Conference Proceedings "Innovative development of agricultural business and rural areas", 3 – 4.10.2024, Sofia
DOI: https://doi.org/10.37075/idara.2024.05

ECOLOGICAL RISK ASSESSMENT IN BULGARIA

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Abstract
The pollution of natural resources in Bulgaria and the pressure on ecosystems make environmental risk assessment a necessary tool to overcome or reduce the environmental challenges in the country. Many environmental challenges make the topic of ecological risk assessment in Bulgaria actual and of significant public importance. The causes of ecological risks are complex. With increasing environmental challenges, the assessment of these risks become more complicated and comprehensive and the assessment process in both global and regional contexts is dynamic, developing and changing. Risk assessment is a necessary tool for identifying environmental threats in order to be undertaken a response regarding them. The aim of the paper is to assess the ecological risk in Bulgaria, on this basis to identify the types of ecological risks and outline proposals for their prevention. The methodological framework of the article includes a theoretical review of ecological risk assessment, analysis of environmental indicators in Bulgaria for the period 2013 – 2022, assessment of environmental risks in Bulgaria based on a survey. The risk indicators that were assessed are contamination of land resources, contamination of water resources, air quality pollution, biodiversity damage, natural disaster, toxic waste contamination, radiation, pesticide contamination, extreme temperatures and climate change. On the basis of the analyses and assessments, generalized conclusions, proposals and recommendations for ecological risk reduction are prepared. Almost all environmental risks assessed are identified as critical, and the strategy that would be most appropriate to address critical risks is risk avoidance. The recommendations that are proposed are as follows: 1) at institutional level – implementation of systems for continuous monitoring of critical environmental indicators, developing early warning systems for natural disasters and climate change, supporting environmental projects and initiatives, and organizing educational campaigns to raise public awareness; 2) at business level – investment in fixed tangible assets with an environmental purpose, renewing facilities and equipment, investing in safe innovative green technologies, optimizing production processes and reducing production waste, building sustainable supply chains and incorporating sustainability into corporate social responsibility; 3) at community and the individual level – collective efforts involving education and awareness raising, sustainable urban planning, effective waste management, public participation and volunteering. These and other measures can help to promote environmental awareness among consumers, while at the same time to be supported policy decisions and initiatives that contribute to sustainable development. Implementing environmentally measures and activities at all levels – institutional, business and community in response to the threats would have a synergistic effect in terms of reducing ecological risk and overcoming environmental challenges.
Key words: ecological risk, assessment, environment
JEL: Q15, Q54

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Introduction

The environment is exposed to a multitude of ecological risks, the causes of which are most often complex. Ecological risk assessment is carried out to predict the probability of an event occurrence that would have an adverse ecological effect on individuals or ecosystems (Norton et all, 1992). Solomon and Sibley (2002) add that the purpose of ecological risk assessment is to predict the adverse effects on communities of species at places that are potentially exposed to contaminants and other harmful substances. Marinova (2023) perceives ecological risk assessment as a scientific study that assesses negative environmental impacts using facts and predictions. Chen et all (2013) relates ecological risk assessment to the probability of an adverse ecological situation occurring due to natural or anthropogenic processes that will adversely affect an ecosystem. Of interest is the view of Hope (2006), who considers ecological risk assessment in terms of the need to its development due to the intensifying environmental challenges. He argues that ecological risk assessment is changing as it moves from assessing negative impacts, which have mostly been spread spatially on a small territory in the past, to complex and comprehensive ecological assessments of impacts on entire populations and communities.

The pollution of natural resources in Bulgaria and the pressure on ecosystems make environmental risk assessment a necessary tool for overcoming or reducing environmental challenges in the country. Borisov, Saikov (2024) making a risk assessment, found that air pollution, waste management and climate change are the environmental risks that Bulgaria will face in the next decade. Dust, sulphur dioxide, nitrogen oxides, lead aerosols, ammonia, etc. are the main air pollutants in Bulgaria, with exceedances of the maximum allowable concentrations leading to environmental pollution and negative consequences for ecosystems and human health (Velikov, 2017). Penchev (2012) defines the air quality in certain regions and large settlements in Bulgaria as unsatisfactory. In addition to air pollution, contamination of water resources is also observed. Regardless of a positive trend of improving water quality, there are water bodies identified at risk, groundwater contamination with nitrates, and prerequisites for the emergence of water deficit in some areas of the country (MEW, 2023). The analysis of the socio-economic development of the country after its accession to the EU (2019) also considers risks related to biodiversity loss due to urban infrastructure development, intensive agricultural practices, and due to overexploitation of species of economic importance. All this and many other environmental challenges make the topic of ecological risk assessment in Bulgaria actual and of significant public importance.

Methodology

The aim of the paper is to assess the ecological risk in Bulgaria, on this basis to identify the types of ecological risk and outline proposals for their prevention.

The methodological framework of the paper includes a theoretical review of ecological risk assessment, analysis of environmental indicators in Bulgaria for the period 2013 – 2022, assessment of ecological risk in Bulgaria based on a survey. On the basis of the analyses and assessments, generalized conclusions and proposals for environmental risk reduction are prepared.

The risk assessment is based on a survey conducted in 2023 – 2024 year among 150 business organizations from different economic sectors, spread throughout the country. To assess the environmental risk, respondents evaluate the probability that the risk event will occur and the impact that is expected as a result of the event occurring.

Each environmental risk is rated on a scale of 1 to 5, with 1 – very low probability of occurrence and 5 – very high probability. In terms of impact, 1 is negligible impact and 5 is catastrophic.

On the basis of the risk assessment, a risk matrix is prepared, which contains the combination of probability and impact and enables the classification of ecological risks into critical risks (high probability and high impact), unforeseen risks (low probability and high impact), systematic risks (high probability and low impact), and irrelevant risks (low probability and low impact) (Operational Program for Regional Development, 2007). Figure 1 presents as the risk matrix, so the risk response matrix. According the risk response matrix if the risk is critical, so the response is to avoid the risk. For the unforeseen risk is used the strategy of mitigation, for the irrelevant risk the used strategy is risk acceptance and for the systematic risk – strategy for transferring the risk (Washington State Department of Transportation, 2014).

A risk rating is also calculated for each ecological risk as the multiplication between the probability and impact scores.

The following risk indicators were assessed:

- ✓ Contamination of land resources;
- ✓ Contamination of water resources;
- ✓ Air quality pollution;
- ✓ Biodiversity damage;
- ✓ Natural disaster;
- ✓ Toxic waste contamination;
- ✓ Radiation;
- ✓ Pesticide contamination;
- ✓ Extreme temperatures and climate change.

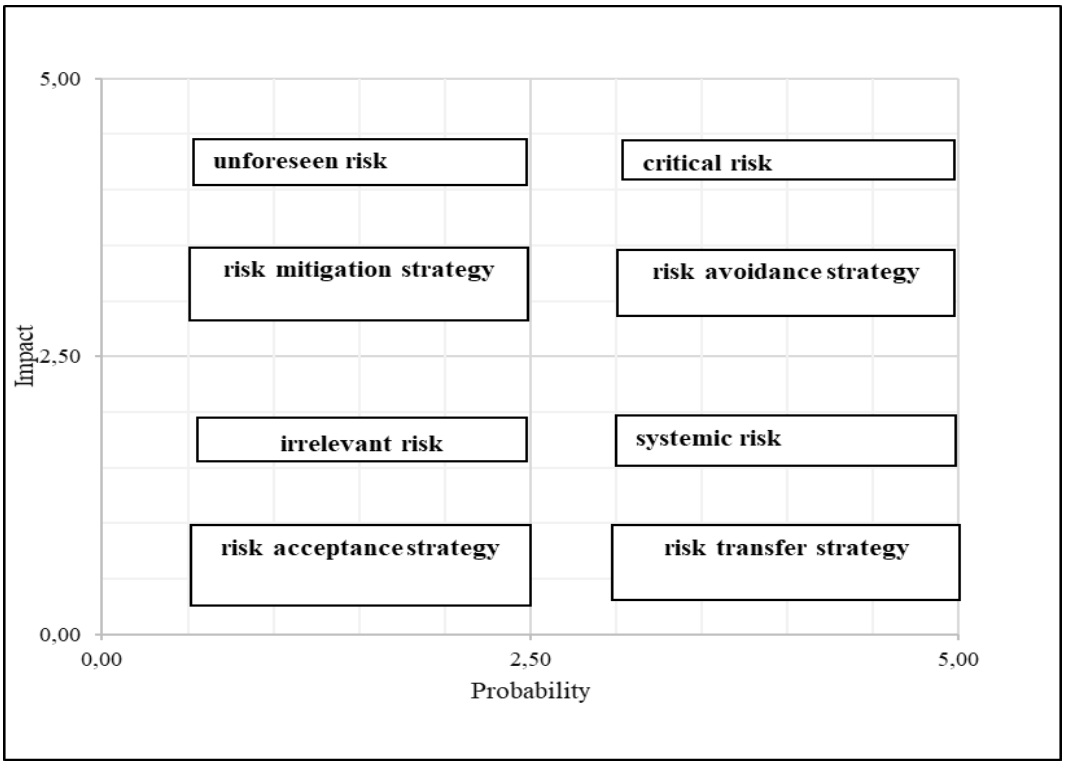

Figure 1. Risk Matrix and risk response matrix

Source: adapted by Operational Program for Regional Development, (2007), Methodology for risk assessment and risk management in relation to the internal control procedures of the OPRD and Washington State Department of Transportation, (2014), Project Risk Management Guide

Analysis of ecological risk and risk assessment in Bulgaria

Table 1 presents data for various environmental indicators in Bulgaria over the period 2013-2022. During the period under consideration, carbon dioxide emissions show fluctuations. The highest level of emissions is in 2015 with 48,204 thousand tones, after which there is a gradual decrease until 2020 (36,644 thousand tones). In 2021 and 2022, emissions increased again to 42,425 and 46,994 thousand tones, respectively. The amount of municipal waste generated over the period analyzed ranges from 2,829 thousand tones to 3,193 thousand tones, with no increasing or decreasing trends. There is a clear downward trend in the amount of wastewater discharged without treatment, from 177 million m^3 in 2013 to 119 million m^3 in 2022. This indicates an improvement in wastewater management over the years. The data on chemical, hazardous waste and other pollutions varies considerably, with 19 cases in 2013 and then decreasing in subsequent years to reach a minimum

of 1 – 2 cases in 2017 – 2018. The disturbed territory in 2021 and 2022 is 471 and 472 sq. km., respectively.

Table 1. Environmental indicators in Bulgaria for the period 2013 – 2022

Year	Carbon dioxide, thousand tones	Municipal waste generated, thousand tones	Wastewater discharged without treatment, million cubic meters/year	Contamination with chemical substances, hazardous waste, municipal waste and others, number	Disturbed territory, sq. km.
2013	42,726	3,135	177	19	
2014	45,251	3,193	182	3	
2015	48,204	3,011	174	8	
2016	45,419	2,881	149	5	
2017	47,521	3,080	131	2	
2018	43,577	2,862	132	1	
2019	42,267	2,838	129	2	
2020	36,644	2,829	127	4	
2021	42,425	3,058	129		471
2022	46,994	3,157	119		472

Source: NSI, Infostat, Data for the period 2013-2022

Tables 2 and table 3 present the distribution of respondents who rated the probability of an indicator occurring, and the extent of its impact in terms of environmental risk. 29% of the respondents rate the probability of air quality pollution occurrence as very high, and a quarter of respondents consider the probability of occurrence of extreme temperatures and climate change to be very high. The probability of water pollution occurrence was rated as high by 28%, pesticide pollution (26%) and the occurrence of a natural disaster (22%). Around and above one third of the respondents considered the probability of occurrence of land resources contamination (41%), natural disaster (39%), water resources contamination (32%), extreme temperature and climate changes (32%) as medium. 29% of respondents rated the probability of occurrence of radiation as very low.

Table 2. Distribution of respondents' assessments of the probability of an environmental risk event occurrence, %

Risk	Probability				
	Very high	**High**	**Medium**	**Low**	**Very low**
Contamination of land resources	19	19	41	13	8
Contamination of water resources	21	28	32	14	5
Air quality pollution	29	19	29	18	6
Biodiversity damage	19	19	35	21	6
Natural disaster	14	22	39	19	5
Toxic waste contamination	11	17	29	28	15
Radiation	11	10	22	27	29
Pesticide contamination	15	26	28	23	9
Extreme temperatures and climate change	25	18	32	14	11

Source: own survey

A very small part of respondents (4 to 9%) considered that the impact of an environmental risk events would be insignificant. Critical impacts would be due to biodiversity damage (51%), land contamination (48%), pesticide contamination (39%), natural disaster (38%), extreme temperatures and climate change (38%).

Table 3. Distribution of respondents' assessments of the degree of impact when an environmental risk event occurs, %

Risk	IMPACT				
	Insignificant	**Almost insignificant**	**Critical**	**Highly critical**	**Catastrophic**
Contamination of land resources	5	15	48	27	5
Contamination of water resources	4	7	36	43	9
Air quality pollution	5	9	32	43	12
Biodiversity damage	5	15	51	23	5
Natural disaster	6	5	38	35	15
Toxic waste contamination	5	7	33	39	15
Radiation	7	5	26	42	19
Pesticide contamination	6	9	39	39	8
Extreme temperatures and climate change	9	10	38	35	8

Source: own survey

The impact of the contamination of water resources and air quality pollution were rated as highly critical by 43% of respondents, followed by the radiation (42%) and pesticide and toxic waste contamination by 39%. Impacts from radiation were rated as catastrophic by 19% of the respondents, followed by the occurrence of a natural disaster by 15% and toxic waste pollution by 15%.
The risk rating calculations show that there are no identified indicators with a high-risk rating (Table 4). Indicators such as Toxic Waste Contamination and Radiation have the lowest rating, while Water Resources Contamination and Air Quality Contamination have the highest rating. Natural Disasters and Extreme Temperature and Climate Change also stand out with a high overall rating due to the high impact and relatively high probability of occurrence.

Table 4. Environmental risk rating

Risk	Probability	Impact	Rating
Contamination of land resources	3,3	3,1	10,2
Contamination of water resources	3,5	3,5	12,0
Air quality pollution	3,5	3,5	12,1
Biodiversity damage	3,3	3,1	10,0
Natural disaster	3,2	3,5	11,2
Toxic waste contamination	2,8	3,5	9,8
Radiation	2,5	3,6	8,9
Pesticide contamination	3,2	3,3	10,5
Extreme temperatures and climate change	3,3	3,2	10,8

Source: own survey

The Ecological risk matrix is presented on figure 2.
The classification of types of risk according to the assessed indicators shows that almost all the indicators – Land Resource Contamination, Water Resource Contamination, Air Quality Contamination, Biodiversity Damage, Natural Disaster, Toxic Waste Contamination, Pesticide Contamination and Extreme Temperature and Climate Change are identified as critical risks (Figure 2). These indicators are assessed to have a high impact and a high probability of occurrence, requiring particular attention in risk management. Radiation risk falls on the boundary between critical and unforeseen risk types. It has a high impact and around and below medium probability of occurrence.

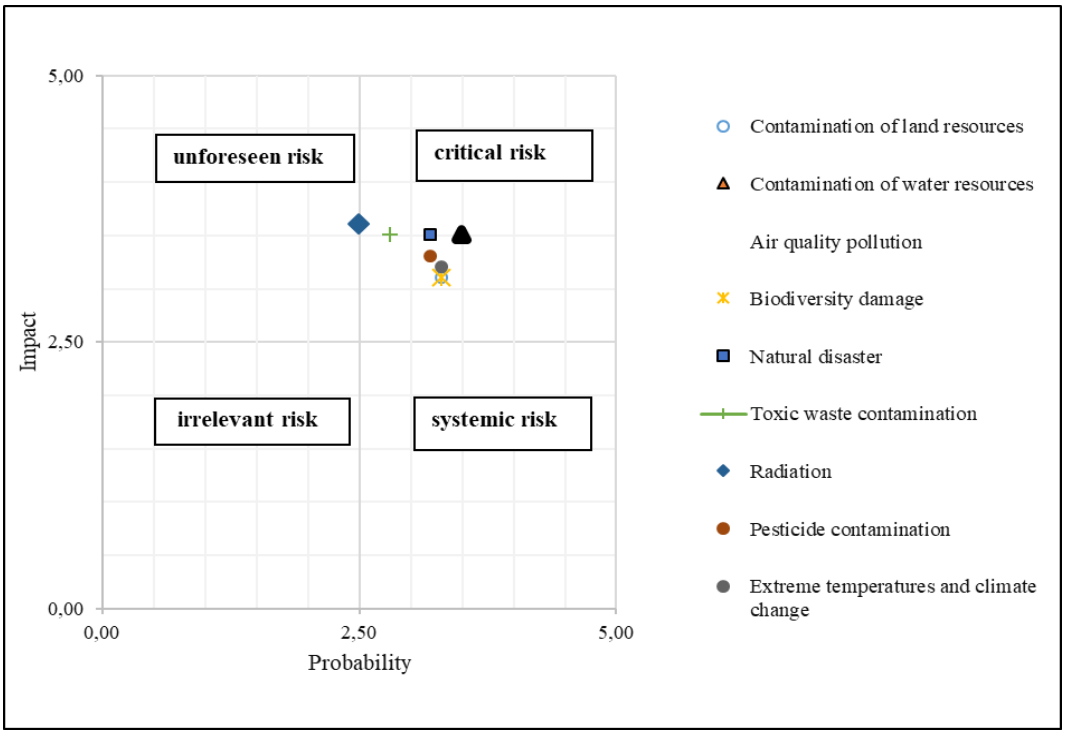

Figure 2. Environmental risk matrix

Source: own survey

Conclusion

Based on the analyses and assessments carried out, the following conclusions and recommendations could be made:

- ✓ In the period 2013 – 2022, different trends are observed in Bulgaria in terms of environmental indicators. Despite fluctuations in carbon dioxide emissions, there is an negative increasing trend. The amount of municipal waste remains unchanged for the period 2013 – 2022. Significant improvement is observed in wastewater management, with a reduction in the volume of wastewater. At the same time, incidents of chemical and hazardous waste pollution also follow a downward trend.
- ✓ Respondents rated air quality pollution and extreme climate change as the risks most likely to occur and with high impact. Water pollution and pesticide contamination are also reported to have a high probability of occurrence. At the same time, a significant part of the respondents considered the probability of occurrence of contamination of land resources and the occurrence of natural disasters as medium. Assessment indicates that the lowest probability of occurrence is of radiation risk.

- ✓ The majority of respondents rate the impact of environmental risks as significant and critical. The most critical impacts are identified as a consequence of biodiversity damage and land resource contamination, while water resource contamination, air pollution, radiation and pesticide contamination are also identified as events with highly critical impacts.
- ✓ Almost all environmental risks assessed are identified as critical, with the exception of radiation risk, which falls on the borderline between critical and unforeseen risks. Indicators such as Land Resource Contamination, Water Resource Contamination, Air Quality Contamination, Biodiversity Damage, Natural Disaster, Toxic Waste Contamination, Pesticide Contamination and Extreme Temperature and Climate Change were identified by respondents as critical environmental risks.
- ✓ Critical environmental risks have a high probability of occurrence and high impact, therefore, they require increased attention and monitoring of risk management activities.
- ✓ The strategy that would be most appropriate to address critical risks is risk avoidance. It should aim to eliminate the cause of the risk.
- ✓ At the institutional level, a risk avoidance strategy can be implemented by building systems for continuous monitoring of critical environmental indicators, developing early warning systems for natural disasters and climate change, supporting environmental projects and initiatives, and organizing educational campaigns to raise public awareness.
- ✓ At the business level, environmental risk avoidance strategy can take actions related to investment in fixed tangible assets with an environmental purpose, renewing facilities and equipment, investing in safe innovative green technologies, optimizing production processes and reducing production waste, building sustainable supply chains and incorporating sustainability into corporate social responsibility.
- ✓ At the level of community and the individual, an ecological risk avoidance strategy can be achieved through collective efforts involving education and awareness raising, sustainable urban planning, effective waste management, public participation and volunteering. These and other measures can help to promote environmental awareness among consumers, while at the same time to be supported policy decisions and initiatives that contribute to sustainable development.

The causes of ecological risks are complex. With increasing environmental challenges, the assessment of these risks become more complex and comprehensive and the assessment process in both global and regional contexts is dynamic, developing and changing. Risk assessment is a necessary tool for identifying environmental threats in order to be undertaken a response regarding them. Implementing environmentally measures and activities at all levels -institutional, business and community in response to the threats would have a synergistic effect in terms of reducing ecological risk and overcoming environmental challenges.

Acknowledgment

The paper was developed under the project "Development of rural territories in the conditions of transforming to sustainability economy" (RTtowardsSE). The project is financed by the Scientific research fund and is fulfilled by the Dimitar A. Tsenov Academy of Economics – Svishtov, in partnership with the University of National and World Economy – Sofia and the Economic university – Varna, 2021 – 2024, contract КП-06Н55/1, 15.11.2021.

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