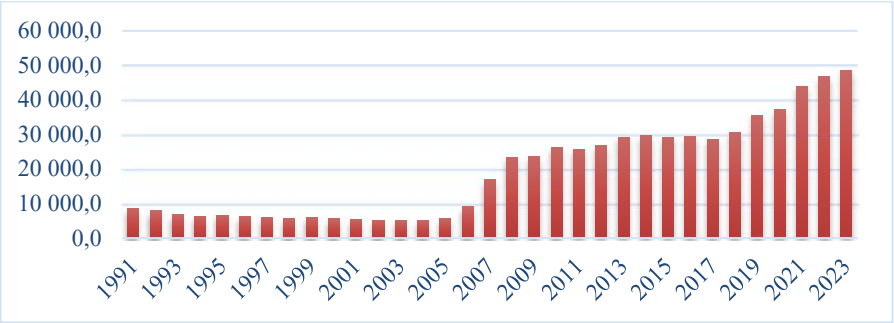


Diagram 2. Natural gas production in 1991-2023, million m3

Source: diagrams were compiled by the author based on data from the official website of the Constituent Assembly of Azerbaijan (stat.gov.az). https://stat.gov.az/source/industry/

Adaptation to price fluctuations in world markets confirms the stability of this sector. In the USA, the share of the oil and gas sector is 8%, in Saudi Arabia it is 50%, in Norway it is 14%, in Kazakhstan it is 13.3%, in the UAE it is 30%, and in Canada it is less than 10%.

In 2022, Azerbaijan produced more than 4.6% of gross domestic product compared to 2021. During this period, the added value produced in the oil and gas sector of the economy decreased by 2.7%, and product production decreased by 2.5%. In 2022, GDP per capita was 13,292.2 manat, an increase of 4.1% compared to 2021 (table 2).

As can be seen from Table 2, significant changes have occurred in the economy and environmental indicators of Azerbaijan in 2023 compared to 2013. Thus, while GDP in 2013 was 74.1 billion. USD, in 2023 this indicator was at the level of 72.3 billion. USD. This indicates a certain decrease in the gross domestic product over the decade.

Table 2

GDP in the Republic of Azerbaijan for 2013-2023

Years	GDP, in million dollars	Greenhouse gases emitted into the atmosphere, thousand tons	Investments in fixed capital for environmental protection and efficient use of natural resources, thousand manats
2013	74164,0	15135,8	304599,4
2014	75234,0	16091,9	216933,9
2015	52996,0	13980,8	84864,4
2016	37862,0	14911,2	109546,0
2017	40867,0	16482,5	13338,7
2018	47112,0	18494,1	247912,2
2019	48174,0	15863,5	309855,6
2020	42693,0	16456,4	170208,7
2021	54825,4	16516,5	71329,4
2022	78807,5	14121,1	160542,8
2023	72356,2	15274,7	594991,4

Source: The table was compiled by the author based on data from the official website of the Constituent Assembly of Azerbaijan https://stat.gov.az/source/industry/

On the contrary, the volume of greenhouse gases emitted into the atmosphere, while it was 15.1 thousand tons in 2013, was recorded at the level of 15.2 thousand tons in 2023. That is, despite the weakening of the economic growth rate, there was no significant decrease in the amount of emissions. This indicates that the environmental burden of economic activity remains consistently high.

The most serious difference is observed in investments directed at environmental protection and efficient use of natural resources. In 2013, this indicator was 304.6 million. manat, in 2023 it increased to 594.9 million manat. Thus, the volume of environmental investments has increased by more than two times in the last ten years.

In the dissertation work, based on the research, the relationship between harmful waste discharged into the environment and economic and environmental indicators in the Azneft PU was analyzed. The initial data was entered into the EViews-12 program, a regression analysis was performed, and the effects between compensation for environmental damage and economic and environmental variables

were evaluated.

In order to build a regression model, the environmental and economic indicators of the Azneft PU for 2019-2024 were selected. In the model, the dependent variable was payments for hazardous waste discharged into the environment (y), and the volume of gaseous and liquid substances discharged into the atmosphere (x1), the amount of hazardous waste generated (x2), and the mechanically recultivated area (x3) were taken as independent variables. The relevant statistical data are presented in Table 3.

Table 3

Ecological and economic indicators of the Azneft PU (2019–2024)

Years	Y – Payments for harmful waste discharged into the environment (thousand manats)	X1 – Gas and liquid substances emitted into the atmosphere (thousand tons)	X2 – Hazardous waste generated (thousand tons)	X3 – Mechanically reclaimed area (ha)
2019	126,8835	80,976	44,465	42,4
2020	2274,447	62,359	47,477	44,84
2021	144,7165	62,83	486,677	30,95
2022	1468,603	64,806	15,056	27,7
2023	72599,13	28,177	10,634	30,6
2024	4656,594	37,425	11,539	29,42

Source: The table was compiled by the author based on the reports of the Azneft PU.

Based on the presented indicators, a multivariate linear regression model was constructed and parameter estimation was performed. As a result of the calculations, the following model was obtained:

$Y=59801.92-1200.78X_1-8.53X_2+640.39X_3Y$

According to the calculations, the total correlation coefficient is R=0.7537, and the determination coefficient is R2=0.5680. These results indicate that the model can explain approximately 56.8% of the variability of the dependent variable. Thus, the model demonstrates an average level of fit. The t-Student criterion was applied to check the statistical significance of the regression coefficients. The study took a probability level of 0.950, and in this case the critical value is 2.57. Analysis of the results shows that the t-

statistics calculated for all variables are less than the critical value. This confirms that the effect of the independent variables on the dependent variable is not statistically significant (table 4).

Table 4

Result of estimation of parameters of linear model of multiple regression in EViews-12 software package

Dependent Variable: Y
Method: Least Squares
Date: 09/28/25 Time: 18:31
Sample: 2019 2024
Included observations: 6

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	59801.92	66254.55	0.902608	0.4620
X1	-1200.780	876.5420	-1.369906	0.3042
X2	-8.529985	77.46541	-0.110113	0.9224
X3	640.3880	2292.789	0.279305	0.8062

R-squared	0.568034	Mean dependent var	13545.06
Adjusted R-squared	-0.079916	S.D. dependent var	28978.86
S.E. of regression	30114.55	Akaike info criterion	23.69813
Sum squared resid	1.81E+09	Schwarz criterion	23.55930
Log likelihood	-67.09438	Hannan-Quinn criter.	23.14239
F-statistic	0.876663	Durbin-Watson stat	2.415191
Prob(F-statistic)	0.571884		

Source: Developed by the author based on the Eviews-12 application software package.

The main reason for the obtained results is that the initial data cover a limited period and the number of observations is small. Since the study is based on the existing database on the Azneft PU, it was not possible to work with statistical data covering a wider time interval.

However, the established regression model is of an experimental nature and can be used as an initial analytical basis for assessing the compensation of environmental damage. The model can be improved in the future by involving a wider database and additional variables [7]

Information on the lands submerged by the formation waters of SOCAR's Azneft PU in 2019-2023 is shown in Table 5 below.

[7] Yadigarov T.A. Operations research and solving econometric problems in Ms Excel and Eviews software packages". Theory and practice. / T.A.Yadigarov – Baku: Europe, – 2019. – 352 p.

Table 5.

Quantity of produced water formed by the "Azneft" PU by OGPDs, thousand m^3

OGDIs	2019	2020	2021	2022	Growth rate in 2019-2022 (in %)
"28 May"	1556,2	1618,6	1867,5	1727,1	11 %
"Neft Dashlari"	607,3	632,1	626,5	568,7	-6,4%
"Absheronneft"	361,0	233,2	165,1	294,8	-18,3%
"Narimanov"	200,2	225,2	221,5	200,6	0,2%
"H.Z. Tagiyev"	816,1	345,5	721,2	777,4	-4.7%
"Bibiheybat"	1252,1	522,9	974,0	1157,0	-7,6%
"A. Amirov"	766,7	285,8	1012,3	1065,7	39%
"Siyazanneft"	327,5	136,2	277,3	284,5	-13,1%

As can be seen from the data in the table, the growth rate for oilfields in 2019-2022 was as follows: "28 May" (11 times), "Narimanov" (0.2%), "A.Amirov" (39%).

As can be seen from Table 6, a significant decrease of 63.7% occurred in the amount of land contaminated with oil products over 5 years. Lands flooded with produced water reached a peak in 2021 and 2022, but a decrease is observed in 2023.

Table 6.

Information on lands contaminated with oil products and submerged in formation waters at SOCAR's Azneft PU, BM and OC, ha

Years	Total contaminated area	Soils contaminated with oil and oil products	Lands under water
2019	1241.13	842.44	398.69
2020	1142.89	800.67	342.22
2021	1 120.23	487.33	632.90
2022	1 008.8	373.38	635.42
2023	841.1	305.93	535.07

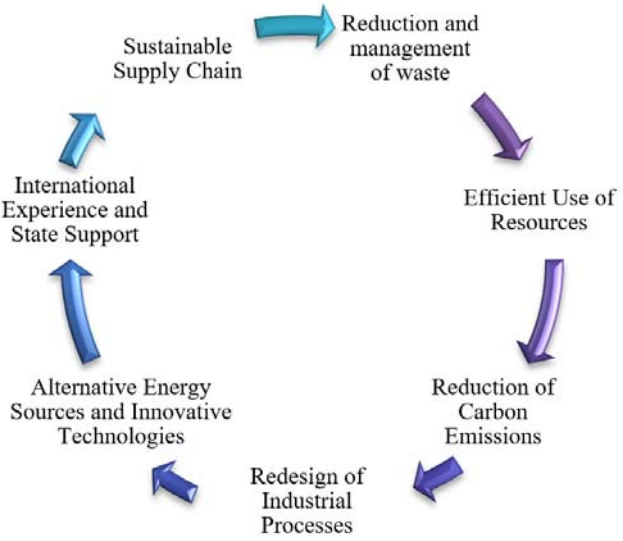
Source: The table was compiled by the author based on SOCAR reports

The third chapter of the dissertation is entitled "Main directions of improving the ecological and economic strategy of the oil and gas industry". Here, measures have been developed to

improve the efficiency of environmental protection measures in oil and gas production, improve the operation of oil and gas production facilities and insure risks in the industry, and improve the socio-economic aspects of the population's living conditions.

The assessment of the economic efficiency of environmental protection measures should be carried out in accordance with existing methodologies for preventing environmental damage. This approach will ensure the reduction of environmental risks and the minimization of economic losses.

We believe that the circular model is extremely important for reducing the environmental impact, increasing resource efficiency, and renewing and improving economic mechanisms in the oil and gas industry in our country. In this regard, the elements of the circular economy applied in the general oil and gas industry have been systematized by adapting them to the technological and production characteristics of the "Azneft" Production Association (scheme 3).



Scheme 3. "Circular Economy" model for the oil and gas industry
Source: Model diagram prepared by the author

This model can reduce environmental risks, ensure more efficient use of resources and transform waste into value-added products. However, it is important to consider both local and international experience in order to solve the problems we have mentioned and to ensure the effectiveness of the strategies to be implemented.

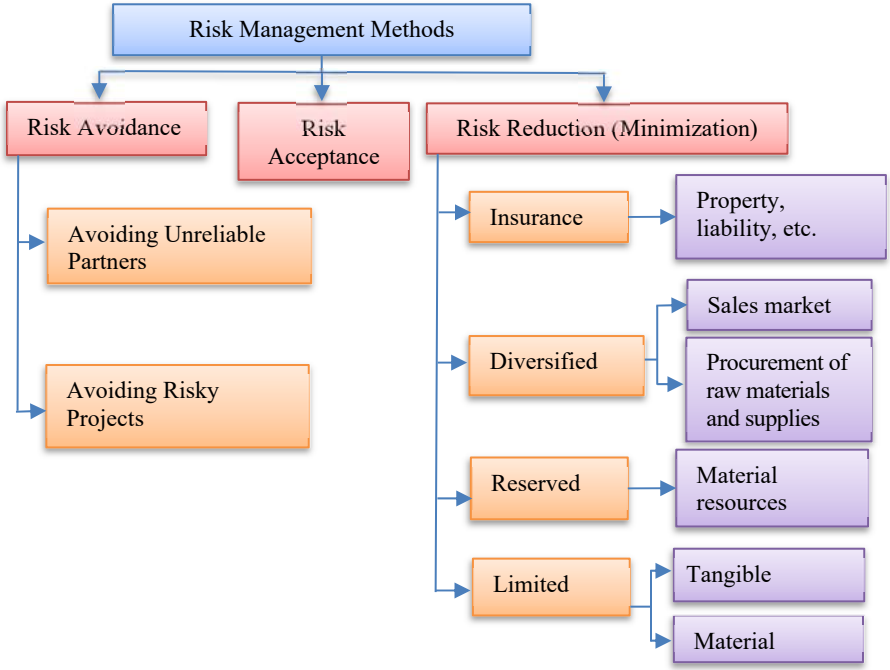
In my opinion, the analysis of the practice of voluntary environmental insurance carried out by working groups of specialists makes it necessary to introduce the following types of insurance related to environmental risks: liability and insurance for damage caused to the natural environment, lives and health of citizens, property of citizens and legal entities; insurance of financial risks associated with the costs of implementing measures provided for in the plan for the prevention and elimination of oil spills.

Taking into account the acceleration of the processes of digitalization, integration and globalization of the economy, a significant increase in the risks of industrial enterprises is observed.

Risk management should be considered not as a separate mechanism for responding to crisis situations, but as an integral part of a continuous and systematic management process. Taking into account the impact of various risk factors on production activities, enterprises use various approaches in practice to reduce the level of risk. These approaches can be broadly classified as follows (scheme 4).

- **risk avoidance** – refusal of risky activities in order to prevent risks with high probability and high impact;
- **risk acceptance** – the readiness of the enterprise to compensate for possible losses at the expense of its internal resources;
- **risk reduction (minimization)** – implementation of preventive measures to reduce the impact of risks.

Modern risk management systems in large enterprises should be implemented with an integrated comprehensive approach based on a holistic consideration of business processes and the risks inherent in them. At the same time, all employees of the company should be involved in the risk management process within their functional capabilities.

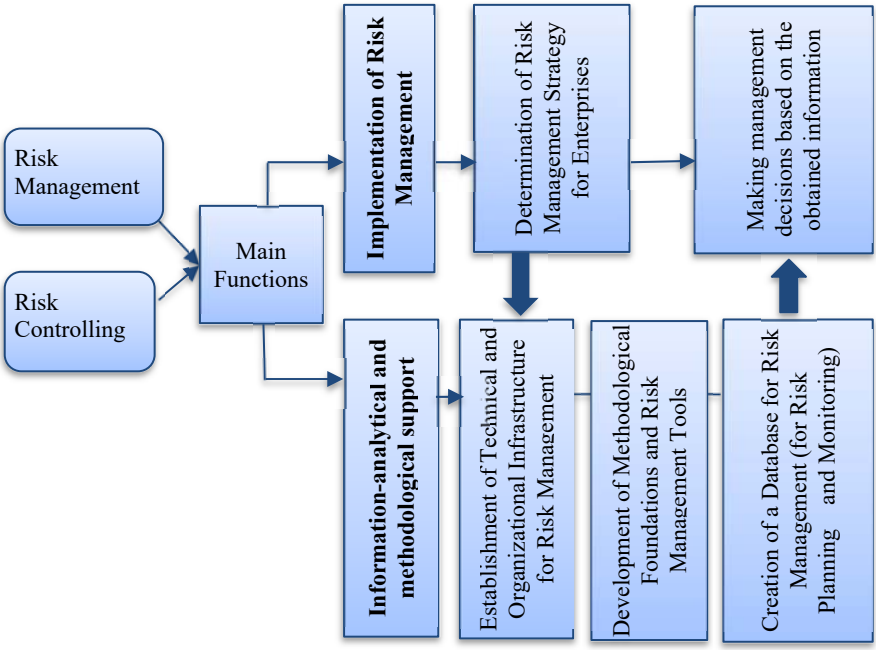


Scheme 4. Risk management methods

Source: Scheme compiled by the author.

The creation and development of an effective integrated risk management system is undoubtedly of great importance for oil and gas industry enterprises. Given that industrial assets are exposed to high risks at all stages of the technological process - from production to processing and sale of products - it is especially important for enterprises to ensure adequate control at all stages of management. Scheme 5 shows the interaction of risk management and risk control systems.

Summarizing the above analysis, it can be noted that as the Azerbaijani oil and gas industry develops dynamically in a market economy, the emergence of new risks is inevitable. These risks include regulatory risks associated with changes in the regulatory framework, uncertainties related to price formation and supply conditions, as well as the impact of geopolitical factors.



Scheme 5. Interaction of risk management and risk control systems
Source: The scheme was compiled by the author.

The application of the insurance system in enterprises as an integral part of a complex risk management mechanism allows not only to reduce losses resulting from events, but also to weaken the overall impact of risks. The implementation of preventive measures and the use of insurance instruments create conditions for replacing uncertain and variable financial losses with more manageable costs.

At the same time, the correct assessment of insurance coverage is of particular importance for oil and gas enterprises. For this purpose, it is important to form a reliable database, monitor the financial performance of insurance companies, and analyze the innovative products and services they offer. As a result, enterprises can use insurance opportunities more purposefully and gain access to quality insurance services.

Thus, it is considered necessary to form a more flexible and adapted insurance model by companies engaged in oil and gas

production. In particular, taking into account the high financial burden of property insurance, the optimization of insurance mechanisms and the application of cooperation models based on partnership can help eliminate existing problems in this area.

The formation of insurance mechanisms for risk management in the oil and gas industry and the elimination of the consequences of man-made accidents is of great importance. There are various approaches to this, one of which is the creation of a centralized insurance fund. This fund can then be distributed voluntarily based on the interests of the general system. The main reason for giving preference to such insurance funds is the possibility of their use for the creation and distribution of not only financial resources, but also material resources.

In our opinion, the creation and management of insurance funds in the oil and gas production industry is important for ensuring the long-term stability of enterprises. The effectiveness of insurance mechanisms on both a state and industrial scale is determined by their economic justification and adaptation to market conditions.

We propose that the economic, social and environmental assessment of industrial safety should be carried out through insurance. This approach will create a basis for ensuring stable, progressive and sustainable development of production. The main priority goal at this time is to ensure the sustainable and sustainable development of the sector for years to come, using the insurance mechanism in close connection with business practices.

CONCLUSION

The proposal and conclusions in the research study are summarized as follows:

1. As a result of the research, it was determined that the oil and gas industry is of great importance not only from an economic point of view, but also from an ecological and social perspective, and therefore it is necessary to study and manage it as an ecological and economic system. The theoretical result of the research is that the concept of an ecological and economic system is a complex structure

formed on the basis of mutual influence, and approaches such as sustainable development, ecological safety, and circular economy should constitute the basis for the management of this system. Environmental impacts, technogenic risks, and inefficient use of resources resulting from the activities of the industry have a negative impact not only on the environment, but also on the potential for economic growth. In order to reduce these impacts, it is necessary to apply ecological and economic regulation methods.

2. Taking into account the requirements of ecological safety, improving the management of natural environmental risks at enterprises of the oil and gas industry requires the application of a number of promising methods related to ecological insurance and economic regulation. In this regard, the formation of strategic ecological and economic plans and programs based on a system of relevant indicators at the industry, regional, and company levels is relevant.

Industrial activity has a significant impact on the ecological balance of the natural environment. Industries in various sectors play an important role in the extraction, processing and use of natural resources and lead to a complete production cycle. This cycle involves not only the transformation of raw materials into final products, but also the formation of production waste, which is often returned to the natural environment.

3. Different industries, based on their specific processes and purposes, affect the natural environment in different ways. Among the industries that have a significant impact on the environment, thermal energy, metallurgy (ferrous and non-ferrous), chemistry, petrochemicals, coke-chemistry, oil refining, cement production, wood processing, fuel industry, meat and dairy production, mining and construction materials production can be especially noted. These industries have a greater impact on the natural environment and can have various negative impacts on ecosystems.

Special attention is paid to “dirty” production sectors, such as energy, metallurgy, basic and organic chemistry, pulp and paper, and certain segments of the food industry. They are labeled as dirty because they have a greater impact on the environment, which, as a

result, harm the natural complex and human health.

The identification of these industries that affect the environment requires continuous practices, technological advances, and regulatory measures to reduce environmental degradation, protect the natural environment and human well-being. Solving the problems created by industrial activity requires a comprehensive approach that includes environmentally friendly technologies, waste reduction strategies, and responsible resource management.

4. Reducing pollution of the natural environment is possible through joint activities of the government, legislation, and product manufacturers. For this purpose, it is important to establish cooperation mechanisms between industrial entities and environmental organizations for the joint development of environmental programs, identification of funding sources, and information exchange. At the same time, not only economic, but also environmental indicators should be taken into account when assessing production efficiency. In this regard, it is considered appropriate to improve efficiency assessment methods and include environmental criteria - such as waste reduction, efficient use of resources - in the system.

5. Due to its characteristics such as dynamism and intensity, the economy of the present era cannot fully function and develop without a sufficient amount of energy reserves, that is, currently oil and gas are the sources that ensure the life of society. Without such vital resources, the development of the economy is impossible, since the exploitation of alternative energy sources that can replace them has not yet been sufficiently achieved.

However, the factor of depletion of global fuel and energy resources is not always taken into account in assessing the negative impact of oil and gas enterprises on the natural environment. The heads of oil and gas companies believe that the situation of economic unprofitability of oil and gas production due to depletion of reserves will never arise or will be impossible. The only criterion that is considered a limitation is the insufficient level of discovery of oil and gas reserves.

In our opinion, ensuring a mutual balance between socio-

economic development and the natural environment, especially the application of the principle of sustainability in the activities of oil and gas production enterprises, necessitates the formation of long-term strategies that take into account not only the current situation, but also the needs of future generations.

6. It can be noted that management entities must have stable and sufficient financial resources before starting geological exploration, production, processing, transportation, storage and sale of hydrocarbon raw materials, as well as the sale of products produced from these raw materials, and must also form strategic financing mechanisms to manage investment risks and ensure the continuity of operations.

7. In order to improve environmental regulation in the oil and gas industry in Azerbaijan, an environmental risk-based differential payment mechanism has been proposed. Within the framework of this mechanism, the potential damage caused by enterprises to the environment is assessed based on the risk level and payments are applied differentially (differentiated) in accordance with this indicator. This approach, in addition to creating incentives for polluters to behave more responsibly, also ensures a fair distribution of funds entering the state budget. The proposed mechanism creates a scientific basis for establishing a balance between environmental responsibility and economic efficiency, as well as for the practical implementation of a sustainable development strategy.

8. In our opinion, the economic optimum reflects short-term efficiency, but in terms of sustainable development, preference should be given to the social optimum. The social optimum acts as a complex indicator of working conditions, human well-being and the preservation of balance with the natural environment.

9. As a result of the study, it was determined that the application of the circular economy model is of great importance for optimizing the ecological and economic aspects of the oil and gas industry. In order to solve existing ecological and economic problems, it is important to effectively manage resources, convert waste into economic value, integrate alternative energy sources and strengthen environmental regulations. The research conducted in the dissertation

shows that in order to reduce the environmental burden in oil and gas production, strategies such as carbon emissions management, waste recycling and effective use of water resources should be applied using international experience. At the same time, optimizing state policy in accordance with environmental standards and increasing the environmental responsibility of the private sector are one of the main conditions for sustainable development.

In order to increase the ecological and economic efficiency of the Azerbaijani oil and gas industry, it is necessary to widely apply the principles of circular economy, form environmental taxes and incentive mechanisms, and integrate innovative technologies into the industry. This approach will contribute to both the preservation of ecological balance and the increase of economic value.

We believe that as a result of waste management and the application of the principles of circular economy, efficient use of resources should be ensured. Special programs should be implemented for the recycling and conversion of waste generated in the oil and gas industry into economic value. For example, the gases and solid waste generated during oil and gas production can be reprocessed using chemical and technological methods and used as energy and other useful products, which can reduce the environmental burden of the industry.

10. We believe that new regulatory mechanisms should be introduced by the state to strengthen environmental policy. Additional obligations should be established for polluting enterprises by increasing environmental taxes and fees, and preferential loans and subsidies should be provided for the application of technologies that have a lower impact on the environment.

11. In our opinion, the implementation of the circular economy model can ensure the efficient use of resources and the minimization of waste in the oil and gas industry. In particular, the use of waste as alternative energy sources and the introduction of recycling mechanisms in the oil and gas industry will contribute to the successful implementation of this model.

12. We can conclude that the integration of alternative energy sources into the oil and gas industry can contribute to environmental

protection and increase energy efficiency. Renewable energy sources such as solar, wind and hydropower should be used to reduce greenhouse gases generated during oil and gas production.

The conducted studies show that as a result of the effective implementation of the proposed strategies, the oil and gas industry can become a sustainable and more innovative sector and achieve long-term environmental and economic sustainability. Future studies in this direction should be aimed at equipping the sector with smart technologies and further improving environmental regulation mechanisms.

13. The application of smart technologies in the oil and gas production industry is scientifically justified in order to strengthen environmental control and increase production efficiency. A mechanism for real-time monitoring and management of waste, produced water and process gases has been developed through SCADA systems, sensor networks and centralized monitoring. These technologies create the opportunity for a quick response to environmental risks.

At the same time, it was proposed to assess the environmental efficiency of enterprises operating in the oil and gas industry through automatic monitoring of environmental indicators and their integration into decision-making systems. Thus, ecological and economic management in the industry has been improved on a digital basis.

14. Management of both economic and ecological risks is important for the development of hazard risk insurance. The creation of ecological insurance in order to protect the environment and people from the consequences of technogenic activity stands out as an urgent problem in modern times. Insurance is a promising area for our country due to both the extension of the transition to market relations and the high degree of depreciation of fixed assets, which significantly increases the risk of emergencies. The dissertation proposes alternative options for insuring hazardous facilities, such as self-insurance, group insurance and the creation of subsidiary insurance companies.

Summing up the results of the study, it should be noted that in oil and gas production enterprises, which are most exposed to

production risks, in accidents and technological failures of varying complexity, the threat of production risk, expressed in technogenic factors, significantly increases the degree and scale of damage to production.

The use of an insurance system in a complex risk management system at an enterprise helps not only to minimize the amount of damage caused as a result of an accident, but also to reduce the scale of the risk itself. Taking preventive measures and applying insurance systems allows the insurer to significantly reduce the company's financial losses, which are uncertain both in terms of time and volume, compared to the amounts of planned insurance premiums.

However, when forming an effective and qualitative assessment of insurance coverage for oil and gas enterprises, there should be a database. Within the framework of the creation of methodological tools, it is important to monitor the quantitative financial indicators of insurance companies, as well as innovative products and services that insurance companies can offer. As part of the results of the effectiveness of insurance services, an economic entity can use insurance investments more efficiently, as well as gain access to comprehensive and high-quality insurance services.

Thus, in order to reduce risks during economic activity, companies engaged in oil and gas extraction should develop an acceptable, more effective and flexible model of insurance coverage, including property, since the occurrence of an insured event is quite expensive, and a competent approach to cooperation can solve this problem.

The following articles and theses of the author on the topic of the dissertation have been published:

1. Mammadova R.E. Environmental risk management in oil and gas industry enterprises // – Baku: Azerbaijan Oil Industry, 2017, – pp. 47-49.

2. Mammadova R.E. Environmental policy as an integral part of socio-economic policy // – Baku: BSU, Republican scientific conference of doctoral students and young researchers, October 24-

25, 2017. – pp. 169-171.

3. Mammadova R.E. “Investment and innovation aspects of oil and gas production // – Bakı: “Azərbausanda iqtisadi islahatların hayata keçirilməsinin aktual problemləri” mövzusunda respublika elmi-praktik konfransın materialları, 2018, – p. 156-158.

4. Mammadova R.E. International cooperation in the field of environmental protection // – Baku: Republican scientific and practical conference on the topic "Modern state of industry and development problems: the impact of technoparks and industrial districts on the economic development of the country", April 30, 2019, – pp. 149-152.

5. Mammadova R.E. Priority directions of environmental monitoring // – Baku: Republican Scientific Conference "Development prospects of the non-oil sector of Azerbaijan", April 25-26, 2019, – pp. 47-49.

6. Mammadova R.E. Economic growth and the environment in Azerbaijan // – Dnipro: Integration of Education, Science and Business in Modern Environment: Summer Debates: abstracts of the 2nd International Scientific and Practical Internet Conference, 2020, – pp. 303-305.

7. Mammadova R.E. Sustainable development and its social, economic and ecological criteria // – Baku: Scientific and practical journal “Cooperation”, 2020, No. 3 (58). – pp. 35-41.

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12. Mammadova R.E. Socio-economic directions of the economy of the natural environment and resources, // – Bakı: Qərbi Kaspi Universiteti Elmi Xəbərlər: İctimai və Texniki elmlər seriyası № 4, 2024, – pp. 47-52.

13. Mammadova R.E. Environmental risk management in the oil and gas industry: insurance mechanisms, integral approach and social sustainability // – Baku: Western Caspian University Scientific News (Social and Technical Sciences Series), 2025, No. 4. – pp. 99-104.

14. Mammadova R., Zeynalova S., Rahimova L. Relıability-centered innovation planning for complex industrial systems // – Michigan, USA: Reliability: Theory & Applications, 2025, № 4 (89). – pp. 471-478.

15. Mammadova R.E. Akhmedova A.A., Eyubov N.B. Efficiency of methods used in the analysis of financial planning in business entities // - Astana: International Scientific Journal “Endless Light in Science”, 2026, No. 2. - pp. 188-195.

16. Mammadova R.E. Using Digital “Control” Technologies to Improve the Performance of Oil and Gas Extraction Facilities // – İstanbul: 2nd International Scientific Research Congress, 22-23.02.2025. – pp. 340-346

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