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HAZARD MONITORING AND APPLICATION OF COMPLEX TERRITORIAL ANALYSIS TO ASSESS THE DEGREE OF PROTECTION FOR A CERTAIN REGION

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Abstract. The analysis of typical natural and man-made hazards for the Lviv region is carried out. The statistics of official documents are processed. The coefficient of protection of the region against dangers is calculated and the degree of its protection is determined.

Keywords: monitoring, risk of nature use, protection coefficient from the dangers.

Introduction

The environment, comfortable climate, landscapes convenient and well-organized management generally determines the region attractiveness and the population living quality. The infrastructure level significantly effects on the ecological stability, associated with the impact on the environment and activities to preserve and restore territories. Changing landscapes, terrestrial and aquatic ecosystems under the influence of human activity requires a rational approach to assessing the risk of nature use, developing monitoring and response programs for a particular region and the state as a whole.

Analysis of natural and man-made threats, development of reasonable preventive measures aimed at the prevention of hazards is an essential part of ensuring the safety of human life at the present stage of development. Ecological, economic and socio-political problems contribute to the growth of man-made or natural processes that bring material damage and adversely affect the health and psycho-emotional state of society [1].

Ukraine, integrating into the European community, needs urgent solution to the issue of the natural environment safety, namely, strategies, tactics and technology of environmental protection measures. To do this, it is necessary to conduct socio-ecological zoning of the country and regions and to classify the selected areas by the degree of nature use balance, the level of pollution and the suitability of the natural environment for human life.

Risk assessment of nature use and systematic analysis of the dynamics changes in load on the ecosystem can be used to substantiate the choice of priorities of both state and regional environmental policy in order to prevent large-scale losses, guarantee public safety and stability of development. Taking into account the change in the distribution of powers between central and local authorities in Ukraine, the regional level of prioritization has the advantage of taking environmental protection decisions.

The purpose of the article is an analysis of the man-made and natural safety, conditions of the threats and risks spread of Lviv region environmental and directions definition of regional ecological policy implementation. It is risk assessment of natural use for the region on the basis of its current socio-economic and environment conditions.

The main tasks and goals of the risk assessment are:

– collecting information on major hazards and risks in the territory;

– determination of the emergencies risk degrees;

– assessment of the dangerous events consequences, the impact of the injurious factors on the population.

Analysis of recent researches and publications

Until recently, the primary attention in resolving the problems of protecting the population and territory from emergency situations was given to the elimination of the consequences of accidents, catastrophes, natural disasters. However, these efforts are becoming less

effective and more expensive. The limited available resources should be primarily aimed at reducing the risk, developing reasonable preventive measures and ensuring human security, not to eliminate the consequences and compensation for the damage.

According to the international experts' calculations, the cost of measures to prevent natural disasters is much smaller compared to the costs required to eliminate damage [2, 3].

The tendency of yearly growth in the quantity and level of the consequences of accidents, catastrophes and natural disasters makes it necessary to seek new solutions to the problems of protecting people and territories from emergencies, to predict future threats, risks and dangers, to develop methods for their prediction and prevention.

In the bases of population and territory safety regulation system and overcoming the number growth negative tendency of natural and man-made emergencies can be used the science of the risks – cindynique [4]. For example, in Western Europe, where measures of state regulation are implemented to reduce the emergency risks, the accident and disaster numbers have decreased by 7–10 times in the last ten years [5]. These measures are the least costly and economically.

Scientific researches on dangers and risks emergencies cover various aspects and relate to the names of many well-known scientists. Particularly, the general issues of ecological safety of Ukraine are highlighted in the works of L. G. Rudenko, A. B. Kaczynski, G. V. Lisychenko, B. M. Danylyshin, A. V. Stepanenko, N. M. Kussul, S. V. Skakun, A. Yu. Shelestov, P. V. Zhuk and others.

The risk analysis methodology of the dangerous environmental factors impact on the population safety is a new and relatively young, interdisciplinary scientific trend that is developing rapidly throughout the world. The main provisions of this methodology, formulated in the United States in the early 80's and in the new conditions are not always sufficient [6]. This necessitates the creation of modernized strategies for preventing and eliminating the consequences of natural disasters and catastrophes.

Since the risk factors of a territory or its protection from them are often closely related to the lives of people in a particular society, safety researches usually refers to well-defined territories [7]. Comparison between different territories and societies is not so common. The absence of comparative elements indicates the complexity of positioning the natural disasters on a certain scale.

An overview of the various definitions proposed for safety assessment shows that two approaches are important: firstly, an approach aimed at assessing the protection from the point of view of financial losses that will be incurred as a result of a natural disaster, and secondly, an approach that combines a wide range of social, demographic, cultural and historical factors.

In his work, Gilles Andre, in a comparative study of the protection degree to natural hazards for each country, combined social and economic probabilistic approaches. In this paper [8], the author highlights the fact that, using a social approach to assessing the safety of countries in the world, there is a large inequality between "rich" and "poor" countries, where the latter present higher levels of exposure to risk, while using the economic approach to assessing the safety, "rich" countries present the highest levels of exposure to risk. In terms of a social approach, the level of risk for Ukraine is the lowest in this comparison, concerning the economic approach, such an assessment for our country is absent.

The article [9] presents the results of assessments of natural hazards, protection from natural disasters and risk of nature use for all countries of the world according to the original author's method. The approach proposed by Kuzmin S. B for assessing the risk of nature use is based on the current (actual) socio-economic and natural state of the countries with the use of integrated territorial analysis and planning. In the statistical analysis, the author included all countries of the world with an area of over 50 km^2 and a population of more than 25 thousand people, for which the necessary statistics are known in open databases and in periodicals over the past 10 years. According to the analysis [9] at low values of natural hazards coefficients (1–1.4 maximum value 4) and the risk factor of nature use coefficient (0.3–0.6 maximum value 4) Ukraine refers to countries with a low degree of protection from natural disasters (1.9–2.9 with a maximum value of 17).

Risk analysis is used to study and understand not only the physical manifestation of natural hazards, but the factors that affect the protection of property, territories and population, as well as to develop preventive measures for their protection.

Research results

The risk assessment methodology includes identifying, analyzing and forecasting the negative impact of hazardous factors on the environment and population. According to the definition of the United States National Academy of Sciences [10], risk assessment is the use of available scientific information and scientifically based predictions to assess the hazard of exposure to harmful environmental factors and conditions on human health.

The main stages of analysis and predicting of risk emergencies are:

– detection and identification of possible sources of natural and man-made disasters;

– assessment of the frequency of natural disasters, accidents, natural and man-made disasters;

– forecasting of the possible consequences of the emergency injured factors influence on the population and territory;

– provision of rescue forces and means for the elimination of predicted emergencies [11].

In our study, we monitored the natural and man-made hazards and attempted to identify a number of indicators that would allow assessing the vulnerability of the territory to emergencies. For this, we were looking across a variety of databases, public institutions, public organizations and publications. Since compilation was conducted from different sources and the level of reliability and exhaustiveness of the information varies from one period to another, so we decided to focus exclusively on the last 10 years, because we believed that this information was more reliable and more complete.

The territory of Lviv region is characterized by the presence of some man-made and natural dangerous processes that can lead to technogenic and ecological disasters and accidents.

Among the most dangerous natural processes and phenomenon in Ukraine most often occur: geological, meteorological, hydrological, natural fires, and medico-biological. According to the data on natural disasters, we grouped the events in the main classes and did not consider natural phenomena, which make up a small part (Fig. 1). Natural threats in the territory of the Lviv region are represented by dangerous exogenous geological processes, hydrometeorological phenomena, natural fires and medico-biological emergency situations.

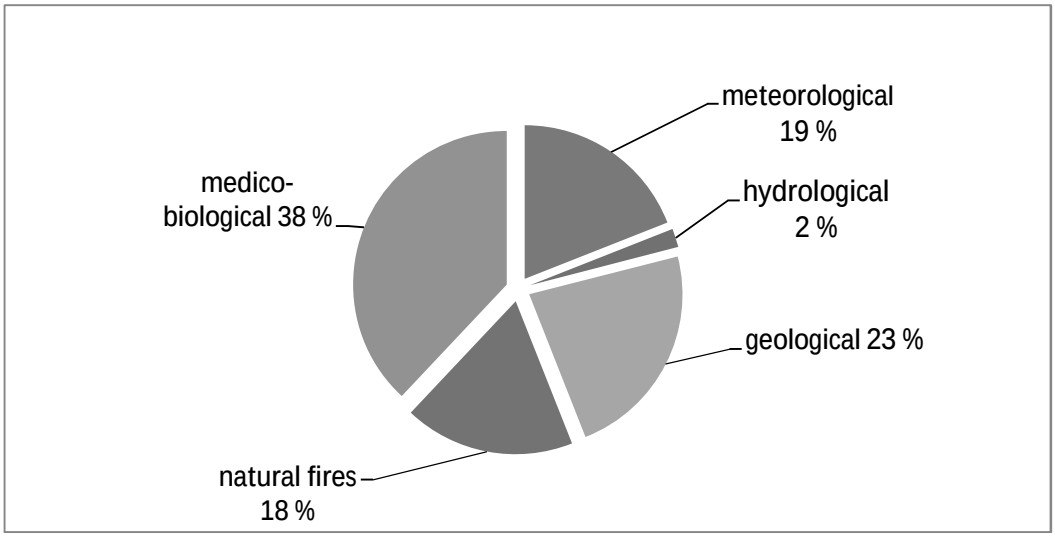

Fig. 1. Ratio of natural emergencies on the territory of Lviv region during 2006–2016 [12]

The specificity of the geological and geomorphological structure of the region determines the basic conditions for the formation and development of exogenous processes: landslides, karsts and mudflows. In Lviv region, the total number of landslides are 1347 units, of which 19, with an area of 0,42 km^2, are active. In the framework of development, 162 landslides were recorded, of which 8 – active, 29 – located near economic objects [12].

The activity of the karst process takes place through economic activity, which leads to an anthropogenic change in the hydrogeological conditions. The development of karst in the region is also associated with the earth subsidence over mining. The created cavities constitute a danger to the sanitary-protection zone of Truskavets resort, Drohobych, Stebnyk, Boryslav cities, for power lines, Drohobych-Truskavets road, water supply and other communications [12]. Natural hazards of a geological nature make up 23 %.

Hydrometeorological dangers of the region, which account for 21 %, are most often manifested in the form of strong precipitation, storms and in recent years the continued containment of hot weather in the summer. Due to significant rainfall, winter thaw and rapid melting of snow, flooding of large areas with the infrastructure, industrial facilities and residential buildings damage in the region is possible.

The largest share among the natural hazards of the area is medico-biological – 38 %. The most common of these are mass poisoning of the population with low-quality products.

The fires in natural ecosystems are 18 %. The reasons for these are anomalous manifestations of atmospheric processes that are associated with global climate change and ignoring the fire safety requirements.

With technical progress the impact of human economic activity on the environment is becoming more and more devastating. The main causes of man-made accidents remain:

– constant growth of anthropogenic impact on the environment;

– potentially dangerous and obsolete production technology;

– high depreciation rates of fixed assets and low rates of production modernizations;

– poor compliance with safety and low technological discipline in the factories;

– ignoring the requirements of fire safety and other norms and standards in industry, construction, public utilities, transport and other economy sectors.

For example, in the Lviv region from 2006 to 2016 the largest number of emergency man-caused accidents were recorded in 2006 (Fig. 2).

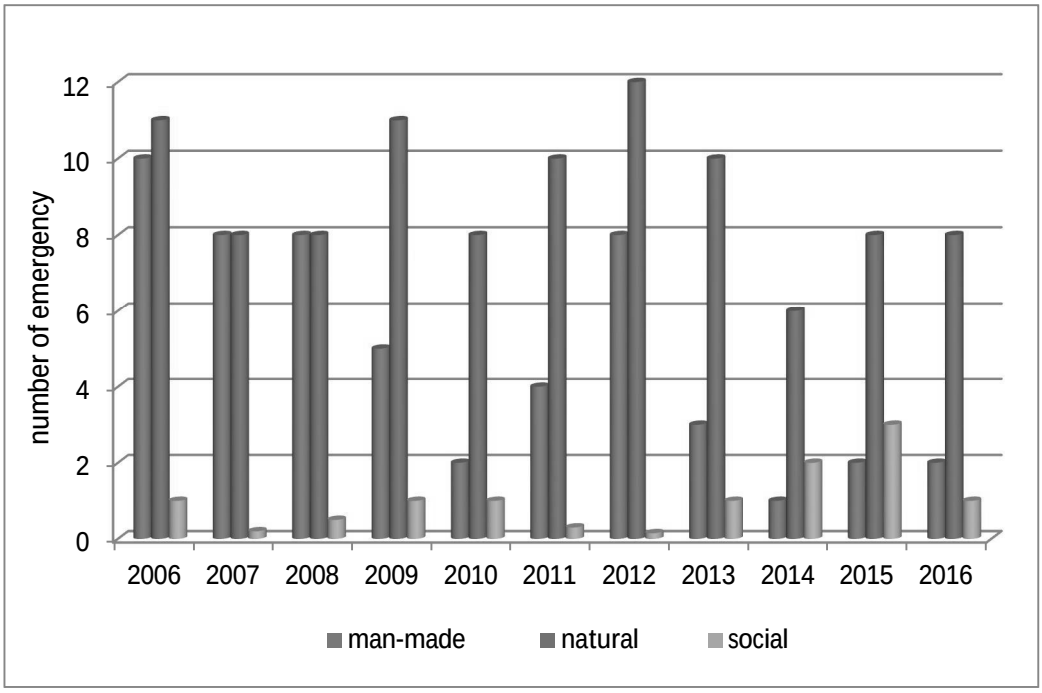

Fig. 2. Emergencies in the Lviv region for the period of 2006 – 2016 [12]

Two types of atmospheric pollution are characteristic to Lviv region: areal (emissions from industrial enterprises and transboundary transport of polluting substances by air) and linear (pollution of the atmosphere along roads by transport).

A significant proportion of the volume of air pollution accounted for road transport, through increased car traffic in urban area and on the main highways. Among pollutants from stationary sources that enter the air, gaseous substances predominate: carbon and nitrogen oxides, sulfur compounds, formaldehyde, dust and ammonium nitrogen. The main pollutants of the air remain Dobrotvyr TPP (within the sanitary protection zones for sulfur dioxide exceeded the limit-permissible concentration) and JSC "Mykolaivcement", as well as losses in gas transportation by the division of UMG "Lvivtransgaz" and State Enterprise "Lvivgazvydobuvannya". At present, 1164 potentially dangerous objects have been registered in the territory of the region, including 370 – increased danger, which are registered in the State Labor Inspectorate in the Lviv region [13].

The chemical safety of the region is conditioned by the operation of 35 chemically hazardous objects classified by the degree of chemical danger: 7 objects of the third degree of chemical danger and 28 objects of the fourth degree of chemical danger. Mainly enterprises of the region use the following hazardous chemicals: ammonia – 16 objects; chlorine – 16 objects, acid (hydrochloric) – 3 objects. Experts estimate that over 60,000 people live in the zone of possible chemical pollution. The maximum amount of chemically dangerous substances transported by rail over the region territory for a day is more than 1,200 tons [13].

The developed network of transit and domestic oil product pipelines, storage and transfer of oil and petroleum products is a problem of petrochemical pollution, as a result of violations during repair and maintenance works, corrosive damage or deliberate damage for the purpose of theft. The developed network of transit and domestic oil product pipelines, storage and transfer of oil and petroleum products is a problem of petrochemical pollution, as a result of violations during repair and maintenance works, corrosive damage or deliberate damage for the purpose of theft. The regions territory includes: the oil pipeline of the branch of MN "Druzhba", JSC "Ukrtransnafta", the Urengoy-Uzhgorod gas pipeline, the product pipelines "Prykarpatransnaftoprodukt" and the interregional gas pipelines, in the case of possible accidents where the threat of environmental pollution is likely. The main pipelines in the cities of Brody and Skole, which have

oil storage tanks, with a total capacity of about 200000 m^3 are dangerous.

A surface water of the Lviv region controlled by several government agencies, but the analysis results in recent years has shown their imperfections and subjectivity. In general, monitoring studies indicate excessive pollution caused by emissions of insufficiently-treated municipal and industrial wastewater. Despite the decline in production and the stop of many enterprises, there is no significant improvement in the quality of waste water and the reduction of discharges of crude and insufficiently treated sewage. The largest number of excessive limit-permissible concentration in the studied water samples was recorded in the basins of the Western Bug and Dniester rivers.

The environmental safety problem has become particularly acute in the Lviv region through the formation of large amounts of hazardous waste. The accumulation of waste in landfills is an important issue that should be solved by reducing the volume of waste production as well as the recovery of secondary raw materials and energy from waste. The largest amount of industrial waste from the Lviv region is concentrated on the waste heaps near coal mines (about 108 million tons). Industrial and communal facilities yearly produce approximately 5.0 million m^3 of solid waste, of which only 1.8 million m^3 (37 %) covered by organized collection. For today, there are 51 organized dumpsites of household waste and about 521 objects of illegal waste storage in the region [14].

Statistical data on the total number of emergencies in the Lviv region during 2006–2016 show a small number of a socio-political emergencies and a tendency to reduce the number of man-made emergencies, especially during the last four years.

Environmental pollution also negatively affects the physical potential of society. Unsatisfactory ecological condition leads to higher rates of mortality and fertility reduction. These negative trends lead to a significant deterioration of natural population increase indicators (Fig. 3).

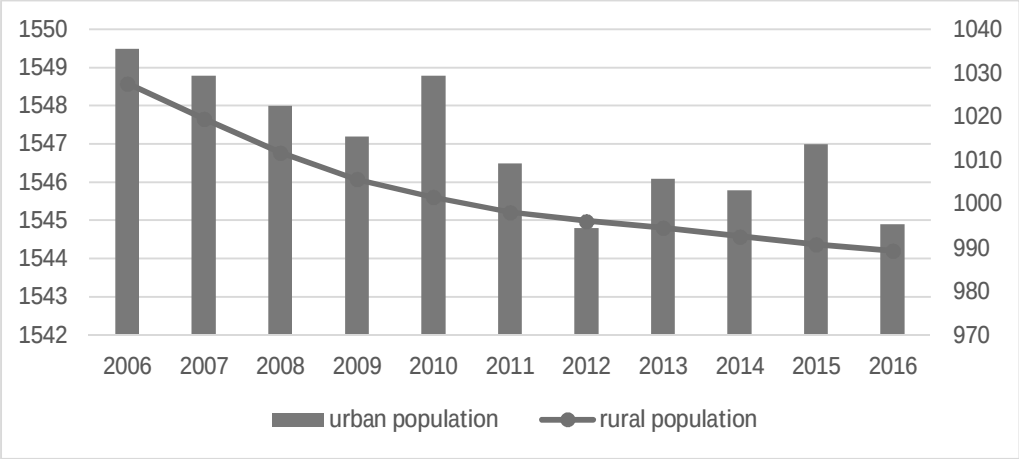

Fig. 3. Dynamics of changes in the region population for the period 2006-2016 [15]

In recent decades, there have also been significant changes in the structure of the diseases, which indicates the growing cases of diseases caused by the use of low-quality drinking water and food, polluted air, in particular, hepatitis, pulmonary diseases and cancer.

Taking into account the assessment of the natural hazards level impact on each country in the world and the protection degree, using various approaches presented in the literature [8, 9], Ukraine refers to the countries with low levels of natural hazards. At the same time, the level of the preparedness of our country to resist natural disasters is low (1.9–2.9 with a maximum value of 17).

Since the readiness of a particular territory or a society to withstand emergency situations depends on the type of construction, prevention and protection policies, as well as the density and level of urbanization of the population, then the degree of the territory protection is better to assess at the local level. It is expedient to assess the territory safety and the society readiness to withstand the dangers at the scale of one administrative unit (city, area or region). In order to determine the protection degree and assessment of Lviv region dangers, the information needed for the calculations was collected [12-16].

The protection coefficient against natural disasters and catastrophes is calculated by the formula (1):

$$Vo = \frac{(GDP + Pj + T + C + W + L + K)}{(Pp + CHD + E)}, \quad (1)$$

where *GDP* (Gross Domestic Product) – *GDP* ratio in the region per capita; *Pj* – the proportion of the working population; *T* – telecommunication coefficient; *C* – transport coefficient; *W* – military resources coefficient; *L* – life expectancy coefficient; *K* – literacy rate; *Pp* – proportion of the population below the poverty line; *CHD* – infant mortality rate; *E* – coefficient of intensity of environmental problems.

All the coefficients are given to the unit which is defined as the maximum value of any indicator.

The telecommunication coefficient T, which reflects the reliability of information transfer, the timeliness and the mass notification of the population about dangers and rescue measures, was calculated according to the formula (2):

$$T = \frac{(Tph + Tmph + Trd + Tv + Tint)}{P}, \quad (2)$$

where *Tph* – number of phones; *Tmph* – number of mobile phones; *Trd* – number of radios; *Tv* – number of TVs; *Tint* – number of Internet users; *P* – region population.

The transport coefficient C, which is an indicator of the country's transport infrastructure development, the possibilities of its use for evacuation of the population from the centers of natural disasters, the placement of refugees, the transportation of food, medicines, and other humanitarian aid, was calculated according to the formula (3):

$$C = \frac{(CR + CA + CL)}{(P + S)}, \quad (3)$$

where *CR* – length of railway tracks, km; *CA* – length of highways, km; *CL* – airlines coefficient (number of airports per 100 km – the minimum radius of the airway); *S* – area of the region, km^2.

The coefficient of military resources W was calculated by the formula (4):

$$W = \frac{PW}{P}, \quad (4)$$

where *PW* – number of human military resources, people.

Having carried out the calculation, we obtained the coefficient of protection against dangers for the Lviv region, the value of which is 2.4 and is within the values calculated for Ukraine (1.9-2.9). The scale of the danger protection coefficient in [9] is in the range of 0.5 to 17. Given the fact that the greater is value of the coefficient, the greater is willingness of a particular territory and society to withstand emergency situations and recover more quickly after the disaster, the Lviv region as well as Ukraine relates to territories with a low degree of protection.

In order to increase the level of protection of the Lviv region from dangers and the necessary regional reserve of material and technical resources creation for carrying out preventive measures in the event of a threat of anthropogenic and nature emergencies, eliminate their consequences, from since March 2016 the “Integrated Program of Civil Protection of Population and Territories of Lviv region from man-made and nature emergencies” is processed.

Conclusions

At the present, the issue of creating and operating of monitoring and forecasting system of emergency situations, which will allow us to analyze and systematize the risks, as well as to collect information in order to increase the level of society readiness to withstand the dangers.

From the above estimates, the Lviv region belongs to the territories with a low degree of protection. The solving problem of protection degree from dangers requires significant investment, organizational and economic, technical and other resources. Performing the Program of Civil Protection of Population and Territories of Lviv region from man-made and nature emergencies that introduced in 2016 will increase the region readiness to withstand the hazards and effectively eliminate the consequences.

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