



## Assessment of the environmental state of tourist resources in the Ivano-Frankivsk Region

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✔ **Abstract.** In view of the rapid growth of the impact of tourism on the world economy, as well as the environmental problems that it can create, the assessment of the environmental state of the tourism sector is becoming particularly relevant. The purpose of the study was to analyse the ecological state of the Ivano-Frankivsk Region and its impact on the attractiveness of the region for tourists, as well as to develop proposals for the sustainable development of tourism, taking into account environmental aspects. In the framework of the study, various methods were used, in particular, statistical analysis of data on pollutant emissions. The impact of industry and other industries on the environmental condition was analysed and assessed using the analysis method. The dynamics of atmospheric emissions by years and their impact on the ecological state of the region were analysed, with a special emphasis on pollution by sulphur dioxide and other compounds. In addition to atmospheric emissions, the issue of the discharge of pollutants into water bodies and the impact on water quality, which is important for the development of tourism, was considered. It was established that emissions of pollutants significantly affect the quality of atmospheric air, which, in turn, determines the tourist potential of the region, especially in the context of the development of ecological tourism. The need to implement measures to reduce the level of pollution, develop sustainable tourism, and implement environmental standards in the tourism industry is emphasized. Ways to improve the ecology of the region have been established and appropriate proposals have been made, including reducing emissions of pollutants, as well as the use of innovative technologies and approaches in the field of environmental safety and ensuring the sustainable development of tourism in the Ivano-Frankivsk Region. The practical value of the research consists in identifying specific directions for improving the environmental policy of the region, which require practical implementation to improve the environmental condition of Ivano-Frankivsk Region, emphasizing the importance of an integrated approach in solving environmental challenges.

✔ **Keywords:** environmental challenges; industry safety; industrial impact; atmospheric air quality; sustainable use of natural resources

### ✔ Introduction

In the context of the rapid development of tourism, the environmental aspect is becoming increasingly important and relevant for research. Tourism, being one of the most dynamic sectors of the global economy, has a significant impact on the natural environment. The anthropogenic impact of tourism on the ecological state of the

Ivano-Frankivsk Region is particularly noticeable through environmental pollution. Intensification of tourism activities leads to an increase in emissions from vehicles, which is a significant source of air pollution. Such pollution affects not only the quality of the air but also the overall health of the local population and visitors. The intensive use of

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water resources and their pollution by waste from tourism activities jeopardizes the quality of water bodies in the region. Pollution of rivers, lakes, and other water bodies can negatively affect aquatic flora and fauna, and limit opportunities for water tourism and recreation. Another important aspect is soil pollution resulting from tourism activities. For example, emissions from campsites and other tourist facilities, uncontrolled waste disposal, and excessive use of fertilizers in agriculture can lead to soil degradation. Significant use of forest resources for tourism purposes will also contribute to the region's environmental problems. Deforestation to create tourist infrastructure and firewood for campsites reduces forest areas and affects biodiversity.

Considering the range of scientific works on the environmental assessment of tourism resources, the study by N.E. Pankiv (2019) deserves special attention. The researcher focused on the use of tourist and recreational resources in the region, with an emphasis on the development of green and ecological tourism. She conducted an in-depth analysis of ecological routes, including ecological and educational trails in the region's national parks, highlighting their role in tourism development and emphasizing the importance of integrating environmental, cultural, and economic aspects into tourism development strategies. Scientists I. Dubovich *et al.* (2021) focused on analysing the impact of mass forms of tourist and recreational activities on the natural environment of the Ukrainian Carpathians. They found that the intensive development of tourism in this region leads to a significant use of natural resources and a decrease in environmental quality, compared to places where tourism is developing in a controlled or balanced manner. The authors paid attention to the environmental aspects of ecotourism initiatives, emphasizing the need to develop sustainable tourism. They conducted a SWOT (strengths, weaknesses, opportunities, and threats) analysis for national parks and the Carpathian Forest Fund, which includes reducing the negative impact of tourism and recreation activities and encouraging environmentally responsible practices.

The study by M. Gedin (2021) is also a significant contribution to understanding the methodology for assessing Ukraine's tourism potential, with a focus on the factors that affect competitiveness in the tourism industry. The author analyses a wide range of determining factors, including historical and cultural heritage, natural and recreational conditions, infrastructure, finance, investment, governance, social and environmental aspects. The researcher also proposes innovative tools for assessing tourism and recreational potential, including an assessment of the attractiveness of regions and the impact of this sector on the economy. The author emphasizes the importance of an integrated approach to assessment and development of criteria for effective determination of the resource potential of tourist areas. M. Lazutkin *et al.* (2022) conducted a study to assess the ecosystem in the most polluted regions of Ukraine. The authors examine the impact of external factors and risks on production facilities

and the environmental situation, which is critical to understanding environmental safety in the region, emphasizing the need for in-depth analysis to ensure environmental sustainability.

In the context of international initiatives and standards, such as the United Nations Environment Programme and ISO 14000, as described by A. Dayankac (2022), as well as in the light of Ukrainian legislation on environmental protection, there is an obvious gap in research related to the development of the environmental aspect in the tourism industry. This situation calls for greater attention to the study and implementation of environmental practices in tourism, which involves the integration of a sustainable approach not only at the level of policy and management but also in the practical implementation of tourism services. Solving this problem requires an integrated approach, including an assessment of the environmental impact of tourism facilities and activities, as well as the development of innovative solutions aimed at minimizing the negative impact on the environment.

In assessing the environmental status of the Ivano-Frankivsk Region's tourism resources, special attention should be paid to analysing the impact of tourism activities on various aspects of the region's ecology. It is important to consider not only direct environmental pollution but also broader environmental impacts, such as changes in biodiversity and landscape alteration. Such a comprehensive approach will help to develop effective mechanisms to minimize the negative impact of tourism on the natural environment, as well as to ensure the sustainable development of the region's tourism sector. Therefore, the purpose of the study was to analyse the environmental state of the Ivano-Frankivsk Region and, on its basis, to further develop directions for sustainable tourism development. Thus, the main objective of the study was to conduct an in-depth analysis of the environmental situation in the Ivano-Frankivsk Region to identify key environmental issues and challenges that affect the development of the region's tourism industry. Based on the data obtained, it was planned to develop strategic directions for sustainable tourism development that would take into account environmental, social and economic aspects in order to achieve a balance between the needs of the tourism industry and the preservation of the natural environment for future generations.

## ✔ Materials and Methods

The study used a comprehensive approach, including an analysis of data on the environmental situation in Ivano-Frankivsk Region, including the volume of air pollutant emissions and their impact on air quality, as well as an analysis of the region's water resources, land use, and soil resources. The study was based on official statistics from the Main Department of Statistics and the Ivano-Frankivsk Regional State Administration. The statistical data used included information on pollutant emissions, wastewater discharges, and other aspects that

directly affect the environmental situation in the region. The use of official data ensured the high reliability and relevance of the information, which is critical for an objective assessment of the environmental situation. A detailed analysis of scientific literature, reports, articles, and other publications related to the research topic was conducted. The analysed sources included the Regional Report on the State of the Environment in Ivano-Frankivsk Region and publications by well-known scientists in the field of tourism and ecology. The application of impact assessment methods, including the calculation of the percentage of emissions by pollution sources and the assessment of the dynamics of changes, made it possible to assess the effectiveness of existing environmental protection measures and identify gaps in the region's environmental policy and to identify the largest pollutants that lead to surface water pollution.

Air pollutant emissions were calculated. The calculation methodology is based on a comparison of annual emissions for the period from 2017 to 2021, with an emphasis on changes in emissions and their structure. This approach allows identifying trends and dynamics of changes in atmospheric emissions, which are critical for assessing the environmental status of the Ivano-Frankivsk Region. For the calculations, 2021 data (Ivano-Frankivsk Regional State Administration, 2022) was used because the lack of information on mobile sources of pollution for 2022 (Ivano-Frankivsk Regional State Administration, 2023) significantly limits the ability to comprehensively understand the anthropogenic impact on the air. Mobile sources, in particular road transport, are significant polluters in many regions, so their contribution must be identified to adequately assess the environmental situation. Also, analysing data for only one year does not allow for the identification of trends and dynamics of environmental change. Whereas, the data for 2021 includes information on both stationary and mobile sources, which provides an opportunity for comparative analysis and determination of the effectiveness of pollution reduction measures. The formula for calculating the percentage share is as follows:

$$\begin{aligned} & \text{Percentage share} = \\ & = (\text{Emissions from the source} / \text{Total emissions}) \cdot 100 = \\ & \text{Percentage share} (\text{Total emissions} / \quad (1) \\ & / \text{Emissions from the source}) \cdot 100. \end{aligned}$$

An in-depth study of scientific publications, reports, articles, and other information resources related to ecology and tourism played a crucial role in shaping the theoretical framework of the study, which in turn helped not only to collect information on current trends and challenges but also to identify successful practices and recommendations that can be adapted and implemented in Ivano-Frankivsk Region. The comparison method allowed accessing the environmental state of the Ivano-Frankivsk Region over different periods of time. The comparison method was used to analyse the dynamics of changes in pollution

levels, water resources, air quality, land use, and other environmentally significant indicators. The comparison was made based on official data collected from the Main Department of Statistics, Ivano-Frankivsk Regional State Administration, and other reliable sources. Thus, the application of impact assessment, analysis, statistical analysis, and comparison methods was an important step in determining the degree of air, water, and land pollution from economic activities. The analysis of the percentage of emissions by the source of pollution, as well as the assessment of the dynamics of these indicators over time, made it possible to identify the main sources of environmental burden, which helped to identify priority areas for the implementation of measures aimed at reducing environmental impact and creating more favourable conditions for tourism development. The involvement of a wide range of information sources and the use of various methods allowed identifying key issues and develop sound recommendations that can contribute to the sustainable development of the tourism industry in the Ivano-Frankivsk Region.

## ✓ Results

Ecology and tourism are closely interconnected, especially in regions with significant natural resources, such as the Ivano-Frankivsk Region. Sustainable development of tourism in this region requires taking into account environmental challenges and ensuring a balance between meeting the needs of tourists and preserving the natural environment. The ecological condition of tourism resources affects the quality of the tourist experience and contributes to attracting visitors. Air quality is an important aspect in this context, as it directly affects the health and well-being of tourists, as well as the preservation of natural landscapes and biodiversity in the region. Among the most important factors affecting the environmental state of the Ivano-Frankivsk Region is a significant increase in air pollutant emissions. According to 2021 data, total emissions in the region reached 210.3 thousand tons (kt), of which 172.4 kt are from stationary sources of pollution, and 37.9 kt are from mobile sources, mainly road transport (Ivano-Frankivsk Regional State Administration, 2022).

The analysis of industrial pollution sources confirms that the main share of pollutant emissions in the region is accounted for by energy sector enterprises, in particular, electricity, gas, steam, and air conditioning, which account for 89.1% of the total regional volume. The Burshtyn Thermal Power Plant of DTEK Zakhidenergo (Burshtyn TPP of DTEK Zakhidenergo) has the greatest impact on air pollution, accounting for 84.4% of total regional emissions. Emissions from this enterprise increased by 24.4% in 2021, amounting to 145.6 kt (Ivano-Frankivsk Regional State Administration, 2022). This increase in emissions has important implications for the environmental situation in Ivano-Frankivsk Region, particularly in terms of air quality. This not only reduces the aesthetic and recreational attractiveness of the region but also poses a direct threat to the health of tourists and the local population.

According to the latest official data released by the Main Department of Statistics, there has been a significant increase in pollutant emissions (Ivano-Frankivsk Regional State Administration, 2023). Among them, dioxide and other sulphur compounds stand out, with a total volume

of 104,884.9 tons (t). This demonstrates the uneven impact of industrial pollution on different districts of the region, with the highest figures in the Ivano-Frankivsk District – 103,487.9 t, in contrast to the Kosiv District, where no sulphur dioxide emissions were recorded (Table 1).

**Table 1.** Dynamics of air emissions in Ivano-Frankivsk Region, kt

Years	Air emissions			Emissions density per 1 km <sup>2</sup> , t	Emissions per person, kg
	Total	Including			
		Stationary sources	Mobile sources		
2017	198.3	198.3	-	14.2	143.8
2018	221.4	221.4	-	15.9	161.0
2019	205.02	205.02	-	14.7	149.6
2020	178.1	140.4	37.7	-	-
2021	210.3	172.4	37.9	-	-
2022	152.3	152.3	-	-	-

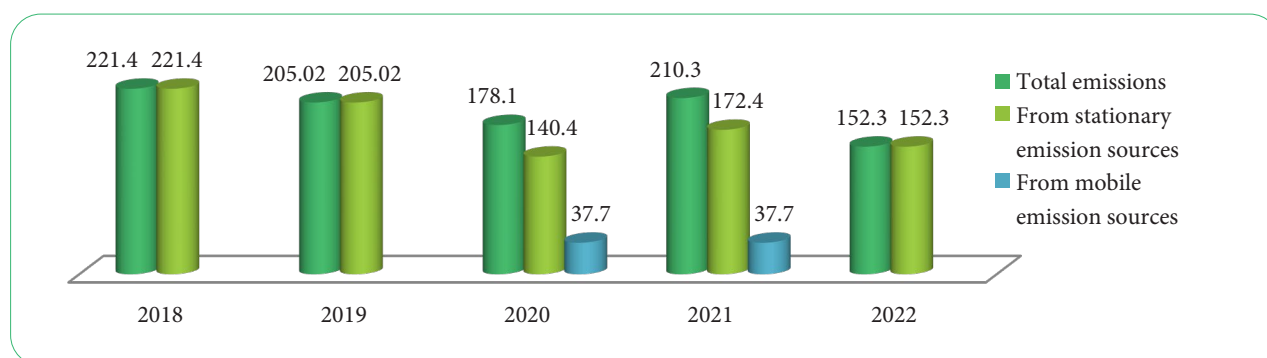
**Source:** made by the author based on Ivano-Frankivsk Regional State Administration (2022; 2023)

Thus, as can be seen from Table 1, in 2017, the volume of emissions was recorded at 198.3 kt, which indicates a significant burden on the ecological system due to the activities of stationary sources of pollution. The emission density indicator was 14.2 t per square kilometre, and the estimated emissions per person were 143.8 kg, demonstrating a high level of anthropogenic impact. In the following year, 2018, there was an increase in total emissions to 221.4 kt, which may be due to an increase in industrial production and insufficient effectiveness of emission control measures. The emission density increased to 15.9 t per square kilometre, and emissions per person reached 161 kg, indicating a further deterioration in the environmental situation.

In 2019, there was a slight decrease in emissions to 205.02 kt, which may be the result of the implementation of certain environmental measures and production optimization. The emission density decreased to 14.7 t per square kilometre, and the level of emissions per person decreased to 149.6 kg. In 2020, a significant decrease in total emissions was recorded to 178.1 kt, which was likely due to a decrease in economic activity as a result of the

COVID-19 pandemic. For the first time, emissions from mobile sources amounted to 37.7 kt, emphasizing the importance of controlling emissions from road transport. 2021 is characterized by another increase in emissions to 210.3 kt, of which 172.4 kt are from stationary sources and 37.9 kt from mobile sources. This growth can be interpreted as the restoration of production capacity after a period of restrictions. However, 2022 showed a noticeable decrease in emissions to 152.3 kt, which may indicate the successful implementation of environmental measures and strategies aimed at reducing pollutant emissions, as well as a change in the structure of the region's economy towards more environmentally sustainable development. The dynamics of air emissions is shown in Figure 1.

Thus, fluctuations in pollutant emissions have a direct impact on the environmental status of the region's tourism resources. A significant increase in emissions in 2021 indicates the need to strengthen pollution control measures and develop sustainable tourism. Table 2 shows detailed information on emissions of certain pollutants by stationary sources of pollution by districts.



**Figure 1.** Dynamics of air emissions in Ivano-Frankivsk Region for 2018-2022, kt

**Source:** compiled by the author based on data from Ivano-Frankivsk Regional State Administration (2023)

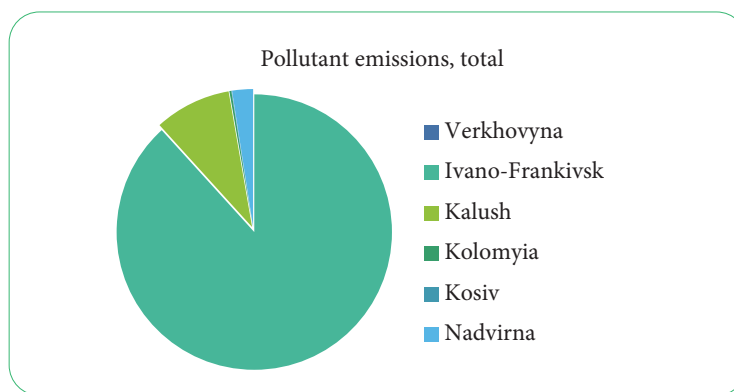
**Table 2.** Emissions of certain pollutants into the atmosphere by stationary sources of pollution by regions, 2022

Region	Pollutant emissions in total	Including						
		Dioxide and other sulphur compounds	Nitrogen compounds	Methane	Carbon oxide	Substances in the form of suspended solids	Non-methane volatile organic compounds	Additionally, carbon dioxide emissions, kt
Region	152,259.2	104,884.9	12,817.8	6,381.5	2,880.8	20,537.3	4,626.2	10,044.8
Verkhovyna	6.1	2.1	0.9	-	3.1	0.0	-	-
Ivano-Frankivsk	139,244.4	103,487.9	11,151.0	2,220.9	1,413.5	19,429.3	1,477.1	9,559.7
Kalush	8,688.0	1,360.2	1,099.0	2,028.1	1,062.9	962.4	2,112.0	410.0
Kolomyia	322.3	5.4	66.9	32.6	134.0	67.4	15.3	11.8
Kosiv	214.8	0.0	34.4	136.6	22.4	0.0	21.4	5.1
Nadvirna	3,783.6	29.3	465.6	1,963.3	244.9	78.2	1,000.4	58.2

Source: made by the author based on Ivano-Frankivsk Regional State Administration (2023)

Analysing the statistical data for 2022 on emissions of certain pollutants into the air by stationary sources of pollution in the districts of the Ivano-Frankivsk Region, it can be stated that the total amount of emissions amounted to 152,259.2 t. Among this volume, the dominant pollutants are sulphur dioxide and other sulphur compounds with a value of 104,884.9 t, which emphasizes their significant role in shaping the environmental load on the region's atmosphere. Nitrogen compounds, with a volume of 12,817.8 t, and methane, with an indicator of 6,381.5 t, also have a significant impact on air quality. Emissions of carbon

monoxide and suspended particulate matter amounted to 2,880.8 and 20,537.3 t, respectively, indicating their presence as pollution factors. Non-methane volatile organic compounds and carbon dioxide, with volumes of 4,626.2 and 10,044.8 t, respectively, complement the picture of anthropogenic impact on the region's atmosphere. There is a significant territorial heterogeneity in the distribution of emissions. Ivano-Frankivsk District makes the largest contribution to total emissions with 139,244.4 t. Kalush District with 8,688.0 t of emissions is also a significant source of pollution, in particular through industrial enterprises (Fig. 2).



**Figure 2.** Structure of the ratio of pollutant emissions in Ivano-Frankivsk Region, 2022

Source: made by the authors

The high emissions of pollutants in Ivano-Frankivsk District reflect potential environmental risks that could have a significant impact on the region's tourism sector. On the other hand, areas with lower emission rates, such as Kolomyia District and Kosiv District, where air pollution levels are much lower, have greater potential for tourism development, especially ecotourism. This is due to the fact that higher air quality and better environmental conditions are attractive to tourists looking for

places to relax and recuperate in a natural environment. To fully understand the impact of the environmental situation on tourism development in the Ivano-Frankivsk Region, it is important to analyse the main air pollutants based on the types of economic activity, as this will allow identifying specific sources of pollution and understand how different sectors of the economy affect air quality and, consequently, the tourism potential of the region (Table 3).



**Table 3.** Air pollutant emissions by type of economic activity in 2022

No.	Type of economic activity	Emission volumes by region	
		kt	percentage of the total
1	All types of economic activity, including:	152.3	100
1.1	Agriculture, forestry and fisheries	2.126	1.4
1.2	Mining and quarrying	5.460	3.5
1.3	Processing industry	4.725	3.1
1.4	Supply of electricity, gas, steam and air conditioning	136.4	89.5
1.5	Transport, warehouse management, postal and courier services	3.201	2.1
1.6	Other types of economic activity	0.388	0.4

**Source:** made by the author based on Ivano-Frankivsk Regional State Administration (2023)

The analysis of data on air pollutant emissions by type of economic activity in 2022 allows drawing important conclusions about the structure and scale of anthropogenic impact on the environment in a particular region. The total volume of pollutant emissions in the region amounted to 152.3 kt, with the main share being emissions from the supply of electricity, gas, steam and conditioned air, which accounted for 89.5% of total emissions. The significant contribution of the electricity, gas, steam, and air conditioning sectors to total pollutant emissions (136.4 kt) emphasizes the critical role of this sector in the anthropogenic load on the region's atmosphere. This distribution of emissions points to the need to focus on reducing emissions in the energy sector to improve the environmental situation in the Ivano-Frankivsk Region. According to the authors, reducing emissions from the supply of electricity, gas, steam, and air conditioning should be a key priority in environmental policy. This approach will not only improve the state of the atmosphere but will also help create favourable conditions for tourism development. A clean environment is a fundamental factor in attracting tourists, especially in the context of the growing demand for environmentally friendly and sustainable tourist destinations.

As part of the study of the interaction between the main sectors of the economy that affect the level of pollutant emissions and the dynamics of tourism development in the Ivano-Frankivsk Region, it is important to analyse the contribution of these sectors to the formation of the tourist attractiveness of this region. The electricity, gas, steam, and air conditioning sector, as a major polluter, has a significant impact on environmental quality, which in turn is a determinant of a region's attractiveness to tourists. Increased levels of pollution associated with this sector can deter potential visitors, especially those looking for vacation destinations with clean air and a natural environment. Thus, modernization of the energy infrastructure and transition to more environmentally friendly energy sources can help preserve natural tourist resources and improve the overall attractiveness of the region.

Other sectors, such as agriculture, forestry and fisheries, mining and processing, and transportation, although they have lower emissions, still have an impact on the region's environmental status. For example, pollution caused by the extractive industry can negatively affect water and soil quality, which is important for the ecosystem and landscape that attracts tourists. On the other hand, effective management of emissions and pollution from agriculture can contribute to the preservation of natural landscapes and biodiversity, which is key to ecotourism.

Therefore, ensuring sustainable development in all these areas is of strategic importance for the development of tourism in the Ivano-Frankivsk Region. This involves not only taking measures to reduce pollution but also developing environmentally sustainable infrastructure that can attract more tourists and help maintain the natural and cultural heritage of the region. In addition, the importance and quality of the region's water resources should be investigated. Water resources are a key element in ensuring sustainable tourism, given their importance for natural ecosystems, recreational areas, and overall ecosystem health. The quality of water in rivers, lakes, and other bodies of water directly affects the quality of the environment and the health of local communities and tourists. Water pollution can come from a variety of sources, including industrial discharges, agricultural runoff, and urban wastewater, which points to the need for an integrated approach to water management. Water resources play an important role in the development of various types of tourism, such as fishing, water sports and nature observation. The latest data released by the Ivano-Frankivsk Regional State Administration for 2022 reflects changes in wastewater discharges to surface water bodies in the region. The total volume of wastewater discharged decreased from 60.552 mln m<sup>3</sup> in 2021 to 55.048 mln m<sup>3</sup> in 2022, which demonstrates a positive trend in reducing discharge volumes (Ivano-Frankivsk Regional State Administration, 2023). Table 4 shows the main indicators of pollutant discharges into water bodies and wastewater treatment.

**Table 4.** Discharge of pollutants into water bodies and wastewater treatment in 2022

Region	Waste water discharged into surface water bodies, mln m <sup>3</sup>									
	Total		Including							
			without treatment		insufficiently treated		normatively clean (without treatment)		normatively cleaned at treatment facilities	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Ivano-Frankivsk	60.552	55.048	0.027	-	1.279	0.198	6.760	7.806	52.485	47.044

Source: created by the authors based on Ivano-Frankivsk Regional State Administration (2023)

An analysis of the list of water users that discharged polluted wastewater into surface water bodies in 2022 in Ivano-Frankivsk Region indicates a critical need to monitor and control the activities of enterprises in various sectors of the economy in the context of their impact on water resources. Of particular interest is the activity of the processing industry and the water supply, sewerage, and waste management sectors as the main sources of insufficiently treated wastewater. Specifically, Uniplyt, a limited liability company specializing in the production of plywood, wood boards and veneer panels, discharged 0.093 mln m<sup>3</sup> of insufficiently treated wastewater, which is a significant share of the total amount of pollution in this area of activity. This demonstrates the need to improve the treatment processes at production facilities and increase the efficiency of treatment facilities.

In the context of water supply and sewerage, there are such enterprises as Tlumachcomunservis and Verkhovyna Water Supply and Sewerage Enterprise, with insufficiently treated wastewater volumes of 0.059 mln m<sup>3</sup> and 0.020 mln m<sup>3</sup>, respectively. The article highlights the need to strengthen control over the quality of wastewater treatment discharged into water bodies and modernize treatment technologies. The activity of medical institutions, in particular the municipal non-profit enterprise Dolyna Multidisciplinary Hospital, with a volume of insufficiently treated wastewater of 0.004 mln m<sup>3</sup>, requires additional measures to improve treatment systems to minimize the potential risk to human health and the ecosystem. The Syniohora National Nature Park, which is represented in the botanical gardens, zoos, and nature reserves segment, also has insignificant discharges of insufficiently treated water, which indicates the importance of ensuring adequate treatment by institutions that use natural resources for their activities. Thus, to ensure the sustainable development of tourism in the Ivano-Frankivsk Region, it is necessary to focus on reducing the level of pollution of water bodies, which requires a comprehensive approach, including the modernization of existing wastewater treatment systems, the introduction of new technologies and methods of treatment, as well as the development and implementation of water management strategies that meet modern environmental standards. Given the importance of these factors, it becomes apparent that effective measures to improve the quality of water resources in the Ivano-Frankivsk Region are needed.

Analysing the main factors of anthropogenic impact on land resources and soils in the Ivano-Frankivsk Region

with updated data for 2022, it becomes clear that these factors continue to be crucial for the sustainable development of tourism in the region. The current state and ratio of land indicate significant challenges, especially in the foothill and lowland areas, where the level of agricultural development continues to be high, varying from 54 to 77%. The overall plowing of these territories indicates that the limits of ecological balance are exceeded, which emphasizes the existing threats to environmental sustainability. It is observed that the high plowing of land, in particular in Kolomyia District and Ivano-Frankivsk District, where it is 63.5-67.3% and 51-57.3%, respectively, indicates the intensive use of land resources for agricultural purposes. Such intensive use can lead to soil degradation and reduced fertility, which negatively affects the environmental stability and biodiversity of the region. This situation poses a significant threat not only to the environmental safety of the region but also to its tourist attractiveness. Healthy ecosystems and preserved natural landscapes play a key role in tourism development, as they are the foundation for various types of tourist activities and recreation.

In the context of sustainable tourism development, it is important to pay attention to the need for rational and balanced use of land resources, the introduction of organic farming methods and the preservation of natural landscapes. Efforts should be aimed at minimizing anthropogenic impact, which will preserve the ecological stability of the region, its biodiversity, and, as a result, its tourist attraction (Ivano-Frankivsk Regional State Administration, 2023). Territorial differences in land use in the Carpathians and adjacent areas, which are caused by the zonation of natural conditions and population settlement patterns, affect the cultivation of crops. The current trend toward intensive land exploitation to maximize production often negates efforts to preserve soil and restore its fertility. Given these factors, it is important to implement measures aimed at the sustainable development of agricultural and other land uses, which would include soil conservation practices, reducing soil degradation and maintaining biodiversity. This will not only increase the environmental sustainability and resilience of the region but will also promote tourism development, ensuring the preservation of natural landscapes and a favourable environment for recreation and leisure.

It is advisable to conduct a detailed analysis and calculations of air pollutant emissions in the Ivano-Frankivsk Region, given their significant impact on the environmental situation and the development of the region's tourism

industry. For this purpose, data published by the Main Department of Statistics was used, which reflects the volume of pollutant emissions over the past few years. Data for 2021 is used for the calculations (Ivano-Frankivsk Regional State Administration, 2022). The availability of comprehensive information from previous years contributes to the development of more informed and targeted environmental management strategies. Without a complete picture of the anthropogenic impact, including all possible sources of pollution, it is difficult to prioritize actions to reduce the negative impact on the environment. In addition, an adequate assessment of the environmental situation requires data from various sources and sectors of the economy. The lack of data on certain categories of pollutants can lead to an incomplete or distorted view of the environmental challenges faced by the region and, accordingly, to the development of ineffective solutions. According to the data, total emissions amounted to 210.3 kt. The calculation for stationary sources of pollution is as follows:

$$(172.4 \text{ kt}/210.3 \text{ kt}) \cdot 100 = 81.98\% (210.3 \text{ kt} / 172.4 \text{ kt}) \cdot 100 = 81.98\%.$$

This means that stationary sources of pollution, such as factories, power plants, and other industrial facilities, account for approximately 82% of total air emissions in the region. Similarly, for mobile sources of pollution (road transport and other vehicles), the calculation looks like this:

$$(37.9 \text{ kt}/210.3 \text{ kt}) \cdot 100 = 18.02\% (210.3 \text{ kt} / 37.9 \text{ kt}) \cdot 100 = 18.02\%.$$

This shows that mobile sources contribute about 18% to the total amount of pollutant emissions. Based on these data, it is important to conduct an in-depth analysis of the impact of anthropogenic activities on the air in the Ivano-Frankivsk Region, as well as to assess the potential consequences for the development of the tourism industry. In 2021, air pollutant emissions amounted to 210.3 kt, which is 15.3% more than in the previous year. Of these emissions, 172.4 kt, or approximately 82%, came from stationary sources, and the remaining 18% (37.9 kt) from mobile sources, mainly road transport. These figures indicate a significant impact of economic activity on air quality in the region. For example, a large share of emissions from stationary sources comes from electricity, gas, steam, and air conditioning companies, which is evidence of the dependence of the region's environmental condition on the energy sector. Burshtyn TPP of DTEK Zakhidenergo remains the largest polluter, accounting for 84.4% of emissions in the region.

Air pollution in the Ivano-Frankivsk Region affects the quality of life of the population and tourists, reducing the region's attractiveness for recreation and tourist visits. Air purity is a key aspect of building tourism potential, especially in an environment where the emphasis is on ecological and nature-based tourism. Increased pollutant emissions can have a destructive impact on the region's ecosystems,

contributing to their degradation and climate change. Such processes jeopardize the stability of the tourism sector, which depends on natural resources and is defined by the beauty of natural landscapes. Therefore, the need for effective control and management of pollutant emissions is of key importance for maintaining environmental safety and promoting sustainable tourism development in the region. An integrated approach that includes the modernization of industrial enterprises, the use of environmentally friendly technologies, the development of eco-friendly transport, and the active involvement of the public and representatives of the tourism industry in solving environmental problems is an integral part of ensuring the harmonious development of tourism in the Ivano-Frankivsk Region.

According to the data obtained in the course of the study, the dominant role in the formation of emissions in the Ivano-Frankivsk Region is played by energy sector enterprises, in particular, those engaged in the supply of electricity, gas, steam and air conditioning. Thus, it is important to develop and implement strategies aimed at reducing environmental pollution. In the context of ensuring sustainable tourism development in the Ivano-Frankivsk Region, a key aspect is the implementation of a set of measures aimed at improving the region's environment. The primary task is to reduce emissions of pollutants into the air, which is possible through the modernization of industrial processes and the transition to the use of environmentally friendly, alternative energy sources. This step will not only reduce the negative impact on the environment but also improve the quality of life of the local population and tourists. At the same time, the development of ecotourism in the region will ensure the preservation of the unique natural resources of the Ivano-Frankivsk Region. The promotion and development of ecotourism play an important role in fostering a sustainable attitude towards nature, both among the local population and among visitors to the region. Particular attention should be paid to the introduction of environmental standards and certifications for tourism enterprises and organizations. This will not only help improve the environmental image of the region but also create additional incentives for the development of the tourism business on the principles of sustainability and environmental responsibility.

## ✓ Discussion

In the context of studying sustainable tourism development and its interaction with environmental challenges in the Ivano-Frankivsk Region, it is important to note the contribution of several modern scientific works that consider aspects of environmental sustainability, carbon footprint, and the impact of pollution on tourism. For example, M.S. Mancini *et al.* (2022), in their article, reveal the development and monitoring of the sustainability of ecotourism packages in protected areas of the Mediterranean, demonstrating a practical approach to the implementation of sustainable tourism. A. Rico *et al.* (2019) and P. Osorio *et al.* (2023) analyse the carbon footprint of



tourism in Spain. A. Rico *et al.* (2019), in particular, take into account even tourists who stay in the city for no more than one night, which turned out to be significant for assessing the overall environmental impact of tourism. Y.-Y. Sun *et al.* (2020) review methods for assessing the carbon footprint of tourism, providing valuable insights for strategies to reduce the environmental impact of tourism activities. In addition, Y.-Y. Sun & C.-M. Hsu (2019) previously found a direct correlation between the increase in the number of tourists and the increase in the water footprint. Together, these studies form a comprehensive view of the problem of tourism's impact on the environment and emphasize the need to integrate sustainable practices into the tourism industry to ensure its long-term development with minimal negative impact on the environment. Especially in the Ivano-Frankivsk Region, where natural and cultural resources are key to the region's attractiveness, it is important to pay special attention to environmental initiatives and sustainable development strategies. The topic of the carbon footprint of tourism, considered by P. Dorta Antequera *et al.* (2021) through the prism of inbound tourism, in particular emissions from air travel, and J. Koiwanit & V. Filimonau (2021) on hotel tourism in Thailand, respectively, also resonate in this study. However, this article focuses more on emissions from the energy sector and non-aviation transport in the Ivano-Frankivsk Region, expanding the scope of the discussion to a wider range of pollution sources, which emphasizes the unique approach that includes a comprehensive analysis of the impact of different economic sectors on the environmental sustainability of the region, which is important for formulating more effective strategies to reduce carbon impact.

According to the latest statistics from the United Nations World Tourism Organization (UNWTO), international tourism rebounded significantly in 2022, showing double the growth of the previous year, with more than 900 mln international arrivals (UNWTO 2022: A year in review, 2022). This growth indicates that the industry has recovered to 63% of the pre-pandemic level of 2019, reflecting significant adaptation and recovery from the global crisis caused by the COVID-19 pandemic. However, along with its economic benefits, tourism can also cause several environmental problems. In their study, O. Dovgal & L. Bezuhla (2020) focus on the analysis of potential risks that may affect the development of rural tourism in the region. The study highlights the importance of rural tourism as a component of the region's economy. The author proposes strategic directions for creating an ecotourism model of the region's state to ensure sustainable development of rural tourism. The author pays special attention to the need for an integrated approach to solving environmental problems, which includes both state regulation and attraction of investments in environmentally friendly technologies. Ecotourism in the Mediterranean was also studied by M.S. Mancini *et al.* (2018). The authors created a methodology for measuring environmental sustainability for ecotourism products. The authors provide an example of

surveys that can be used to determine the ecological footprint of the tourism sector through further analysis.

The conclusions drawn by L.-C. Lee *et al.* (2021) regarding the impact of tourism on water resources in China are particularly interesting. The researchers found that the largest indirect impact on the water footprint is the supply of food, which, accordingly, occurs by various modes of transportation. Scientists E. Skrimizea & C. Parra (2019), in turn, emphasize the lack of research on the tourist impact on the waters of the popular Greek islands, which is caused, in particular, by the geographical remoteness of the islands from the mainland. In a sense, this is similar to the problem of the narrowly focused analysis of the Ivano-Frankivsk Region in this study. S. Villa *et al.* (2020) note that seasonal tourism at ski resorts in the Alps has a significant impact on the quality of drinking water in the region. The distinguishing aspect is that S. Villa *et al.* (2020) focus on the pollution of alpine waters caused by tourists themselves, pharmaceutical products, and personal care products, while this article examines the discharge of pollutants into water bodies in Ivano-Frankivsk Region by local enterprises, which has a direct negative impact on both the ecological state and the tourist attractiveness of the region.

The research conducted by I. Klymchuk *et al.* (2022) and K. Matiyiv *et al.* (2022) significantly contributes to the understanding of the necessity of preserving natural resources. Through an analysis of the quality of soil and surface water in a mountain tourist region, they highlight the importance of maintaining the cleanliness of water resources for ecological sustainability and the sustainable development of tourism. The studies emphasize the need to implement a comprehensive approach to environmental protection in areas of tourist activity, which should include water monitoring, the development of water treatment technologies, and educational programmes to engage local communities and tourists in water conservation.

As can be seen, the environmental impact of tourism is of considerable interest in the global scientific community, as reflected in the study by U. Phumalee *et al.* (2018), which highlights the impacts of tourism activity on Mu Ko Surin National Park. Similarly, this study focuses on analysing the impact of tourism on air pollution in the Ivano-Frankivsk Region, exploring both direct and indirect effects that may have far-reaching implications for the region's sustainable development. Both studies open up a discussion on the need to integrate environmental sustainability into tourism development strategies, which is critical to ensuring the harmonious coexistence of humans and the natural environment. The aspect of sustainability assessment and monitoring, which is central to the research of Y. Shi *et al.* (2020), and M.S. Mancini *et al.* (2022), reflects the focus of this article on the need to systematically assess the environmental impact of tourism. Thus, comparing the study with other work in the field emphasizes the importance of continuing research to better understand the interaction between tourism and the environment. Given the similarities in the focus on environmental impact and

carbon footprint, as well as the need to assess sustainability, the study complements existing research by offering a unique perspective on these important issues in the context of the Ivano-Frankivsk Region.

The differences between the study and other scientific works in the field of sustainable tourism development and its interaction with environmental challenges emphasize the unique contribution of the work to understanding the specifics of the problem at the regional level, in particular in the context of the Ivano-Frankivsk Region. One of the differences is the regional focus of the study. By focusing on the Ivano-Frankivsk Region, the study provides a detailed understanding of the impact of tourism on the environmental condition of a specific region, which differs from the more general approaches of other studies. This regional focus allows for a deeper analysis of the local ecosystems, economic features, and social aspects that affect sustainable tourism development, providing valuable insights that can be used to develop more targeted sustainability strategies. Another significant difference lies in the analysis of the impact that the energy sector and mobile sources of pollution have on the environmental state of the region. In contrast to the part of the research that focuses mainly on direct emissions from tourism activities, this study broadens the scope to include the impact of a wider range of pollution sources, allowing for a more comprehensive understanding of the environmental challenges facing the region and formulating appropriate recommendations to reduce the negative impact of not only tourism but also other key sectors of the economy.

In addition, the difference lies in the integration with other sectors of the economy in the study of the impact of tourism on the environment. Through the interconnection with sectors such as energy and transportation, the study goes beyond the traditional analysis of tourism, emphasizing the importance of cross-sectoral cooperation to achieve sustainable development, which in turn reinforces the idea that sustainable tourism development cannot be achieved without taking into account the impact and capabilities of other sectors of the economy, which will make an important contribution to the development of comprehensive strategies to reduce the environmental burden on the region.

## ✔ Conclusions

Ivano-Frankivsk Region has significant tourism potential based on the diversity and uniqueness of its natural resources. However, the environmental situation in the region poses a serious challenge to this development. A significant increase in air pollutant emissions, especially in large and industrialized areas such as Ivano-Frankivsk, is

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taking its toll on air quality and the overall environment. This not only reduces the aesthetic value of natural landscapes but also poses real threats to the health of tourists and the local population. The analysis of data on air pollutant emissions, wastewater discharges, and the impact of these factors on the region's land resources has highlighted the critical role that environmental safety plays in ensuring sustainable tourism development.

The significant increase in emissions of pollutants, including sulphur dioxide and other harmful compounds, by 15.3% in 2021 compared to the previous year indicates a rise in the environmental burden on the atmosphere. Of particular concern is the high share of emissions from stationary sources, such as energy sector enterprises, which accounts for about 82% of total emissions. On the other hand, a significant decrease in emissions in 2022 to 152.3 kt indicates the successful implementation of environmental measures and strategies aimed at reducing pollutant emissions and changing the structure of the region's economy towards more environmentally sustainable development. The analysis of wastewater discharges showed that the volume of wastewater discharged into surface water bodies decreased from 60.552 mln m<sup>3</sup> in 2021 to 55.048 mln m<sup>3</sup> in 2022, which demonstrates a positive trend in reducing discharges. A significant portion of these discharges do not meet environmental standards, which emphasizes the need to improve wastewater treatment systems and strengthen water quality control.

In terms of land resources, intensive agricultural use of land, especially in the foothills and plains, leads to soil degradation and reduced fertility. This threatens not only the environmental sustainability of the region but also its tourism potential. Thus, it is important to implement sustainable land use practices and preserve natural landscapes. As part of future research, the priority is to conduct a comprehensive analysis of the dynamics of pollutant emissions into the air by territorial distribution within the Ivano-Frankivsk Region, which will allow the identification of areas with increased concentrations of pollutants and the development of targeted programmes for their remediation. Particular attention should be paid to analysing the impact of atmospheric pollution on public health and tourist flow, as this plays a critical role in shaping the region's image as a safe and attractive vacation destination.

## ✔ Acknowledgements

None.

## ✔ Conflict of Interest

None.

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## Оцінка екологічного стану туристичних ресурсів Івано-Франківської області

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✔ **Анотація.** З огляду на стрімке зростання впливу туризму на світову економіку, а також екологічні проблеми, які це може створювати, оцінка екологічного стану туристичного сектору набуває особливої актуальності. Мета дослідження полягала в аналізі екологічного стану Івано-Франківської області та його впливу на привабливість регіону для туристів, а також у розробці пропозицій зі сталого розвитку туризму з огляду на екологічні аспекти. Застосовувалися різноманітні методи, зокрема статистичний аналіз даних щодо викидів забруднювальних речовин. Проаналізовано та надано оцінку впливу промисловості та інших галузей на екологічний стан за допомогою методу аналізу. Проаналізовано динаміку викидів в атмосферне повітря за роками та їх вплив на екологічний стан регіону, з акцентом на забруднення діоксидом сірки та іншими сполуками. Окрім атмосферних викидів, розглянуто проблематику скидання забруднюючих речовин у водні об'єкти та вплив на якість води, що має значення для розвитку туризму. Встановлено, що викиди забруднюючих речовин значно впливають на якість атмосферного повітря, що визначає туристичний потенціал області, особливо в контексті розвитку екологічного туризму. Підкреслено необхідність реалізації заходів для зниження рівня забруднення, розвитку сталого туризму та впровадження екологічних стандартів у туристичній індустрії. Встановлено шляхи покращення екології регіону та надано відповідні пропозиції, що включають зменшення викидів забруднюючих речовин, а також застосування інноваційних технологій та підходів у галузі екологічної безпеки та забезпечення сталого розвитку туризму в Івано-Франківській області. Практична цінність дослідження полягає у виявленні конкретних напрямків вдосконалення екологічної політики регіону, які вимагають практичного впровадження для поліпшення екологічного стану Івано-Франківської області, що підкреслює важливість інтегрованого підходу у вирішенні екологічних викликів

✔ **Ключові слова:** екологічні виклики; безпека галузі; вплив промисловості; якість атмосферного повітря; стає використання природних ресурсів