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## *DPSIR model for assessing the state of the environment*

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### **Abstract**

*An analysis of the current ecological state of the Poliskyi region of Ukraine was carried out, environmental problems of the region caused by the war were identified. The post-war recovery of Ukraine should be based on the principles of sustainable development and the use of advanced environmental tools, which will ensure the country's environmental security.*

*With the help of the DPSIR model, indicators for measuring the state of environmental security at the regional level have been identified and structured. 5 groups of indicators are proposed for determining the state of environmental security at the regional level.*

**Key words:** *environmental safety, environmental problems, environment, regional development, SWOT analysis, competitive advantages, sustainable development.*

**JEL:** *O 13, Q 20, R 10, R 58.*

### **Introduction**

Environmental security is an integral component of national security, which can be ensured through the comprehensive application of measures of an economic and legal nature. In modern conditions, the tasks of preserving natural ecosystems, creating an effective system of environmental monitoring, ensuring balanced nature management, reducing the level of environmental pollution, forming a system of processing and disposal of production and consumption waste, as well as those formed during military operations, are becoming urgent.

The environmental situation in Ukraine is critical, as Russia's full-scale invasion of the territory of Ukraine since February 24, 2022 has caused and continues to cause enormous damage to people and infrastructure in settlements where hostilities continue. As a result of the hostilities, forests are being destroyed, in particular, part of the forests in Zhytomyr, Kyiv, Chernihiv, Sumy, Luhansk, Donetsk, and Kherson regions. Environmental pollution with military waste, emissions, and wastewater from all types of industrial or agricultural production and city utilities has become global in nature and has put humanity on the brink of an ecological disaster. In addition, there is a high probability of the spread of

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poisonous substances outside the territory of Ukraine as a result of shelling of oil depots, gas storage facilities and chemical industry facilities.

During the 11 months of the war, the armed aggression of the Russian Federation caused more than 46 billion dollars in damage to the Ukrainian environment. As a result of the Russian invasion, more than 42 million tons of greenhouse gases entered the air [1]. The main causes of these emissions were forest fires and attacks by occupiers on energy infrastructure facilities.

The relevance of the study is determined by the need to develop a system of measures to restore the environmental security of the Polissky region of Ukraine in the post-war period on the basis of sustainable development to ensure the reduction of environmental pollution, the preservation of natural ecosystems, and the creation of an effective environmental monitoring system.

The purpose of the study is to analyze the environmental problems caused by the war, with the aim of developing measures to restore the environmental security of the Poliskyi region in the post-war period in accordance with the requirements of the Sustainable Development Goals of Ukraine until 2030.

To achieve the goal, the following tasks were solved:

- to analyze the impact of the war on the ecological condition of the Poliskyi region of Ukraine;
- to highlight the competitive advantages of the Poliskyi region of Ukraine in order to develop a strategy for the further development of the region in the post-war period on the basis of sustainable development.
- using the DPSIR model to identify and structure indicators for measuring the state of environmental security at the regional level.

### **Theoretical base of the research**

The works of foreign and domestic scientists such as: V.O. Bezuhla [2], Burlacu S., et al. [3], Bran F., et al. [4], Ciobanu G. et al. [5], O.V. Vasyliiev and K.A. Fisun [6], Z.V. Harasymchuk [7], K.V. Illiashenko [8], V.V. Kuzmenko [9], O.I. Liashevskaya [10], L.O. Petkova [11], D.Zh. Furtado [12], Li Dzheims A. [13], Kh Suzuki [14] are devoted to issues of state regulation of the development of regions and regional management. The scientific works of these scientists are devoted to the substantiation of prerequisites, resource provision, methodical approaches to assessing the sustainability of economic development, and mechanisms of financial stimulation of regional development.

The problems of increasing the environmental safety of the regions are revealed in the works of domestic scientists. At the same time, considerable attention is paid to the relationship between the level of development of economic systems and the level of environmental safety [15, 16, 17], the search for financial instruments to ensure the implementation of environmental projects

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[18, 19], planning the development of regions taking into account the ecological component of the process [20, 21], the introduction of the so-called environmental accounting [22]. Shmandiy V.M. [24] developed an algorithm for managing the environmental safety of the region under conditions of intense man-made seismic load.

Kachynskyi A.B. made a significant contribution to the development of the theoretical foundations of environmental safety, who carried out a detailed analysis of environmental safety criteria. The scientist believed that the main indicators characterizing the state of environmental security are the social development index (Human Development Index, HDI) and the human rights index (Human Freedom Index, HFI) [25].

In the work of T. Horuzhai three groups of methods for ensuring environmental safety are distinguished, in particular:

1) environmental quality control, including measurement methods and biological methods;

2) modeling and forecasting, in particular methods of system analysis, system dynamics, informatics, combined methods, for example, ecological-toxicological methods, which include various groups of methods (physico-chemical, biological, toxicological, etc.);

3) environmental quality management (environmental certification, environmental insurance, environmental audit, state environmental expertise [26].

Zhulavsky A.Yu. and Gordienko V.P. [27] studied the mechanism of ensuring environmental safety. The authors consider regulatory, administrative-organizational, economic mechanisms and their information support to be the main tools for ensuring environmental safety. Omarov A. [28] includes financial and economic, organizational, technological, legal and informational mechanisms to the main management mechanisms of environmental security. No publicized results of scientific research on the specified topic were found in open information sources. However, at the moment, research on the restoration of ecological security of the regions in the post-war period requires special attention. No publicized results of scientific research on the specified topic were found in open information sources.

The research methods of the specified problem are based on dialectical and systemic approaches to the assessment of modern environmental problems of the Poliskyi region of Ukraine, which threaten its ecological security. Methods of analysis and synthesis were used to determine the natural resource potential of the Poliskyi region and its impact on the environmental security of the region. The DPSIR concept was used to structure indicators for measuring the state of environmental security at the regional level.

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The information base for the research is the official data of the State Statistics Service of Ukraine and the Department of Ecology and Natural Resources, State Environmental Inspection of Ukraine, scientific articles devoted to environmental safety and sustainable regional development.

### **Results**

Environmental safety is extremely important for the environment, human health and the preservation of the population as a whole. The concept of «environmental security» is a component and prerequisite of national and international security. There are different approaches to defining the concept of «environmental safety». The most common of them are the following:

- ecological safety is «such a state of the surrounding natural environment, which ensures the prevention of the deterioration of the ecological situation and the occurrence of danger to human health» [29];

- environmental security – the state of protection of the vital interests of the individual, society and the state from threats of a natural, man-made and social nature, as well as pollution due to anthropogenic activity, from natural phenomena and natural disasters [25];

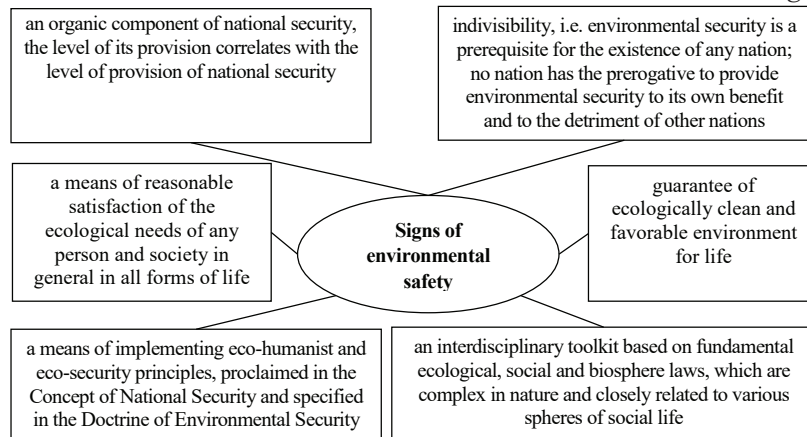
- environmental safety is «a state characterized by the provision of all vital human needs while observing the negative impact on the surrounding natural environment at a level that guarantees safe living conditions and people's health, does not foresee deterioration of living conditions in the future and creates a system of measures for prevention and elimination of the consequences of natural phenomena and natural disasters» [30].

In the process of research, environmental security is considered as a dynamic component of the regional system, which ensures its harmonious development in conditions of protection from real and potential anthropogenic and natural influences. The level of security is mainly determined by the probability of danger manifestations. This requires a comprehensive study of the conditions for the formation and management of environmental hazards.

In fig. 1. characteristic signs of environmental safety are given.

## Characteristic signs of environmental safety

*Figure 1*



Source: [11].

The principles of environmental safety management strategy include:

- prevention of the complication of environmental situations based on the implementation of the control system for man-made activities (issuance of permits, licenses, environmental audit of problematic enterprises, etc.);
- identification of pre-crisis states of technological facilities, development of measures to prevent accidents and disasters;
- development and implementation of a short- and long-term program to reduce environmental hazards to acceptable levels.

The priority direction of the regional environmental policy is to guarantee the environmental security of the regions. One of the important tasks of ensuring environmental safety is to ensure the population's vital activities in a technologically safe and ecologically clean world. An ecologically clean world is possible only if there is no threat from natural objects or if security objects are protected from these threats.

The specifics of environmental security management are related to regionalization, as regions differ in rates of economic development, provision of natural resources, state of infrastructure, and have their own environmental problems. The social and economic problems that have accumulated in the regions are aggravated by the ecological situation, which is constantly deteriorating due to military actions.

Regions - oblasts, as units of the administrative-territorial system, differ sharply from the point of view of the formed structure of production, export potential, provision of infrastructure.

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One of the most important aspects of the analysis of the economic potential of the region is the assessment of the direction of its development for the economic efficiency of the functioning of all components of the regional system. Efficiency is understood as ensuring the highest overall level of well-being of the population of the region with the available resources [6, p. 11]. Therefore, from the point of view of the methodology of system analysis, the economic potential of the region must be considered as a subsystem that is part of the socio-economic system of the region.

The object of the research is the region of Polissia of Ukraine, which is located within the boundaries of the Polissia lowland, in the basin of the Pripyat and the middle Western Bug rivers.

Before the military invasion of Russia on the territory of Ukraine, the Poliskyi region of Ukraine was considered ecologically clean with favorable conditions for life, which was confirmed by the ecological rating of the regions of Ukraine as of February 2, 2022. Thus, Zhytomyr Oblast took first place in the rating, Volyn Oblast – 4th, Rivne Oblast – 5th, Chernihiv Oblast – 7th, and Kyiv Oblast – 16th. The ecological rating of the regions was developed by Ukrainian ecologists based on the following criteria: the state of waste management, in particular with agrochemicals, the level of air and water pollution.

In 2020-2022, the Zhytomyr region rose in the ranking from 8th place to 1st. This is due to a significant improvement in the state of water resources, as their level of pollution has significantly decreased thanks to the inspection of Zhytomyr's treatment facilities and sewers. The main ecological problems of the region include: atmospheric air pollution due to vehicle emissions and from agricultural and industrial enterprises of the region. The biggest environmental threat is gas emissions from agricultural enterprises, because they have a high content of nitrogen and methane, factories and enterprises of the energy industry being the second source of danger.

During the analyzed period, the Volyn region rose in the ranking from 6th place in 2020 to 4th in 2022, which is due to the creation of a water distribution system to prevent floods. The main ecological problems of the region include: problems with flooding due to seasonal precipitation, atmospheric pollution by motor vehicle enterprises, mining enterprises, oil refineries, illegal sand extraction with violation of technology and causing damage to the environment.

The ecological situation in the Rivne region has worsened, which is confirmed by the decrease in its position in the rating from 2nd place in 2020 to 5th in 2022. The main ecological problem of the region is: polluted sewage, which is 747.4 cubic meters/sq. km [32] which is the average level for the country, while other indicators of environmental pollution in the region

are generally low. In addition, chemical plants operating in the region have a negative impact on the environment, in particular: PJSC «Rivneazot», PJSC «Kostopil'skyi glassware factory», LLC «Kronospan».

The ecological condition of the Chernihiv region has worsened, which is confirmed by the decrease in its position in the rating from 5th place in 2020 to 7th in 2022. The main problem of the region is the presence of unusable chemical means of plant protection on its territory, in particular, 266.3 tons of chemicals, which are stored near river basins for a year and require disposal. Illegal logging is another problem of the region. According to the State Environmental Inspection, in 2021, more than 7,700 trees were destroyed in the region, the damage caused is estimated at almost 40 million hryvnias [32].

The worst environmental situation is observed in the Kyiv region, which ranks 16th in the ranking in 2022, which is caused by the negative impact on the environment of emissions from vehicles, electricity and gas supply enterprises, and processing enterprises. Dumping of waste into sewage by business entities and oil leaks are the main problem of the region.

In addition, the land resources of the Poliskyi region of Ukraine are contaminated with radionuclides due to the accident at the Chernobyl nuclear power plant, in particular: Zhytomyr - 156,000 ha, Rivne - 52,000 ha, Chernihiv - 52,000 ha, Kyiv - 34,000 ha [36, 37, 38]. The most difficult situation regarding contamination of agricultural products with cesium-137 occurred in the Rivne region, where 18.6 thousand hectares of peatlands (37%) were contaminated [37]. In these areas, radionuclide migration occurs most intensively.

Table 1 shows the dynamics of atmospheric emissions in the Poliskyi region of Ukraine for 2017-2021.

#### **Dynamics of atmospheric emissions in the Poliskyi region of Ukraine for 2017-2021, thousand tons**

*Table 1*

<i>Region</i>	<i>Years</i>					<i>Deviation 2021 to 2017</i>	
	<i>2017</i>	<i>2018</i>	<i>2019</i>	<i>2020</i>	<i>2021</i>	<i>absolute</i>	<i>relative, %</i>
Volynska	35,10	35,30	36,50	40,10	36,40	1,30	3,70
Zhytomyrska	74,45	72,97	73,44	53,90	58,70	-15,75	-21,16
Kyivska	162,00	197,00	214,70	223,30	247,20	85,20	52,59
Chernihivska	31,52	29,66	27,43	20,89	22,97	-8,55	-27,13
Rivnenska	46,70	44,10	45,10	39,50	42,40	-4,30	-9,21
<b>In total</b>	<b>349,77</b>	<b>379,03</b>	<b>397,17</b>	<b>377,69</b>	<b>407,67</b>	<b>57,90</b>	<b>16,55</b>

*Source: compiled by the authors on the basis of [34, 35, 36, 37, 38].*



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Therefore, for 2017-2021, there was an increase in the volume of emissions of harmful substances into the atmospheric air in the Poliskyi region by 57.90 thousand tons or by 16.55% compared to 2017. The most critical situation is observed in the Kyiv region, where the volume of emissions increased by 85.20 thousand tons or 52.59%.

Atmospheric air is one of the components of the environment, and human health, the flora and fauna of the region depend on its state. Therefore, regional policy should be aimed at reducing the anthropogenic load on the environment and ensuring safe conditions for the life of its population.

Analyzing the indicators of the volume of emissions of pollutants into the atmospheric air for 2017-2021, it should be noted that the lowest volumes of emissions are in the Volyn and Rivne regions, and the most difficult situation is in the Kyiv region. Forecasting using a linear function showed that during 2022-2025 the situation will not change significantly under other unchanged circumstances. In order to reduce the amount of emissions of pollutants into the atmosphere, regional state environmental inspections should more thoroughly check the main polluting enterprises. In addition, since 2022, additional sources of pollution related to military actions have appeared, which requires finding ways to eliminate them from both science and practice.

Kyiv, Zhytomyr and Rivne regions were the most affected by the Chernobyl disaster, which led to significant depletion of the environment, pollution of surface and underground water, atmospheric air and land, accumulation of large quantities of harmful, including highly toxic, production waste, and radiation pollution was added.

The problem of waste management, which is one of the biggest polluters of the environment and has a negative impact on all its components, is particularly acute among the environmental problems that occur in the Polissia region. Their number has increased many times as a result of military operations. The situation is complicated by the fact that there is a significant gap between the volumes of accumulated waste and the volumes of its disposal and processing. Taking into account natural and economic factors, the main component in the total mass of waste generated in the region is occupied by solid household waste and industrial waste of the 4th hazard class, which are mainly disposed of in landfills and dumps.

Thus, the Poliskyi region is fully provided with water, land and forest resources. In addition, the powerful potential of the extractive industry of Zhytomyr Oblast is based on the explored natural resources of the region, in particular: placer ilmenite, complex apatite ilmenite ores, gems, quartzites, facing stone, kaolins, mineral raw materials for the production of various construction materials, lignite, peat, pyrophyllite. Titanium reserves in Zhytomyr Oblast make up more



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than 85% of all explored reserves of titanium ores in Ukraine. In the Zhytomyr region there is a unique Volyn deposit of piezo quartz, the reserves of which also contain accompanying raw materials - a variety of semi-precious stones: morion, beryl, topaz, rock crystal, amethyst, opal, chalcedony, agate. Deposits of granites, gabbros, labradorites occupy a special place in the mineral and raw material potential of the Zhytomyr region, which provide a mineral and raw material base for mining and production of decorative and facing stone and products from it [32]. Explored reserves of varieties of facing stone make up 60 % of all Ukrainian reserves, and labradorite and gabbro reserves make up almost 90 % of the reserves of these minerals in Ukraine. Regarding their reserves, the region occupies a leading position not only in the country, but also in Europe.

The Rivne region has a unique raw material base of such minerals as basalt and amber, the extraction of which is carried out only within the region and makes up 100% of the total extraction in Ukraine. The Volyn region has 2 potential oil and gas facilities prepared for deep drilling (reserves are estimated at 1.553 billion m<sup>3</sup>, and oil - 0.085 million tons) [37].

The availability of natural resources in the Poliskyi region contributes to the development of industry, in particular: heat energy, enterprises of the metallurgical and mining complex, the petrochemical industry, motor vehicles, the production of construction materials, furniture production, the production of rubber and plastic products, and the food industry.

Therefore, the Polissky region has significant natural resource potential, which distinguishes it from other regions of the country. Regional competitiveness is interpreted as the ability to produce goods and services that meet the requirements of international markets, while maintaining high and stable levels of income [39].

Mokii A.I. considers the competitiveness of the region as the ability of the regional economy to optimize its own internal assets and resources in order to compete and prosper at the national and global markets and to adapt to changes in these markets [40].

That is, the competitiveness of the region is the ability of the region to ensure a relatively high level of employment and income of its population in conditions of external competition. Therefore, the region is competitive if it provides the necessary number of jobs and employment of the population at the level of natural unemployment.

Highlighting the competitive advantages of the region is necessary for the development of a strategy to improve the economic well-being of the region and the distribution of the national product.

However, the full-scale invasion of Russia on the territory of Ukraine led to a violation of the ecological security of the country and the region of Polissia, in particular, because the forest was destroyed in the areas of hostilities, land resources

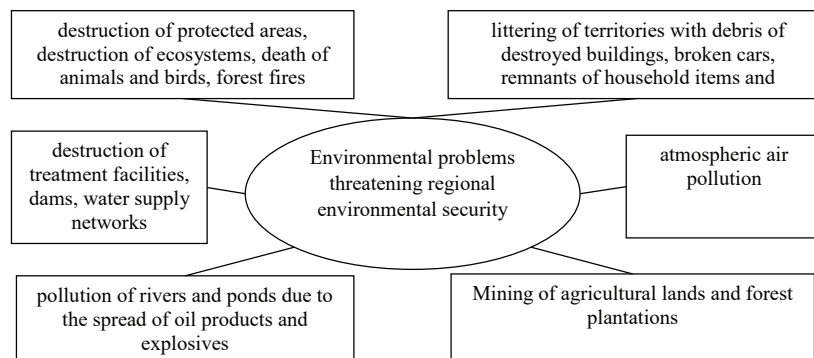
were mined, and the environment was polluted with poisonous substances as a result of the shelling of oil tanks, gas storage facilities, and chemical industry facilities. Mining of agricultural lands and forest plantations is the most critical consequence for the ecological security of the region and the country, as mine explosions lead to soil contamination with heavy metals - lead, strontium, titanium, cadmium, nickel. This makes the soil dangerous, and in some cases, unsuitable for further agricultural use. In addition, explosions lead to forest fires and an increase in harmful emissions into the atmosphere.

The unsatisfactory ecological situation in the region endangers the existence of future generations and the further development of the state based on the principles of sustainable development, which are declared as strategic and priority. In connection with the above, there is a need for purposeful actions of the state aimed at protecting and restoring the environment.

Based on the analysis of empirical data, reports of the Ministry of Environmental Protection and Natural Resources of Ukraine, the State Environmental Inspection of Ukraine, the Department of Ecology and Natural Resources, problems threatening the ecological safety of the region were identified (Fig. 5).

#### **Environmental problems threatening the regional ecological security of Ukrainian Polissia**

*Figure 5*



Source: [41, 42, 43].

Environmental problems caused by the war threaten not only the ecological security of Ukraine and its regions, but may also go beyond its territory. Since the domestic ecosystem is of great importance for Europe, because it covers 35 percent of Europe's biodiversity, 29% of the territory of Ukraine consists of natural vegetation, as well as cultivated natural vegetation, 15.9% of the territory of Ukraine consists of forests [41].

There are almost 63,000 rivers that flow into other European rivers on the territory of Ukraine, so there is a threat of their pollution due to the spread of oil products and explosives. 11 % of the Carpathian massif where a third of all plant species in Europe grow is located in Ukraine. 687 species of animals and 857 species of plants which are at risk of extinction due to military actions [39] are registered in the latest 2021 edition of the Red Book of Ukraine.

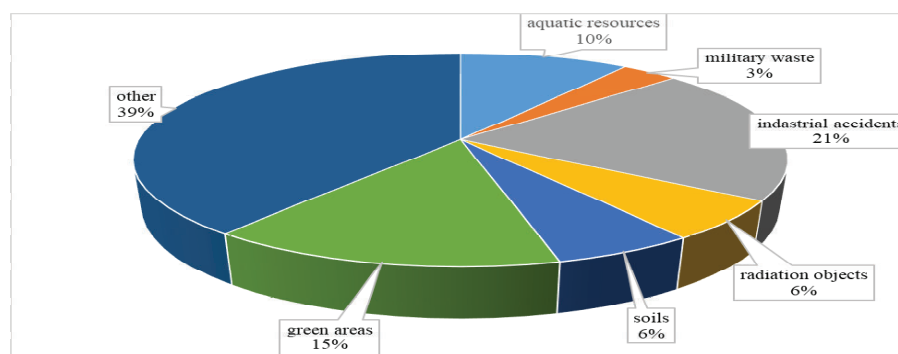
The largest nuclear power plant in Europe – Zaporizhzhia NPP has been captured by the Russian army. Another threat is tailing dumps, where liquid industrial waste is stored. There are a total of 465 of them in the country, where more than 6 billion tons of waste are stored. 200 of them are located in eastern Ukraine which is the region most affected by the war.

Due to Russia’s military aggression, 2.5 million hectares of Europe’s nature protection network are under threat of destruction today. These are 160 objects of the Emerald Network - territories of existence of species and habitats protected at the pan-European level. And there are 17 Ramsar sites with an area of 627.3 thousand hectares – wetlands of international importance [43].

As of January 1, 2023, 277 war crimes against the environment were recorded, in particular, the largest number of them occurred in the Kyiv region – 45, Odesa – 26, Dnipropetrovsk – 24, Zaporizhzhya – 20 [42]. In the Poliskyi region, 68 crimes were recorded (Kyiv – 45, Zhytomyr – 11, Chernihiv – 5, Volyn – 4, Rivne – 3), which is 24.55 % of all crimes (fig. 6).

#### The structure of war crimes against the environment in Ukraine as of of January 1, 2023

Figure 6



Source: [14]

Therefore, the largest share in the structure of recorded war crimes falls on industrial accidents – 21 %, i.e. damage or destruction of oil depots,

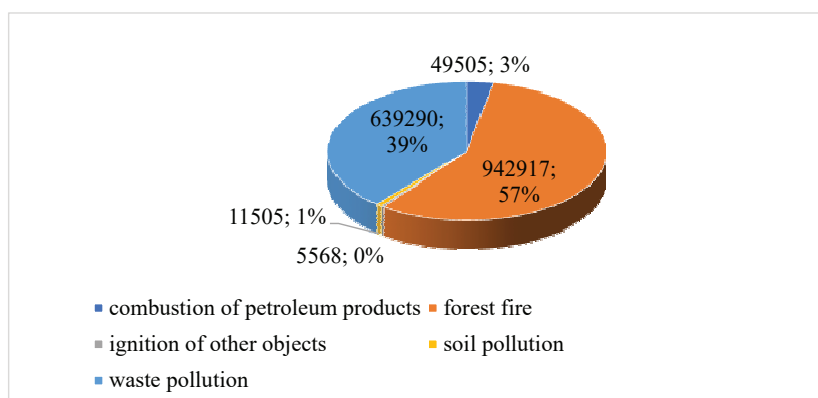
destruction and fires at industrial enterprises, emission of ammonia at PJSC «Sumikhimprom», emissions into the air or discharge of liquid pollutants into the environment as a result of military operations. Military actions lead to serious disruptions in the energy network of Ukraine. Sixteen war crimes against nuclear security were also recorded. Not so much is said about the negative impact on marine ecosystems that is of a transboundary nature (seven ones have been recorded so far).

According to official data of the Ministry of Environmental Protection and Natural Resources of Ukraine, as of 01.01.2023, 2,285 appeals have been processed regarding damage caused to the environment of Ukraine due to the war for a total amount of 441 US dollars billion [1].

As of January 1, 2023, according to the estimates of the State Environmental Inspection, the amount of losses incurred due to the war is UAH 1,704 billion. (Fig. 7).

#### Damage caused to the natural environment of Ukraine due to the war as of January 1, 2023

Figure 7



Source: [1].

Thus, according to preliminary calculations of State Environmental Inspection of Ukraine the most damage was caused to air - in the amount of UAH 997,995 billion, which is 58.57 % from all currently determined losses, of which: 55.34 % were caused by forest fires, 2.91 % by the burning of oil products, 0.32% by the burning of other objects. Damage to the environment due to its contamination by military waste amounts to 37.52 % of all identified damages. The smallest share

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in the structure of the calculated environmental damages is the damage caused to the soil, 3.91%.

In order to assess the consequences and start implementing programs for the reconstruction of the destroyed territories, it is necessary first of all to stop the war and return the occupied territories. The ecological damage in the de-occupied territories is incredible. One of the methods of determining the amount of environmental damage is determined by the amount of land that can no longer be used for its intended purpose. In Chernihiv Oblast and Kyiv Oblast, a third of the territory is polluted due to the actions of the Russian occupiers.

Solving ecological problems requires a perfect state environment-oriented management system, taking into account the Sustainable Development Goals of Ukraine until 2030. The provision of the country's economic interests is based on the sustainable development of regions, when the implementation of goals and objectives in the field of regional policy reflects the formation of opportunities for systemic purposeful actions against threats at the regional level. But at the same time, one should take into account regional differences in the level of economic security, which are determined by the unevenness of social development, the peculiarities of economic development and the placement of productive forces, the degree of dynamism of innovative transformations, the quality of human potential, the investment climate and many other factors.

The post-war reconstruction of the regions should be based on the concept of sustainable development. The transition to sustainable development of Ukraine's regions is a profound process in which each territorial community must coordinate its actions at the national level and take measures to implement the goals and principles of the new civilizational model.

The Ukraine Recovery Conference, which took place on July 4-5, 2022 in the city of Lugano, was an important contribution to the future restoration of the environment. The program «Reconstruction of a clean and protected environment» [45] was adopted at this conference. Under this program, the construction of more than 100 modern waste management facilities, 10 national parks organized according to EU standards, and 9 forest seed centers for growing tree seedlings is planned.

Analyzing the competitive advantages of the Poliskyi region, we can outline strategic directions in the field of its development (Table 3).

### Strategic directions of the development of the Poliskyi region of Ukraine

Table 3

<i>Nº</i>	<i>Strategic direction</i>	<i>Actions involving a strategic direction</i>
1	Environmental safety of the region	Development of programs at the state and regional levels to ensure the restoration of the environment in the post-war period, as well as the adaptation of domestic regulatory and legal frameworks for the regulation of the environmental condition to the current standards of the European Union
2	Using the potential of key comparative advantages of the region	Transition to innovative technologies for mining titanium ores, granites, gabbros, labradorites
3	Developed transport potential	Reconstruction of transport highways, bridges; transition to widespread use of electric transport
4	Improvement of the region's potential for growth and improvement of living conditions	Creation of new jobs, reconstruction of social infrastructure
5	Development of rural areas	Introduction of innovations in agriculture, forestry and fisheries and in rural areas; strengthening of small farms, their cooperatives and young farmers; compensation for damages caused by natural disasters; development of programs for the rational use of natural resources; transition to organic agriculture; modernization management of rural landscapes; preservation of biodiversity.

Source: developed by the authors

The post-war reconstruction of Ukraine must be based on the principles of sustainable development and the use of advanced environmental tools. Ukraine, like the UN member states, has joined the global process of ensuring sustainable development. In the complex of measures aimed at the protection of the environment, several directions are distinguished, including the protection of the air basin, water resources, preservation of soils and forest resources.

A significant improvement of the environmental situation in the region, as well as in Ukraine as a whole, will be possible under the conditions of the availability of adequate funding for the implementation of environmental protection measures, strengthening the authority and approval of environmental law at the European level, as well as the responsibility of local self-government bodies and every citizen for making ecologically balanced decisions in their everyday practical actions. The country can ensure the transition to sustainable development only through the effective use of all types of resources, structural and technological modernization

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of production, and the use of the creative potential of society for the development and prosperity of the state. For this, it is necessary to improve the system of environmental monitoring, state control, state accounting, and environmental audit at the regional and local levels, as well as apply those statistical approaches that are recognized at the international level. That is, the ecological development of regions is the most important in the concept of sustainable development of the country.

#### **An optimistic view into the future**

To analyze the impact of environmental problems on the state of environmental security of the region, the DPSIR model was used, which allows to identify the cause-and-effect relationship between the state of the natural environment and anthropogenic influence on it. This model can be used at different levels of government - from local to national and international depending on the available powers.

DPSIR is used in the analysis of environmental and economic information to identify problem areas and assess the correctness of establishing cause-and-effect chains in order to select the right sets of indicators to achieve a specific goal.

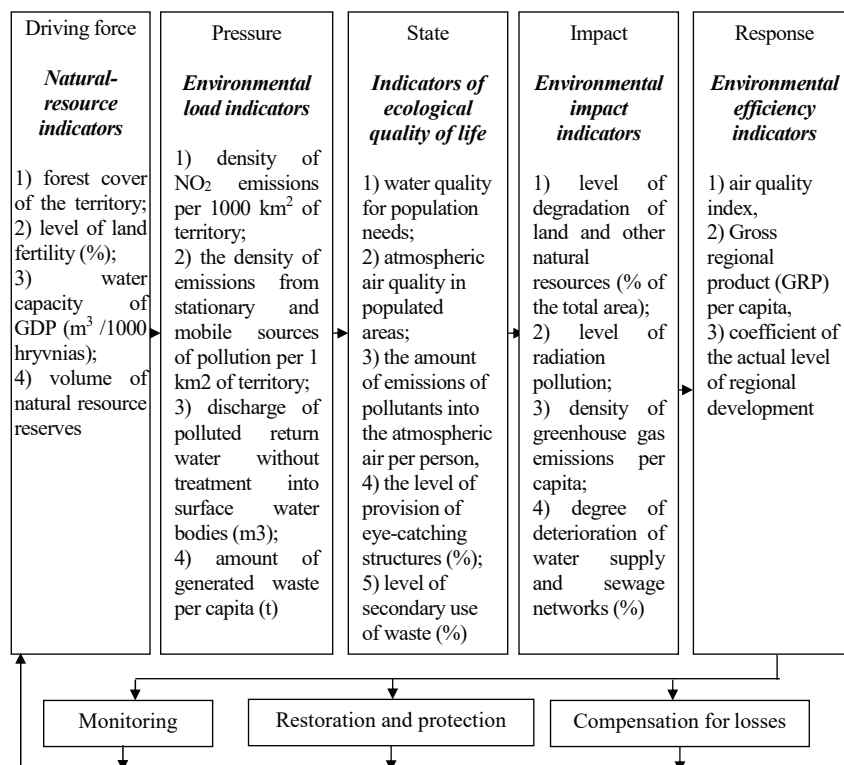
The DPSIR model was developed by the UN Commission on Sustainable Development [46] and contains the following structural elements: 1) driving force – a set of natural, social, economic and institutional factors that affect the state of the environment, exploitation of natural resources and emissions of pollutants into atmospheric air; 2) pressure – reflects the anthropogenic load on the state of the natural environment, which is carried out due to emissions and discharges of pollutants, use of natural resources; 3) state – characterizes the current state of the ecosystem and trends in environmental changes; 4) impact – reflects the consequences of anthropogenic influence on the state of the natural environment and ecological safety of the region; 5) response – particular actions aimed at solving environmental problems.

According to the DPSIR model and the concept of sustainable development, 5 groups of indicators are proposed for assessing the state of ecological security of the region. Fig. 8 shows the system of indicators according to the DPSIR model for determining environmental security at the regional level.



## DPSIR model for determining environmental security of the region

Figure 8



Source: developed by the authors

To assess the driving force component, a group of natural-resource indicators is proposed, which includes the following indicators: forest cover of the territory; the level of land fertility (%); water capacity of GDP (m<sup>3</sup>/1000 hryvnias) and the volume of natural resource reserves. The selection of these indicators is due to the fact that they allow a comprehensive assessment of the natural resource potential of a specific region.

With the help of a separate group of environmental load indicators, it will be possible to generate information about the density of emissions of pollutants into atmospheric air and water resources and the amount of waste per capita of the region.

The group of environmental quality of life indicators reflects the influence of the pressure component on the state of environmental security of the region. Based on the results of the analysis of this group of indicators,

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it is possible to develop appropriate measures to reduce the negative impact and condition of the environment and the health of the population of the region.

When developing decisions to improve the environmental safety of the region, indicators of environmental impact should be taken into account, as they reflect the intensity of resource use and their state at the current moment, describe existing problems arising as a result of changes in their state.

The group of environmental efficiency indicators includes 3 indicators that help evaluate the effectiveness of policies aimed at ensuring a balance in the use and preservation of environmental resources. The air quality index is used by government agencies to communicate to the public the level of air pollution at that time. If the index increases, a large part of the population will face serious health consequences.

Thus, the air quality index makes it possible to assess the impact of industrial activity on the size of the gross regional product (GRP), the level of environmental pollution and the degree of degradation of ecological systems, to determine the strengthening or weakening of the ecological development trajectory of regions.

According to the DPSIR model, it is possible to analyze the region and assess the active driving forces, their pressure, the consequences of the changed state and their final impact in order to restore and protect the natural environment and monitor the state of the ecosystem.

To analyze the environmental security situation at the regional level in order to recognize progress in achieving sustainable development in specific local territories (parts of the country, regions), it is appropriate to use an integrated index. It should take into account a set of indicators given in the DPSIR model characterizing various aspects of the interaction between the economy and the environment.

### **Conclusions**

The ecological security of the Polissky region of Ukraine is in a state of crisis, which was caused by the full-scale invasion of Russia into the territory of Ukraine. However, the ecological situation in the region is critical, which is caused by the full-scale invasion of Russia on the territory of Ukraine. As a result of hostilities, forests are destroyed, in particular, part of forests in Zhytomyr, Kyiv, and Chernihiv regions, the environment is polluted with military waste and emissions of toxic substances as a result of shelling of oil depots, gas storage facilities, and chemical industry facilities. Therefore, it is necessary to develop strategic directions for the recovery of the region, which should be based on its competitive advantages.

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In the post-war period, the key strategic direction of both state and regional policy should be to ensure environmental safety. This will allow not only to restore the state of the environment, but also to increase the efficiency of using the country's natural resource potential.

To analyze the environmental security situation at the regional level in order to recognize progress in achieving sustainable development, the DPSIR model for determining the environmental security of the region is proposed, which consists of 5 groups of indicators that allow reflecting various aspects of environmental security at the regional level. The proposed approach to assessing the state of environmental safety does not take into account many indicators due to the complexity of calculations or limitations in data access, others are under development. The prospect of further research is the development of a construction methodology and a scale for evaluating the integrated index of environmental safety for its implementation in practical activities.

#### REFERENCES

1. Shooter R. (2023). The amount of damage to the Ukrainian environment from the armed aggression of the Russian Federation already amounts to more than 46 billion dollars, URL: <https://mepr.gov.ua/news/41095.html>.
2. Bezugla V.O. (2006). Basics of the formation of competitiveness of the regions of Ukraine (on the example of the Poltava region): autoref. thesis Ph.D. economy Sciences: 08.10.01 «Allocation of productive forces and regional economy»; Hark. national Acad. urban Mrs. X., 20 p.
3. Burlacu, S., Patarlageanu, S. R., Diaconu, A., & Ciobanu, G. (2021). E-government in the era of globalization and the health crisis caused by the covid-19 pandemic, between standards and innovation. In *SHS Web of Conferences* (Vol. 92, p. 08004). EDP Sciences.
4. Bran, F., Ciobanu, G., Popescu, M. L., & Vasilache, P. C. (2020). Sustainable Local Development in Romania in the Opportunity of Creating Jobs. *European Journal of Sustainable Development*, 9(3), 287-287.
5. Ciobanu, G., Gole, I., Bălu, O. F., Popescu, I. M., & Vasilache, C. P. (2020). Development of the Green Economy and the Creation of Green Objectives Through Digital Networks. *Revista de Management Comparat International*, 21(3), 401-411.
6. *Management of regional development: monograph.(2010)*. / edited by O.V. Vasyliieva, K. A. Fisun; Hark. national Acad. urban farm. Kh.: KhNAMG. 375 p.
7. Gerasimchuk Z. (2008). *Regional policy of sustainable development: theory, methodology, practice*: Monograph. Lutsk: Nadstyrya, 528 p.
8. Ilyashenko K. (2009). Sustainable development of the city as a result of social partnership of the state, business and community. *Bulletin of the Khmelnytskyi National University*. Vol. 6, T. 3. P. 238-242.
9. Kuzmenko V (2008). *Economic security and sustainable development: regional aspect: monograph*. Donetsk: DonNUET, 144 p.
10. Lyashevska O.I.(2015). The system of state policy is the sustainable development of regions. *Bulletin of the National University of Civil Defense of Ukraine. Series: Public administration*. Vol. 2. P. 202-209. URL: [http://nbuv.gov.ua/UJRN/VNUCZUDU\\_2015\\_2\\_30](http://nbuv.gov.ua/UJRN/VNUCZUDU_2015_2_30)

- 
11. Petkova L., Marushchak D. (2017). Sustainable development of the regions of Ukraine in the conditions of the European approach to decentralization. *Economics Bulletin*, Vol. 3. P. 58-65.
  12. Furtado, J. (2000). Economic Development and Environmental Sustainability Policies and Principles for a Durable Equilibrium / Jose I. dos R. Furtado, Tamara Belt, Ramachandra Jammi. The International Bank for Reconstruction and Development / The World Bank. 130 p.
  13. Lee, James A. (1985). The Environment, public health, and human ecology / James A. Lee. International Bank for Reconstruction and Development. The Johns Hopkins University Press. 278 p.
  14. Suzuki H. (2010). Ecological Cities as Economic Cities / Hiroaki Suzuki, Arish Dastur, Sebastian Moffatt, Nanae Yabuki, Hinako Maruyama. The International Bank for Reconstruction and Development / The World Bank. 392 p.
  15. Garkava V., Klishchevska A. (2021) Management of the environmental component of the region's economic security system. *Agroworld*. Vol. 13-14. P. 11-16.
  16. Datskiv R. (2006). Economic security of the state in the conditions of globalization competition. Lviv: Center of Europe, 160 p.
  17. Zhalilo Ya. (2001). National security strategy of Ukraine in the context of the experience of the world community. Kyiv: Satsanga, 2001. 224 p.
  18. Muntiyani V. (1998). Economic security of Ukraine. Kyiv: KVIC Publishing House, 462 p.
  19. Mink S. (1993). Poverty, Population, and the Environment. World Bank Discussion Papers. The International Bank for Reconstruction and Development. 54 p.
  20. Nijkamp P. (1990). Regional Sustainable Development and Natural Resource Use / Peter Nijkamp, C. J. M. van den Bergh, and Frits J. Soeteman. Proceedings of the World Bank Annual Conference on Development Economics, pp. 153-205.
  21. Responsible Growth for the New Millennium. Integrating Society, Ecology, and the Economy (2004). The International Bank for Reconstruction and Development. The World Bank. 196 p.
  22. Tymchyshyn-Chemerys J. (2019). Features of economic security of the region as a composition of national economic security. International scientific journal «Internauka». Vol. 4. URL: <https://doi.org/10.25313/2520-2057-2019-4-4826>
  23. Kostrykina K., Gribovskaya A., Galunets N. (2019). Environmental security of the region: organizational and theoretical aspect. Accounting, analytical and financial support of business entities: national, globalization, European integration aspects: materials of the IV International Scientific and Practical Internet Conference, (November 20-21), Mykolaiv: MNAU, pp. 168-171.
  24. Shmandiy V.M. and Bredun V.I. (2009). Algorithm of management of environmental safety of the region in conditions of intense man-made seismic load. URL: [http://www.kdu.edu.ua/EKB\\_jurnal/2009\\_3\(7\)/PDF/13.PDF](http://www.kdu.edu.ua/EKB_jurnal/2009_3(7)/PDF/13.PDF).
  25. Kachynskyi A. (1997). *Environmental security of Ukraine: analysis, evaluation and state policy: monograph*. Kyiv: NISD, 127 p.
  26. Khoruzhaya T.A. (2006). Environmental hazard assessment M.: Book service. 2002. 208 p.
  27. Zhulavsky A. and Gordienko V. (2016). The mechanism of ensuring ecological safety. *Bulletin of Sumy State University. Economy series*. Vol. 1. pp. 7-14.
  28. Omarov A.E. (2016). Administrative mechanisms of the state policy of ensuring environmental safety. *Theory and practice of public administration: collection of science pr. Kh.: HarRI NADU Publishing House «Master»*. Vol. 3 (54). pp. 203-208.

- 
29. The Verkhovna Rada of Ukraine (1991), The Law of Ukraine “On environmental protection”, available at: [//zakon.rada.gov.ua/laws/show/1264-12#Text](http://zakon.rada.gov.ua/laws/show/1264-12#Text) (Accessed 29 Dec 2022).
  30. Dudyuk V. and Gobela V. (2015). Theoretical approaches to the definition of the concept of ecological safety. *Scientific Bulletin of the National Forestry University of Ukraine: Coll. science and technology Ave.* Vol. 25.5. Lviv: RNV NLTU of Ukraine. pp. 130-135.
  31. Khilko M. and Kusherets V. (2006). Ecological safety of Ukraine: in questions and answers. K.: Knowledge of Ukraine, 144 p.
  32. Ecological rating of the regions of Ukraine 2022: Kyiv is the most polluted, Zhytomyr Oblast is good (2022). URL: <https://focus.ua/uk/ratings/504721-ekologicheskij-rejting-oblastey-ukrainy-2021>.
  33. You can live, but not everywhere. What did the environmental rating of the regions of Ukraine 2021 say (2021) URL: <https://focus.ua/uk/ratings/473439-zhit-mozhno-no-ne-vezde-cto-rasskazal-ekologicheskij-rejting-oblastej-ukrainy-2021>.
  34. Regional report on the state of the natural environment in the Volyn region in 2021 (2022). URL: <https://mepr.gov.ua/news/39936.html>.
  35. Regional report on the state of the natural environment of the Zhytomyr region in 2021 (2022) URL: <https://mepr.gov.ua/news/38742.html>.
  36. Regional report on the state of the natural environment in the Kyiv region in 2021 (2022) URL: <https://mepr.gov.ua/news/38742.html>.
  37. Regional report on the state of the natural environment of the Rivne region in 2021 (2022). URL: <https://mepr.gov.ua/news/38784.html>.
  38. Regional report on the state of the natural environment of the Chernihiv region in 2021 (2022). URL: <https://mepr.gov.ua/news/38784.html>.
  39. Methodology of regional development planning in Ukraine (2014). URL: [https://cg.gov.ua/web\\_docs/1/2014/11/docs/Methodology\\_of\\_RD\\_planning.pdf](https://cg.gov.ua/web_docs/1/2014/11/docs/Methodology_of_RD_planning.pdf).
  40. *Strategy and mechanisms for strengthening the spatial and structural competitiveness of the region: Monograph* (2010). / Under the editorship A.I. Mokia, T.G. Vasylytsiva. Lviv: Liga Press, 488 p.
  41. Scorched earth and polluted water: catastrophic environmental consequences of Russia’s war against Ukraine (2022) URL: <https://www.radiosvoboda.org/a/ekolohichna-katastrofa-cherez-vyynu-rosiyi/31921705.html>.
  42. War and eco-modernization: is it possible to reform industrial pollution in Ukraine (2022) URL: <https://www.epravda.com.ua/columns/2022/10/13/692591>.
  43. An overview of the impact of the war on the industry of Ukraine and a forecast of prospects in the economy (2022) URL: <https://uspp.ua/news/actual/2018/ohliad-vplyvu-viiny-na-promyslovisht-ukrainy-ta-prohnoz-perspektyv-v-ekonomitsi>.
  44. War crimes against the environment (2023) URL: <https://www.saveecobot.com/features/environmental-crimes>.
  45. Environmental reforms of Ukraine on the way to the European Union (2022). URL: <https://www.epravda.com.ua/columns/2022/08/10/690226>.
  46. Indicators of Sustainable Development: Framework and Methodology. (1996). N.Y.: United Nations.