

ANALYSING THE QUALITY OF THE PROCESS OF IDENTIFICATION AND EVALUATION OF NATURAL ENVIRONMENTAL RISKS ON THE MAIN INDUSTRIES IN THE REPUBLIC OF MOLDOVA

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ABSTRACT – In present times, in order to prosper and have a raised standard of living, human society needs a stable and healthy environment. Often, humans are not aware of the state or the evolution of the environmental components. To obtain an objective image and to be able to coordinate its daily activities, humans must identify and evaluate the sources of natural environmental risks. These processes of identification and evaluation offer the information needed in decision-taking and implementing risk management methods. For a pertinent evaluation of natural environmental risks and of the quality of the environment, this action has to be interdisciplinary, based on a complex system of investigation methods, procedures, techniques, feasible principles, and instruments.

Keywords: natural environmental risks, industry, environmental management, risk identification, risk evaluation, probability, vulnerability, impact, damages

INTRODUCTION

Uncertainty and risk are indispensable parts of our life, and there is no other domain where this statement could be more evident than the environment and the processes taking place within. It is known that human society is often exposed to very dangerous phenomena, which can be the result of natural processes, or may occur due to human activities. Because of irrational exploitation of natural resources and natural imbalances caused by economic activities, the number of natural disasters is rising continuously.

The situation at global level is offering a clear view about how vulnerable human society is in the face of environmental risks, because of increased dependence on the benefits brought by technical and scientific progress and by social, environmental, and demographical changes that take place. One of the most dangerous trends in present times is the increased frequency, intensity, and consequences of natural hazards.

NATURAL ENVIRONMENTAL RISKS SPECIFIC TO THE REPUBLIC OF MOLDOVA

Analysing statistical data available for the Republic of Moldova, we reached the conclusion that a large number of natural risks, especially the following natural risk phenomena, affects the country's territory: drought, floods, frost, earthquakes, hail, etc. All these natural risk phenomena, excepting earthquakes, have a progressive pattern. Agriculture and the industries using agricultural products as raw materials, namely the food and beverage industries, are the most vulnerable.

According to the data provided by the Civil Protection and Emergency Situations Service of the Republic of Moldova, 920 emergency situations occurred over the last three years; 230, representing 25% of the total, had natural origins, causing 99.6% of all property damage, most of them

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being induced by meteorological phenomena. At the same time, in 2012, the number of emergency situations of natural origin almost doubled, and over 78% of the losses had drought as a cause.

Table 1. *The number of emergency situations that took place in the Republic of Moldova, 2010-2012*

Class and type of emergency situations	2010		2011		2012	
	No.	Damages (€)	No.	Damages (€)	No.	Damages (€)
Total	70	20981893.75	58	7431987.5	102	99994056.25
Geological hazards						
Landslides	2	78375.0				
Meteorological hazards						
Storms	6	19962.5	3	108462.5	11	224287.5
Tempests					2	8850.0
Heavy snowstorms					1	
Thunderstorms	1	10743.75				
Heavy rainfall	15	1648637.5	12	1362268.75	12	963525.0
Heavy rainfall with hail	18	10052812.5	15	1491550.0	13	1971368.75
Heavy rainfall with gale	4	420681.25	1	475293.75	9	821350.0
Heavy rainfall with hail and wind	9	1608487.5	3	1447575.0	15	4296262.5
Continuous rainfall			1	10000.0		
Hail	7	1829850.0	23	2536837.5	38	13453606.25
Drought					1	78254806.25
Frost	2	31500.0				
Glaze	1	3187.5				
Strong layers of sleet	1					
Hydrological and hydro-geological hazards						
High levels of groundwater	3	15887.5				
Flooding	1	5261768.75				

Source: Statistical Indices for 2013, Civil Protection and Emergency Situations Service of the Ministry of Internal Affairs of the Republic of Moldova, <http://www.dse.md/node/16> (retrieved on 01.10.2013)

Since 1990, in the Republic of Moldova there have been nine natural disasters, among which five were floods. Most human lives were lost during the 1994 flood, when 47 people died. The highest material damages were recorded after the 2007 drought and reached approximately 406 million USD.

ANALYSIS OF THE NATURAL ENVIRONMENTAL RISK IDENTIFICATION AND EVALUATION PROCESS

In order to perform a scientific analysis of the current situation of natural environmental risk management and of the complex effects caused by the impact of a certain human activity on the environment, as well as the impact of natural hazards on human activities, we conducted a survey-based study. The questionnaire focuses on investigating the perception of domestic industries, especially in respect of administration methods and environmental risk management, but also on evaluating the steps involved in natural environmental risk management. This is a pilot, quantitative study, with a possible extrapolation on all economic activities in the Republic of Moldova. Data acquisition was done through survey-type interviews, both over the phone and face to face. The forms were filled in, in Romanian; interviews were taken in Romanian or Russian, according to respondents' requests. The interviewed persons had to check the respective answers considering their activity area.

We realised the final version of the survey based on the results gained after pre-testing it on eight companies, two for each analysed economic activity, thus excluding the possibility of multiple meanings or misinterpreted questions. Following the preliminary research, we adapted the

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questionnaire so that it could be applied univocal on the entire target sector of respondents. The survey respected the sectoral, territorial, and strategic distribution of industrial companies in the Republic of Moldova. In the majority of cases, the managers or the chief engineers of the companies filled in the forms.

Considering the very low level of cooperation of the business community, it is important to highlight the fact that domestic companies are not interested in participating in such scientific researches. The participation rate did not exceed 40% of those invited. There are multiple and highly situation-related causes for the lack of interest: shortage of time, insufficient information, low interest, indifference, non-understanding or resignation concerning environmental problems, incompetence, fear, etc.

The questions in the survey analysed each step of the natural environmental risks management, its impact on companies, and the degree of implementation of natural environmental risks management within companies. Thus, we structured the questionnaire as follows:

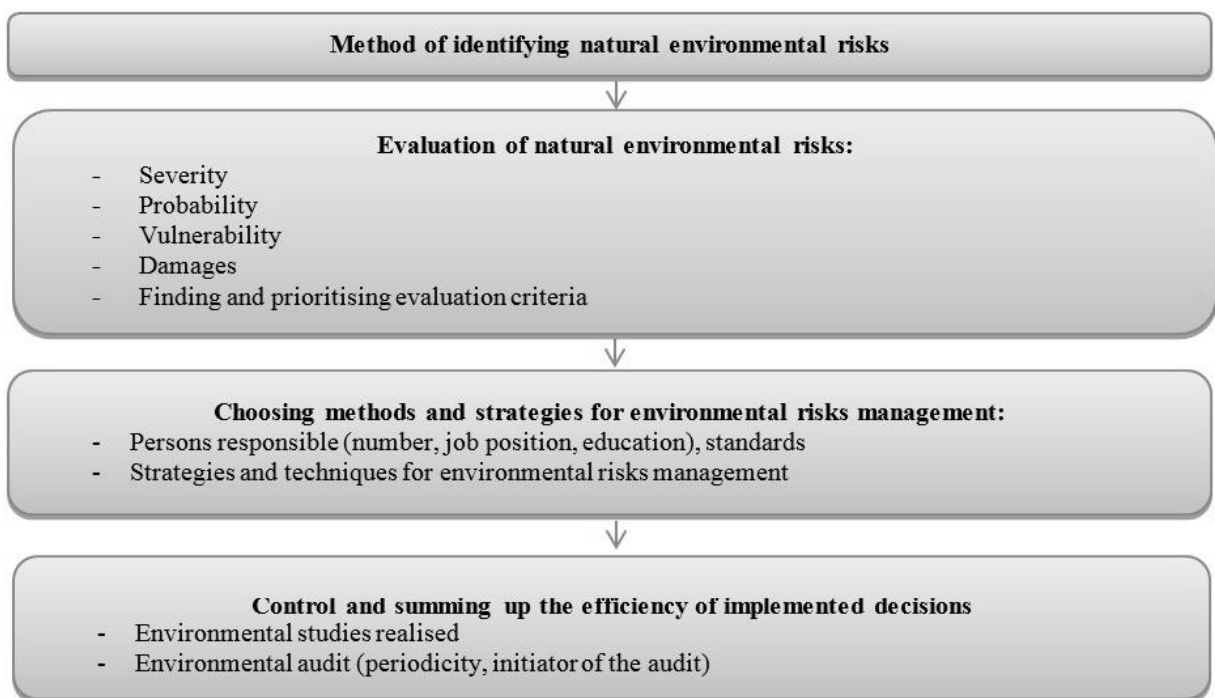


Figure 1. *The steps involved in evaluating the quality of environmental risks management in major industries in the Republic of Moldova*

For the beginning, we aimed to analyse the way in which the identification of natural environmental risks is done, and the areas in which the companies can take action regarding the environment. For this purpose, the companies pointed out ways to trace potential risk sources, indicating three methods:

- Intuitively, using their own experience, including that of collaborators or other companies;
- Analytical, using one or more methods and techniques of risk identification;
- Synthetic, using a complex mix of methods and techniques from both above-mentioned categories.

In order to find out the characteristics of the second step of environmental risks management, namely risk evaluation, the interviewed persons were invited to evaluate the severity and the probability of risk phenomena, but also the vulnerability of their activity to such phenomena, of the population in the surrounding area and the environment.

Usually, for the quantification of the three environmental risk components, evaluation scales are being used, with numerical values attached.

The first two steps of the management, namely the identification and the evaluation of environmental risks, comprise the totality of actions meant to offer the knowledge needed by decision-makers. The latter, as information beneficiaries, can be either economic agents, or public authorities with competence in elaborating and implementing legislative and normative framework, or in elaborating planning projects and public goods management projects.

Based on the results obtained by following these steps, we can elaborate an action plan regarding the environment, with elements ordered according to the importance of the objective and the urgency of its realisation.

In order to analyse the quality of the process of identification and evaluation of natural environmental risks within the surveyed companies, we asked if they could identify this type of environmental risks related to their activity and how do they do it; respondents were given the possibility to choose “I don’t know” as an answer.

According to the analysis of collected data, approximately 91% of the interviewed companies declared that they identify natural environmental risks, 7% do not use any method of identification, and 2% do not know if their company conduct an identification of natural environmental risks.

Thus, we can observe that the vast majority of companies (70%) use intuitive methods of identifying natural risks. Analysing the answers according to the activity area and size of the company, we can conclude that the wide gap is caused by the characteristics of each type of risk, but also by the legislative and normative shortcomings, especially in large and medium companies.

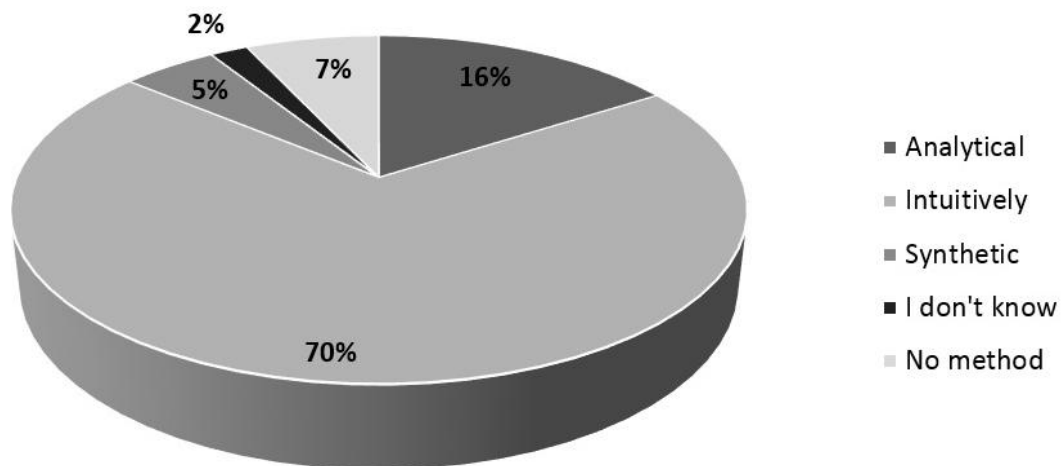


Figure 2. *Methods for identifying natural environmental hazards*

Usually, for quantifying the three natural environmental risks components, probability, severity and vulnerability – evaluation scales are realised and numerical values attached. This evaluation can be conducted in several ways, depending on the decision-takers’ needs, their interpretation capacity and the knowledge level of the process, the phenomena or factor (Rojanschi V., Grigore F., Ciomoş V., 2008, p. 54).

Even if the formula does not seem complicated, a number of limitations and restrictions inhibit the evaluation process of this kind of risks. The difficulty consists mainly in the quantitative evaluation of the possibility that some interrelations among different phenomena, processes or natural or anthropogenic factors can occur, and in the understanding of their effects. The solution consists in the initial identification of several prime indicators, followed by computing general indicators through aggregation; the level of detail is set according to pre-established priorities.

Considering the probability variation between 0 and 1, the realisation of the scale is not difficult and consists in dividing it into 3, 4, 5 or more categories.

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Table 2. *The probability scale for risk occurrence*

Qualitative estimation of risk occurrence	Probability	Scale	Qualitative estimation of risk occurrence	Probability	Scale
Certain occurrence	1.0	7	Probable occurrence	1.0-0.66	3
Highly probable occurrence	0.9-0.8	6			
Probable occurrence	0.60-0.80	5			
Medium probability occurrence	0.40-0.60	4	Medium probability occurrence	0.66-0.33	2
Unlikely occurrence	0.20-0.40	3	Unlikely occurrence	0.33-0	1
Highly unlikely occurrence	0.0-0.20	2			
Certain non-occurrence	0.0	1			

For our research, we chose the probability scale with five levels.

Table 3. *Probability levels of risks occurrence*

Scale	Probability	When it may occur
1	Rare	Only under exceptional circumstances
2	Unlikely	It might happen someday
3	Possible	It can occur every 2-3 years
4	Probable	It can happen in most situations
5	Almost certain	It is expected to happen in most situations

The effects of the occurrence of critical phenomena can also be analysed using numerical scales, but the elaboration of the scale is more difficult, as the research object has multiple dimensions that cannot be always quantified by means of a single indicator. Usually, for each category of effects, a separate scale is realised, which subsequently may or may not be generalised by means of coefficients, regarding their respective importance. The impact level of each category on the result is identified by using the structural analysis method, which is included in the category of qualitative analytical methods. The purpose of this method is to offer information regarding the shape and structure of a system, and is used for the succeeding analytical modelling of risk processes and phenomena.

Table 4. *The risk phenomena effects severity scale*

Qualitative evaluation of the risk occurrence effects severity	Scale	Qualitative evaluation of the risk occurrence effects severity	Scale
Insignificant severity	1	Low severity	1
Low severity	2		
Medium severity	3	Medium severity	2
High severity	4	High severity	3
Very high severity	5		

Table 5. *Economic severity levels of risk phenomena*

Scale	Severity	Economic impact
1	Insignificant severity	Unidentifiable of insignificant effects
2	Low severity	Acceptable production hold-ups
3	Medium severity	Production hold-ups
4	High severity	Temporary production stop or considerable production hold-ups
5	Very high severity	Total production stop

Likewise, for the evaluation of the severity of natural risk phenomena, we included in the survey a five-level scale. The quantification of the severity of economic effects caused by risk phenomena is presented in Table 5.

Once the information collected and the above-mentioned environmental risk components calculated, we proceeded to data processing, realised through: bi- or tri-dimensional graphical representation, impact matrix, control lists, or integrating models. Their utilisation allows a better understanding of the situation, compared to the plain introduction of the results in a formula. A deficiency of this calculus is that we can obtain identical risk values for different processes and phenomena that differ in intensity and amplitude of negative effects. Therefore, the obtained value is a conventional one. Even the most similar situations cannot be considered as identical, and a perfect identical occurrence is possible only in abstract models, and can serve only as a simplified evaluation scheme.

According to interview results, the main general mark for the severity of natural risk phenomena in the Republic of Moldova (drought, flood, hail, extreme temperatures, heavy rainfall, earthquakes, soil erosion, landslides) is 1.9 points out of 5, proving the effects of natural environmental risks as having low severity. Five points are reserved for those phenomena that can stop economic activities, while zero points for those with no risk for the company. At the same time, the most severe effects for the companies' activities, according to those interviewed, are caused by earthquakes, estimated to 3.1 points, qualitatively ranking as medium severity phenomena. In the low-medium severity range of effects, other four phenomena are classified: floods, with 2.6 pts., drought with 2.3 pts., extreme temperatures with 2.2 pts., and heavy rainfalls with 2.1 pts. The relatively objective evaluation of the above-mentioned phenomena is due to the last years' experience, when drought, extreme temperatures, floods, and heavy rainfall caused the highest losses. Among the four industries analysed, there are significant discrepancies between their evaluations on the severity levels.

Table 6. *Evaluation of the severity of natural risk phenomena*

	Production and distribution of power, thermal energy, gas, and warm water	Food and beverage industry	Mining	Rubber, plastic, and other non-ferrous mineral products industry	Average
Drought	0.80	3.39	0.00	0.82	2.30
Flood	2.40	2.39	3.50	2.91	2.60
Hail	1.40	2.10	0.00	1.09	1.60
Extreme temperatures	2.00	2.94	1.00	0.73	2.20
Heavy rainfall	2.20	1.81	1.25	3.18	2.10
Earthquakes	4.60	2.65	4.50	3.09	3.10
Soil erosion	0.60	1.26	0.00	1.82	1.20
Landslides	1.40	1.16	1.00	1.55	1.30
Other risks	1.20	0.48	0.00	1.00	0.60
Average per industry	1.84	2.02	1.25	1.80	1.89

We can observe that the phenomena that could cause most damages to the companies involved in the production and distribution of power and thermal energy, gas, and warm water are earthquakes, with a very high severity risk factor. The other phenomena are ranked at an insignificant severity level (drought, erosion, hail, landslides), or a low one (floods, extreme temperatures, heavy rainfalls), with erosion and drought gaining the lowest mark.

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Comparatively, the food and beverages industry companies evaluate drought as the most severe natural phenomena, with 3.39 points, followed by extreme temperatures with 2.94 pts., which are evaluated as severe and medium-severe phenomena, respectively. The explanation lies in the direct dependence of this industry to the price and availability of raw materials. For instance, sugar companies declared losses of 40-50% caused by drought.

Companies in the mining industry are less affected by natural risk phenomena, giving them only 1.25 points out of 5, which means a general insignificant severity, according to the results of the research. In the meantime, floods and earthquakes were included in the high and very high severity category, as these phenomena could affect their activity, especially the security of workers and machinery involved in the exploitation of natural reserves.

The production of rubber, plastic, and other non-ferrous mineral products may be affected at a medium-severe level, by floods, heavy rainfall and earthquakes, all these phenomena obtaining approximately 3 points. If earthquakes represent a natural risk phenomenon whose severity was relatively objectively evaluated, as the Republic of Moldova lies in a seismically active region, floods and heavy rainfall are to interrelated phenomena with an indirect influence on this type of activity. Their evaluation as a risk source of medium severity is given entirely by the particular location of surveyed companies.

The main damages in 2007 were caused by drought and extreme temperatures. Over 80% of the companies declaring damages due to natural phenomena were affected exactly by these phenomena, especially 22.2% of companies in the food and beverages industry. In 2008, the damages continue to be caused by drought and extreme temperatures, but also by heavy rainfall and floods, and the highest damages were again registered in the food and beverages industry. The year 2009 also registered losses due to natural risk phenomena, especially drought, which affected over 1/5 of the surveyed companies. The same situation repeated itself in the following three years.

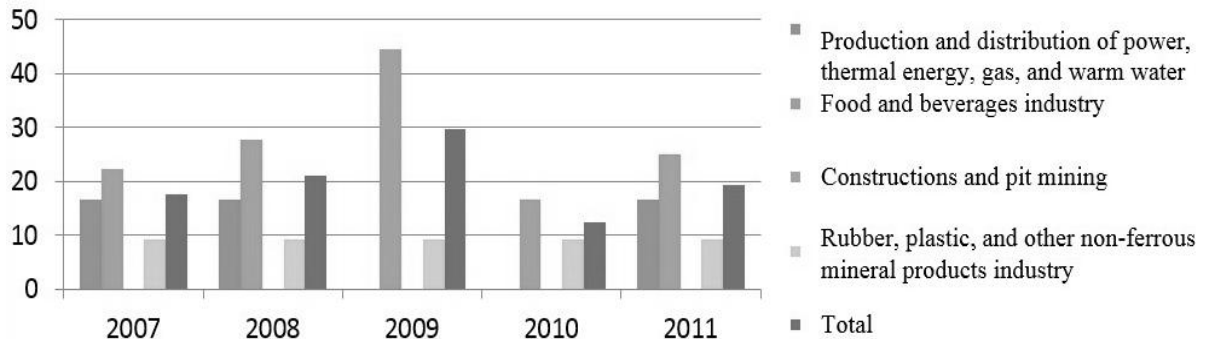


Figure 3. *Losses suffered by companies due to the occurrence of natural hazards*

In order to evaluate correctly natural risk sources, the survey comprises questions regarding the probability of phenomena occurrence and the vulnerability of companies confronting them. The companies were asked to evaluate these environmental risks components with marks from 0 to 5. The highest mark was to be appointed to phenomena with certain occurrence during the year, and the highest vulnerability mark was obtained by those phenomena to which companies are most vulnerable.

According to the interviewees' opinion, the probability of at least one natural risk phenomena to occur during a year in the Republic of Moldova was estimated at 1.81. In the meantime, droughts and extreme temperatures were evaluated with the highest occurrence probability, obtaining 2.7 points. The next-ranking phenomena, gaining over-average marks, were floods and heavy rainfall, with 1.9 points. The natural risk sources with the lowest occurrence probability during a year were hail and earthquakes.

Table 7. Evaluation of natural risk phenomena probability

	Production and distribution of power, thermal energy, gas, and warm water	Food and beverage industry	Mining	Rubber, plastic, and other non-ferrous mineral products industry	Average
Drought	2.8	3.2	0	2.4	2.7
Flood	2.2	1.8	2.25	2.1	1.9
Hail	2.0	1.9	0	1.5	1.7
Extreme temperatures	2.8	3.0	1	2.4	2.7
Heavy rainfall	2.8	1.7	1.25	2.2	1.9
Earthquakes	1.8	1.5	1.75	2.2	1.7
Soil erosion	2.2	1.0	0	1.4	1.1
Landslides	2.2	0.8	1	1.4	1.1
Other risks	0.6	0.5	0	0.9	0.5
Average per industry	2.1	1.7	0.8	1.8	

From the interview output we can observe that the most optimistic attitude towards natural risk phenomena is found within mining companies, whereas the companies engaged in power and thermal energy, gas, and warm water production stand at the other end, with 2.1 points.

Analysing the answers regarding the vulnerability level of the companies from all the four surveyed industries, we can observe that companies evaluate their vulnerability to natural risks as low, with 1.9 pts. in the case of the companies in the energy sector, the food and beverages industry, and the industries producing rubber articles, plastic, and other non-ferrous mineral products. The vulnerability level in the mining sector is at 1.3 pts. In accordance with their specific activity, each of the above-mentioned industrial sectors has a high vulnerability to a certain risk phenomena.

For example, companies in the energy sector are more vulnerable to earthquakes, extreme temperatures, and heavy rain, as the latter two phenomena affect the demand for thermal energy, gas, and warm water.

The top natural risk phenomena for the food and beverage industry is held by those phenomena with direct influence on quality, supply, and thus price of raw materials: drought (high level of vulnerability), extreme temperatures and hail (medium vulnerability), risks that are impossible or very expensive to mitigate.

The highest vulnerability level of mining is to earthquakes and flood, that could block all activity, causing massive losses, including human lives, and avoiding them is very difficult.

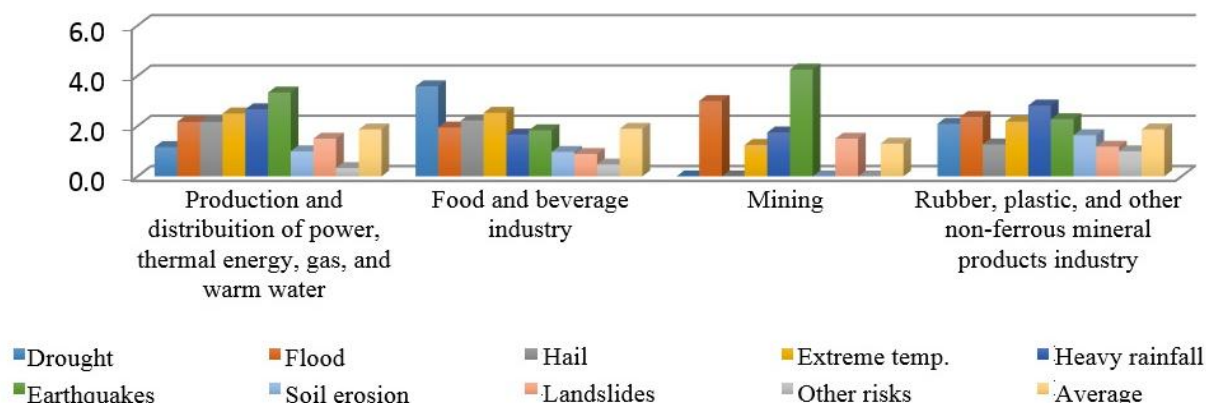


Figure 4. Companies' vulnerability to natural risk phenomena according to activity branch

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The average vulnerability to natural risk phenomena of the surveyed companies is 1.8 points, leading us to the conclusion that they do not consider themselves vulnerable to these phenomena.

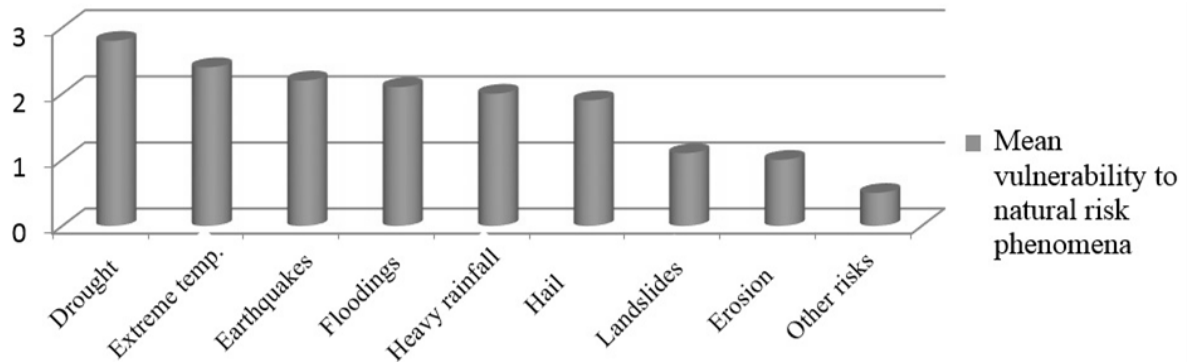


Figure 5. Companies' mean vulnerability to natural risk phenomena

Likewise, we have to mention that the highest vulnerability mark for the entire range was gained by drought. This is explained by the high percent of food and beverage companies among economic companies, and therefore among the surveyed lot. Another cause is the large territorial expansion and high frequency in last years. The evaluation of vulnerability to extreme temperatures, earthquakes, flood, heavy rain, and hail was relatively uniform, with approximately 2 points, meaning a rather low vulnerability. Because of the punctual occurrence of erosion and landslides, as well as due to the efficient methods to fight these phenomena, the vulnerability to them is very low.

For an adequate evaluation of the risk impact generated by each phenomenon, we determined their respective position according to the three dimensions: probability – x, severity – y, and vulnerability – z, for every surveyed company. Depending to their position and the above-mentioned criteria, there risks management strategies and techniques will be determined.

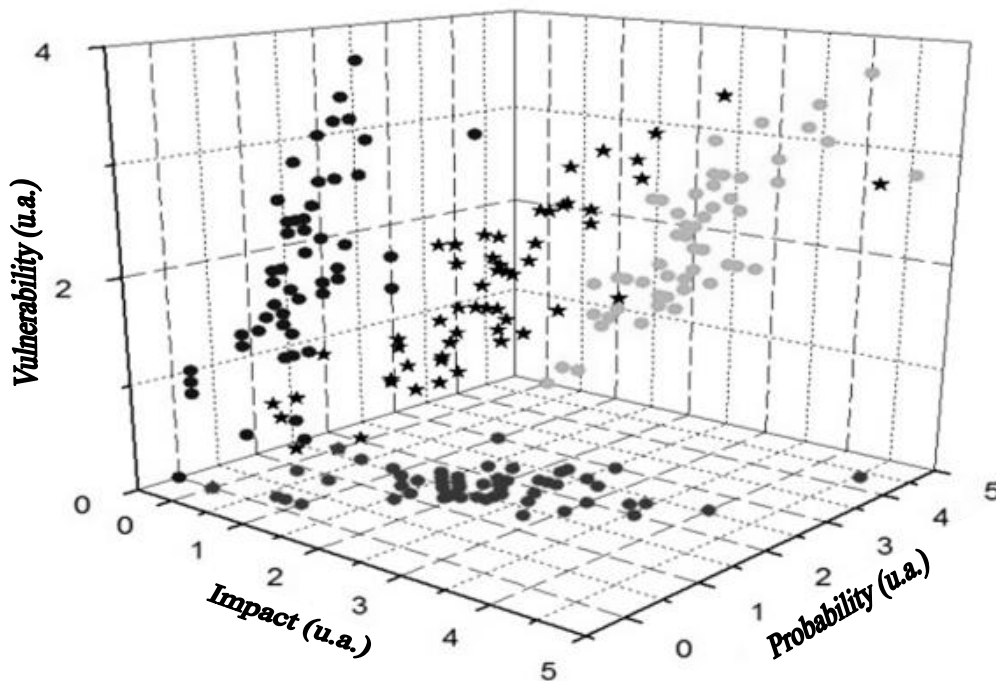


Figure 6. 3D projection of environmental risks

Even if all respondents pointed out that they are vulnerable to natural risk phenomena and evaluated the probability and severity as quite high, only 35.1% answered that their company evaluates the dimension of natural risks, whilst the rest of 56.1% said that they do not evaluate this dimension, and 8.8% did not know if such actions were being undertaken. Following our request to prioritise the criteria of evaluating the dimension of natural environmental risks, the economic agents assessed their importance with marks from 0 to 5, the maximum being given to the most important ones. These criteria are intensity and dimension of the impact, duration of effects and recovery time, level of interrelation with other phenomena, costs, population affected, and inflicted area. The importance of assessing the dimension of environmental risks for companies is highlighted by the interest level towards risk assessment criteria.

The criteria for environmental risks evaluation hold a higher importance for companies in the energy sector, followed by the food and beverages industry, the mining industry and the rubber, plastic, and other non-ferrous mineral products manufacturing (Figure 7).

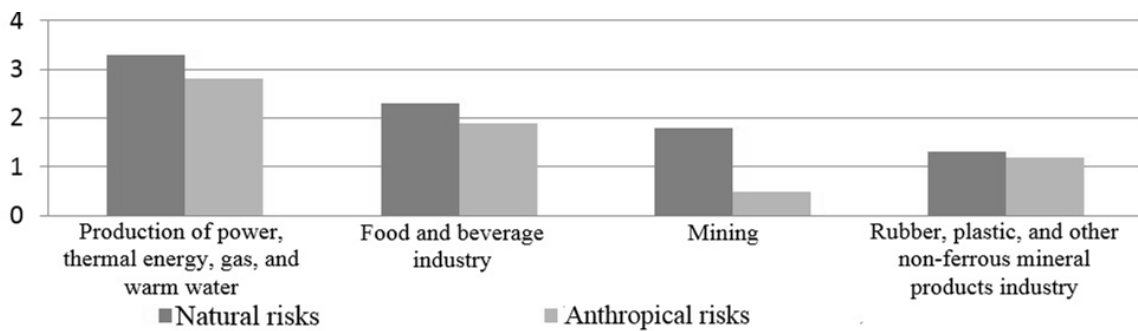


Figure 7. Implementation level of risk evaluation criteria

The evaluation of the dimension of natural risks is highly regarded, with costs as an evaluation item for the dimension of natural risks considered an important criteria, gaining 3.3 points (Figure 8).

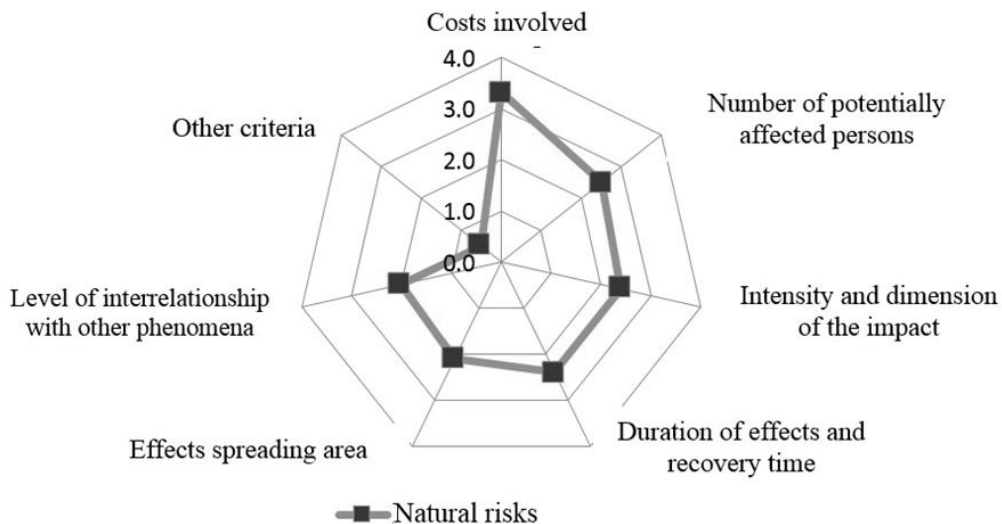


Figure 8. Criteria for evaluating the dimensions of environmental risks. Assessing their importance

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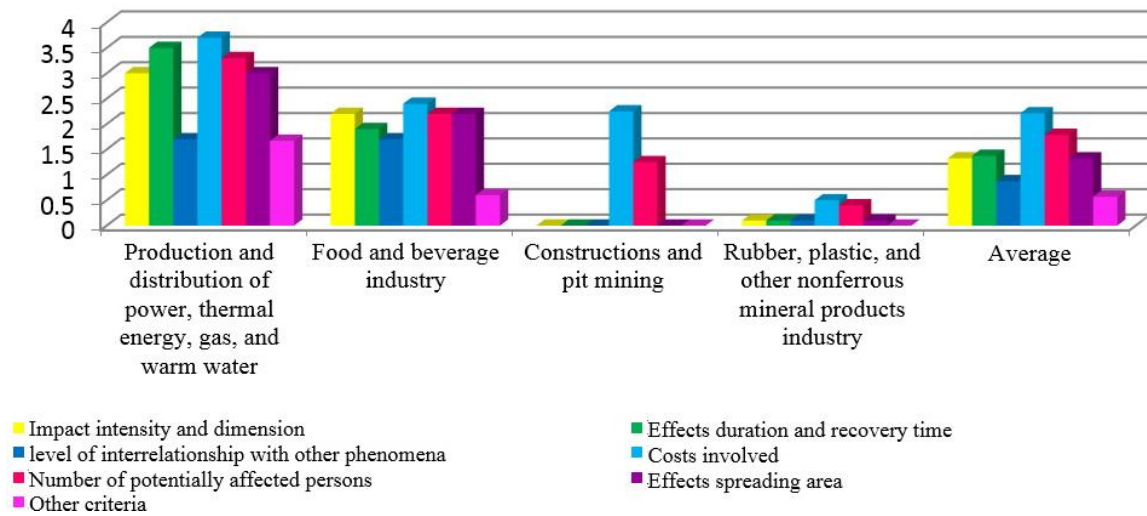


Figure 9. *Assessing the importance of criteria for dimensioning the natural risk phenomena by activity type*

For the qualitative evaluation of environmental risks management methods and actions within the surveyed companies, the main environmental costs were analysed, namely prejudice costs, prevention costs, amelioration costs, effects costs, resources costs for projecting, planning, following, and risk control. Approximately 19% of the companies declared to have such costs over the last five years. For example, 33% of the surveyed companies in the energy sector bear avoidance and following costs. The same cost categories are dominant within food and beverages companies, where the percent of companies declaring environmental costs rises at 23.3%.

Other economic instruments for environmental risk management are investments. After analysing the results of the study, we may conclude that the investments in minimising natural environmental risks are very low, sporadic, and the decrease of environmental risks is a side effect rather than a purpose in itself. Likewise, the percentage of companies that made such investments varies between 11% and 14%.

CONCLUSIONS

Environmental and related risk management is a direction that has benefited lately of an increasing attention by specialists, and, implicitly, by numerous theoretical studies. Naturally, the methodological basis can be the general risks management theory, but there are also several peculiarities (due to the characteristics and the importance of the managed object) that cannot be ignored. Even if in the Republic of Moldova there were numerous studies on various aspects of risk management, such as financial risks, bank risks, currency risks, etc., no research was made on environmental risks, especially on the evaluation and management methodology for this type of risks. There was little study and analysis on an optimal form of management with respect to local trends and particularities.

At this stage, the study and the efficient treating of environmental risks present considerable deficiencies caused by the complexity of the research and management object, but also by its flexible features, as the environment suffers ongoing changes. Another cause is the lack of objective and wide-ranging estimations on the cause-effect relationship. Knowing environmental risks is not only a prime requirement in realising an efficient economic management (i.e. minimising costs or losses, or maximising profit), but also, more important, it contributes to diminishing the population's vulnerability to natural risks. To the same effect, poor and low developed, or developing countries cannot yet afford the luxury to harmonise economic activities with the environment, which drags society in a vicious circle.

Within the surveyed companies, environmental risks management is poorly implemented. The actions of environmental risk management and environmental protection are sporadic, mostly intuitive. In most cases, there are no implemented environmental protection practices or such meant to minimise the vulnerability to natural risk phenomena, and the management actions and strategies are not a continuous process.

Along all steps of environmental risk management, we identified weak points and the deficiencies oscillated according to the company's dimension, activity sector, and production process characteristics. Most companies have an environmental risk management that can be classified in the risks management typology as beginner-combatant. For a better environmental risk management, companies have to follow all steps of an efficient environmental risk management. Identifying environmental risks is one of the basic steps. The individual as decision-taker is much more aware of the existence of individual risks than of organisational or global risks. Evaluating every-day risks is based mainly on empirical methods and on intuition. Using this approach is not acceptable for decisions regarding environmental risks, as their proper management needs vast and genuine knowledge, which can be acquired only through risk identification techniques and actions. Unfortunately, most companies surveyed identified risks relying only on intuition, own experience or the experience of collaborators and other companies.

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