

20 November 2020

DOI: 10.5281/zenodo.4277924

Risk management in the event of emergencies of the state and local levels (on the example of Kharkov region)

*Hryhorii Ivanets*¹, *Ihor Tolkunov*¹ and *Ivan Popov*¹

¹ National university of civil defence of Ukraine, Chernyshevskaya street 94, Kharkov, 61023, Ukraine

Abstract. Comparative assessments of hazardous factors in different regions of Ukraine differ significantly, due to the development of their industrial complex, as well as natural resource potential, social and environmental situation. Each region of Ukraine has its own territory with an appropriate population, its own levels of man-made and natural hazards, which must be taken into account to prevent emergencies and adequately respond to them. The study of risk factors for the territory and population on the example of Kharkov region, risk management in case of emergencies, the level of danger for the territory and population of the region. The usefulness and expediency of research is due to the fact that such an analysis is the basis for substantiation of organizational and technical measures to prevent and adequately respond to emergencies in the region, taking into account potential dangers in this area and throughout the country as a whole.

Introduction

Recently, due to irrational economic activity, predatory exploitation of natural resources, huge regional load of the territory of Ukraine with powerful industrial and energy facilities, the risks of emergencies (EM) are increasing, the losses of which can be compared with the national budget of some countries. Analysis of open data on emergencies in Ukraine for the period from 1997 to 2018 [1, 2] shows that during this time there were 6745 emergencies, in which 8342 people died, 35294 people were injured, and material damage due to emergencies amounted to more than 15166,7 million UAH.

The presence in Ukraine of large areas with adverse natural influences and prone to manifestations of dangerous natural phenomena exacerbates the problem of national security for sustainable development of the country. Ensuring national security is an integral function of every state as a social entity, which should guarantee favorable conditions for life and productive activities of its citizens. Emergency prevention and elimination is one of the components of national security, which cannot be ensured without a detailed analysis of the current state of man-made and natural security, the development of measures to reduce the risk of emergencies [3-5].

Among the main factors that characterize the state of danger for the territory and population of the region of the state should be noted the following [6-8]: area, territory; possible natural phenomena; population; number and properties of potentially dangerous objects (PDO), state of technogenic safety of life support objects of the population (gas pipelines, power systems, etc.); the level of threats of man-made, natural and social nature.

Man-caused factors are manifested through the operation of PDO and the risk of man-made emergencies: fires, explosions, accidents with the release of hazardous chemicals, radioactive substances, hydrodynamic accidents, accidents on life support systems and others. The level of natural danger is determined by factors of natural origin that occur in Ukraine.

20 November 2020

The diversity of these factors and their ratio indicates the diversity of regions of Ukraine by types of natural hazards and the degree of their impact on the lives of the population of Ukraine [9].

Comparative assessments of dangerous factors in different regions of Ukraine differ significantly, due to the development of their industrial complex, natural resource potential, environmental and social situation.

Each region of Ukraine has its own territory with a corresponding population, its own levels of man-made and natural hazards, which must be taken into account to prevent emergencies and adequately respond to them. Peculiarities of the geographical position of Kharkov region and the variety of weather processes that determine its weather conditions, the presence of a powerful industrial complex, a large number of PDO and fire and explosion facilities significantly affect the state of man-made, natural and social security of the region. Therefore, the relevance of research aimed at analyzing the risks of sources of emergencies, assessing the state of man-made, natural and social hazards in the Kharkov region on the basis of statistical data, there is no doubt that can be successfully used for the country as a whole.

The usefulness and expediency of the research is due to the fact that such an analysis is the basis for substantiation of organizational and technical measures to prevent and adequately respond to emergencies in the region, taking into account the potential dangers in this area.

Theory of the matter

The analysis of the scientific literature shows that there are separate approaches to quantitative assessment of risks of man-made natural hazards. In works [10, 11] indicators of an estimation of a condition of danger of territories of regions of the state are developed and attempt of their distribution on several levels of dangers separately for emergencies of technogenic and emergencies of natural character is made.

The analysis of methods for assessing the level of danger to life in the event of an emergency presented in [12, 13] does not take into account the causes of danger factors and the peculiarities of the manifestation of nonlinear relationships between them.

The risk-oriented approach used in [14], along with the assessment of the level of threats, requires the determination of losses from the consequences of emergencies, but does not take into account human losses.

To form a comprehensive indicator for assessing the level of threats to the territory and population of the region in [15] proceeded from the fact that the level of danger of each region is determined by the average intensity of emergencies and their possible consequences. However, this approach is limited and does not take into account the fact that the consequences of emergencies for the territory and population of the region depend not only on the number of emergencies, but also the area and population living in this area.

Thus, the existing methods of assessing the level of danger to the territory and population of the region of the state do not fully take into account the causes of danger factors and the relationship between them (egg area, population), material damage and human losses due to emergencies. In addition, the features of the regions of Ukraine that affect the state of man-made, natural and social hazards are insufficiently studied, and therefore require further analysis.

The aim of the work is to analyze the risk factors, the risks of emergencies in the Kharkov region and to determine the level of danger for the territory and the population of the region.

To achieve this goal it is necessary to solve the following tasks:

- to analyze the risk factors for the territory of Kharkov region;

20 November 2020

- to analyze the risks of emergencies in the Kharkov region;
- to determine the level of danger for the territory and population of the region.

Discussion of results

1. Analysis of danger factors for the territory of Kharkov region

Kharkov region is located in the north-eastern part of Ukraine, in the steppe and forest-steppe zones. The area is 31418 km², which is 5,21% of the total territory of Ukraine (it ranks fourth in area in Ukraine after Odessa, Chernihiv and Dnipropetrovsk regions). The population of the region is 2 696 427 people (6% of the population of Ukraine, 4th place in Ukraine), including urban – 2 181 130 people (80,89%), rural – 515 297 people (19,11%), population density – 86 people / km². The territory of the region is divided approximately equally into two climatic sub-zones of the temperate zone: forest-steppe (northern half) and steppe (southern half). The region has a high level of economic development and concentration of industry. This is due to both the favorable economic and geographical position, and a fairly rich set of own raw materials. These resources allow the development of fuel and energy, chemical industry, etc. The leading complex of energy, electrical, transport and agricultural engineering in Ukraine was formed here.

Kharkov region is one of the industrially developed territories of Ukraine, which significantly affects the state of danger in the region.

The main factors influencing the state of danger for the territory and population of Kharkov region [1, 2] are presented in table 1.

Table 1. Danger factors for the territory of Kharkov region.

Region	Natural threats	Man-made threats
Kharkov region	flooding processes, landslides and karst processes, subsidence of loess soils, complex hydrometeorological phenomena	radiation, chemical, fire, explosion

The analysis of the factors listed in Table 1 shows that among the natural threats the greatest danger is the processes of flooding, landslides and karst processes, subsidence of loess soils, complex hydrometeorological phenomena.

The development of the economic complex of the region takes place in the conditions of increasing man-caused destabilization of the geological environment, which results in a further increase in the number of crisis phenomena in ecological systems, including the intensification of dangerous exogenous geological processes (EGP). Among the most dangerous EGP in terms of damage caused annually to economic facilities in the region include landslides, flooding, karst, subsidence of forest soils.

Active economic activity, lack of proper engineering and environmental measures for the development of territories causes the active spread of landslides in settlements, which poses a threat to the safety of life, infrastructure and territory as a whole. In the Kharkov region, 1615 landslides were recorded, the area of landslides was 40,3 km², the number of active landslides was 16, the area of active landslides was 0,009 km², the number of landslides in the built-up area was 68, and the number of economic objects in the landslide zone was 6.

Karst is a particularly dangerous process, and its sudden activation can lead to instantaneous failures or subsidence of the earth's surface. The spread of underground and surface karst manifestations is observed in the areas of water intake structures of the Kharkov region.

Flooding is one of the most common modern geological processes that develop both under natural conditions and under the influence of man-made factors. According to

20 November 2020

long-term observations in the Kharkov region, where the predominant factors in the development of flooding are natural (climatic) conditions, in high-water years the process intensifies, and in low-water – attenuates. In recent years, significant areas of flooding have been recorded, where the process develops not only within floodplains, floodplain terraces of river valleys and bottoms of large beams, but also on watersheds.

Peculiarities of the geographical position of the region and the variety of synoptic processes that determine its weather conditions contribute to the frequent occurrence of natural phenomena and the extreme complexity of their distribution in time and space. The most common natural meteorological phenomenon is very heavy rain, which causes floods, causes significant damage to agricultural land, and kills people. In second place in terms of the number of natural meteorological phenomena is the strengthening of the wind and the related phenomenon such as a gust. In quantitative terms, there is an increase in cases of strong winds on average one case per year, as well as some increase in the frequency of gusts. Recently, there is a predominance of a combination of several phenomena simultaneously, which can lead to negative consequences, both in the short term (when their destructive power is immediately manifested) and in the long run (for several years).

The fire situation in forests has been dangerous in recent years, mainly under the influence of human factors and natural and climatic conditions. At the beginning of the fire-hazardous period, the main cause of forest fires is the burning of dry vegetation and its remnants on farmland and roadside lanes near forests. Very hot and long summers with windy, no precipitation weather exacerbates the fire hazard.

The main causes and factors that cause the emergence of medical and biological emergencies in the region are the following: the constant growth of anthropogenic impact on the environment and abnormal manifestations of atmospheric processes; environmental pollution by infectious diseases; lack of domestic drugs for the diagnosis of a number of infections (especially exotic ones that can be imported); unsatisfactory compliance with safety requirements and low technological discipline in production, ignoring the requirements of norms and standards in industry, construction, utilities, transport and other industries; non-compliance of drinking water quality with regulatory requirements, pollution of sources of both centralized and decentralized water supply (especially sewage) due to the deterioration of water and sewage networks; low level of improvement of settlements; insufficient level of well-being and sanitary-educational culture of the population; consumption by the population of substandard food products purchased, as a rule, in places of spontaneous trade; insufficient or untimely implementation of measures aimed at preventing the occurrence of emergencies and reducing their consequences.

Among man-made threats, the greatest danger to the territory and population of the region are radiation, chemical and fire – explosion hazards. The radiation danger is caused by the functioning of the Kharkov State Interregional Special Plant of the Ukrainian State Association «Radon».

Chemical hazards in the area are associated with the presence of facilities that use hazardous chemicals (HCH), environmental pollution and waste generation, and a significant number of banned and unusable pesticides. There are 81 chemically dangerous facilities in the Kharkov region. Degree of chemical danger – III. To date, the region has accumulated HCH – 19,98 thousand tons, and the population in areas of possible chemical contamination – 346,72 thousand people.

According to the SES, the danger during transportation is posed by main oil, ammonia and gas pipelines, which are dangerous due to their working substance, which is under high pressure. The territory of the region is a unique object of transport infrastructure of the chemical complex – the ammonia pipeline. It is part of the main ammonia pipeline from Togliatti (Russia) to Yuzhnoe (Odessa region) and is on the verge of safe operation. In

20 November 2020

addition, the ammonia pipeline is close to the combat zone, so there is a risk of damage or sabotage. According to the State Emergency Service of Ukraine, between 200 and 15000 people may be in the zone of possible damage due to an ammonia pipeline accident.

The border region of Kharkov borders on the Belgorod region of the Russian Federation, where the Shebekino Chemical Plant, the Belgorod and Starooskol Cement Plants, the main gas pipelines Shebelinka-Belgorod (gas volume 4700 m³) and Shebelinka-Ostrogozhsk (gas volume 18700 m³) are located. Togliatti – Odessa (480 tons of ammonia, the depth of the affected area up to 20,9 km).

Enterprises and objects of oil and gas, petrochemical and oil refining complex have a high level of fire and explosion danger, which includes a significant number of fire and explosion objects, namely: 8 objects of UMG KharkovTransGaz, more than 14 thousand km of distribution pipelines, 3 gas filling stations, gas station network, 12 gas filling stations, as well as a tank farm for gas storage of more than 2 thousand tons.

Thus, the state of the natural environment and the technogenic situation in the Kharkov region due to many interrelated factors are characterized by an increase in the potential for the risk of emergencies and their consequences.

2. Analysis of risks of emergencies in the Kharkov region

The risks of emergencies in the Kharkov region are due to natural factors and hydrometeorological phenomena, as well as the state of fixed assets of enterprises, the presence in the regions of PDO, other economic and social indicators of development.

The dynamics of emergencies in the region for 2009-2018 is presented in Fig. 1.

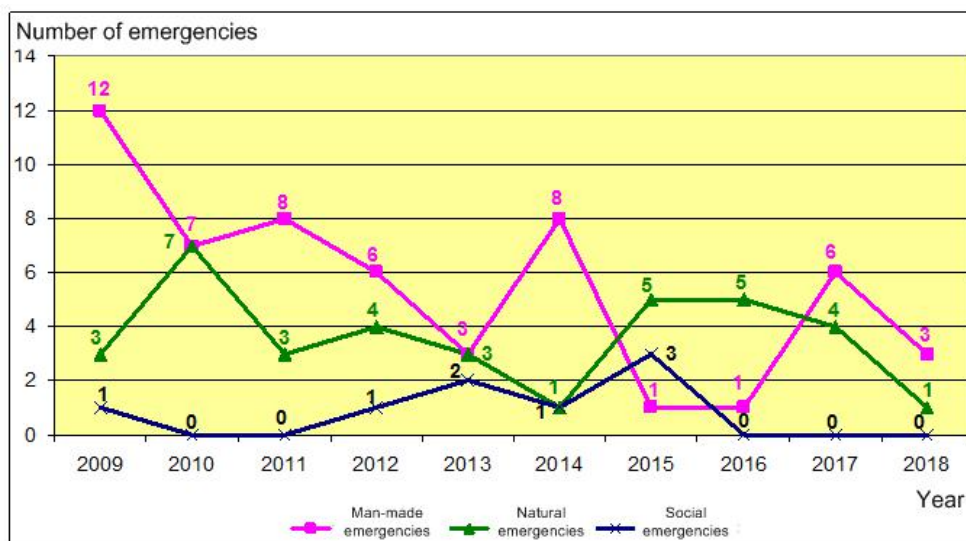


Fig. 1. Dynamics of the number of emergencies that occurred during 2009-2018.

The decrease in the indicators of the total number of emergencies and their components indicates a tendency to reduce the level of man-made and natural hazards in the region. However, given the preservation of the level of consequences of emergencies, which are determined not only by the number of emergencies of man-made and natural nature, but their levels, it should be noted that the risk of damage remains virtually unchanged and quite high for the region [1, 2].

The average annual number of emergencies in Kharkov region is about 11 (including man-made about 6, natural about 4, social about 1), and the average annual damage due to

20 November 2020

emergencies is about 26 million UAH. The percentage of emergencies observed in the Kharkov region during 2009-2018 is presented in Fig. 2.

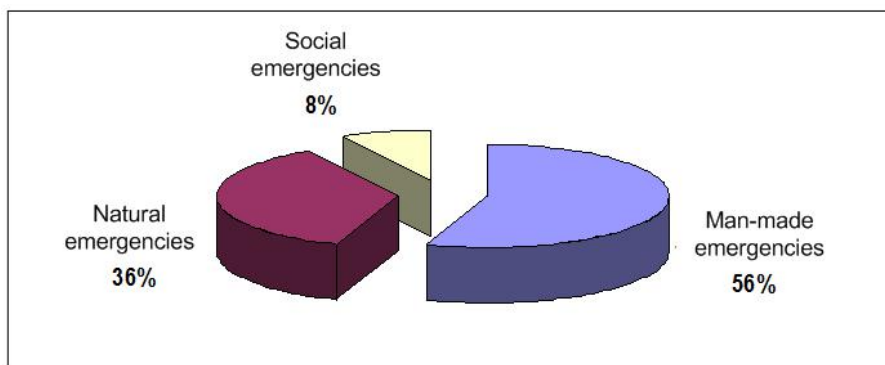


Fig. 2. Percentage of emergencies according to statistics for 2009-2018.

The analysis of statistical data (Fig. 2) shows that man-made emergencies are 56%, natural disasters – 36%, social emergencies – 8%. Thus, emergencies of man-made and natural nature are almost 92%.

Natural and biological emergencies are dominated by medical-biological, meteorological and emergencies related to fires in ecosystems; among man-caused – emergencies due to fires and explosions and emergencies due to accidents or catastrophes in transport.

Analysis of statistical data [1, 2] shows that for the period from 2009 to 2018 in Ukraine there were 842 natural disasters (of which in the Kharkov region – 36), 880 man-made emergencies (of which in the Kharkov region – 55), 107 Emergencies of a social nature (8 of them in the Kharkov region). Based on this, based on statistical data, the probability of man-made emergencies in the region is 0,06; natural – 0,04, social – 0,07 in case of emergencies of the appropriate nature in Ukraine.

3. Determining the level of danger for the territory and population of the region

The danger for the territory and population of the state (region) is characterized not only by the intensity (average annual number) of emergencies, but also by the severity of the consequences of emergencies. The consequences of an emergency depend on both the number of emergencies and the area of the territory and the population living in the area [16].

Based on these positions, a comprehensive indicator that characterizes the state of threats to the territory and population of the region of the state, taking into account the population and area of its territory is determined as follows:

$$Z_i = P_{Popul.}^{Reg} \cdot \overline{n}_{i Reg}, \quad (1)$$

where $P_{Popul.}^{Reg} = \frac{N_{Popul.}^{Reg}}{S_{Territ.}^{Reg}}$ – the share of the population of the i-th region of the state per unit

area of its territory; $N_{Popul.}^{ATU}$ – the total population of the i-th administrative-territorial unit of the state; $S_{Territ.}^{Reg}$ – the total area of the territory of the i-th region of the state; $\overline{n}_{i Reg}$ – the average annual number of emergencies in the i-th region of the state.

20 November 2020

The generalized complex indicator characterizing a condition of threats of the territory and the population on one administrative-territorial unit of the state has the form:

$$Z_{State} = P_{Popul.}^{State} \cdot \bar{n}_{State}, \quad (2)$$

where $P_{Popul.}^{State} = \frac{N_{Popul.}^{State}}{S_{Territ.}^{State}}$ – the share of the population of the state per unit area of its territory;

$N_{Popul.}^{State}$ – the total population of the state; $S_{Territ.}^{State}$ – total area of the state; $\bar{n}_{Держе.}$ – the average annual number of emergencies per region of the state.

Rationing Z_i relatively Z_{State} allows you to enter the coefficient of annual intensity of emergencies in the regions of the state:

$$k_{z_i} = \frac{Z_i}{Z_{State}}. \quad (3)$$

Comparative assessment of threats to the territory and population of regions of the state is carried out by comparing Z_i and Z_{State} : the level of threats to the territory and population of the region of the state is considered relatively optimal if the relevant values are more than a third lower than Z_{State} in the country; the level of threats to the territory and population of the region of the state is considered relatively acceptable if the relevant values Z_i differ from the value Z_{State} by no more than a third; the level of threats to the territory and population of the region of the state is considered relatively unacceptable if the relevant values Z_i exceed the values Z_{State} in the country by more than a third.

Based on statistical data for 1997-2018 [1, 2] it is established that the relative level of danger for the territory and population of Kharkov region is 1,28. With this in mind, the region can be classified as a region with a relatively acceptable level of danger to the territory and population.

Conclusion

The analysis of the state of man-caused, natural and social danger in Kharkov region on the basis of monitoring data showed that due to many interrelated factors it is characterized by an increase in the risk of emergencies and their consequences, which is typical for the country as a whole. Natural threats include flooding, landslides and karst processes, subsidence of forest soils and complex hydrometeorological phenomena, man-made threats include radiation, chemical, fire and explosion hazards.

The average annual number of emergencies in Kharkov region is about 11 (including man-made about 6, natural about 4, social about 1), and the average annual damage due to emergencies is about 26 million UAH. In percentage terms, man-made emergencies predominate, accounting for about 56% of all emergencies.

20 November 2020

Based on statistical data, it is established that the relative level of danger to the territory and population of Kharkov region is 1,28, and therefore the region can be attributed to a region with a relatively acceptable level of danger to the territory and population.

References

1. Report on the main results of the Civil Service of Ukraine for Emergencies in 2017. URL: [http://www.dsns.gov.ua/files/2018/1/26/Zvit%202017\(KMY\).pdf](http://www.dsns.gov.ua/files/2018/1/26/Zvit%202017(KMY).pdf).
2. Report on the main results of the Civil Service of Ukraine for Emergencies in 2018. URL: [http://www.dsns.gov.ua/files/2018/1/26/Zvit%202018\(KMY\).pdf](http://www.dsns.gov.ua/files/2018/1/26/Zvit%202018(KMY).pdf).
3. Tiutiunyk, V. V., Ivanetz, H. V., Tolkunov, I. A., & Stetsyuk, E. I. (2018). System approach for readiness assessment units of civil defense to actions at emergency situations. Doi: <https://doi.org/10.29202/nvngu/2018-1/7>. *Scientific Bulletin of National Mining University*, Vol. 1, 99-105.
4. Golovan, Yu. V., & Kozyr, T. V. (2015) Protection of the population in emergency situations. Organizational and methodological complex. Prospect Publishing House, Far Eastern State Technical University, 219 p.
5. Nivolianitou, Z., & Synodinou, B. (2011). A Towards emergency management of natural disasters and critical accidents: The Greek experience. Doi: <https://doi.org/10.1016/j.jenvman.2011.06.003>. *Journal of Environmental Management*. Vol. 92, Issue. 10, 2657-2665.
6. Ivanets, H., Horielyshev, S., Ivanets, M., Baulin, D., Tolkunov, I., Gleizer, N., & Nakonechnyi A. (2018). Development of combined method for predicting the process of the occurrence of emergencies of natural character. Doi: <https://doi.org/10.15587/1729-4061.2018.143045>. *Eastern-European Journal of Enterprise Technologies*. Vol. 5, Issue 10(95), 48-55.
7. Kelman, Ilan. (2017). Linking disaster risk reduction, climate change, and the sustainable development goals. URL: <http://www.emeraldinsight.com/toc/dpm/26/3>. *Disaster Prevention and Management: An International Journal*, Vol. 3, 254-258.
8. David, O. (2017). Urban critical infrastructure interdependencies in emergency management: Findings from Abeokuta, Nigeria. URL: <http://www.emeraldinsight.com/toc/dpm/26/2>. *Disaster Prevention and Management: An International Journal*, Vol. 2, 162-182.
9. Ivanets, G. V., Gorelyshev, S. A., & Ivanets, M. V. (2017). Risks of emergencies of technogenic and natural character in the territory of Ukraine. *Scientific journal «Power and Society»* (History, Theory, Practice). Tbilisi, Georgia, Open Diplomacy Association, Vol. 2(42), 180-193.
10. Tyutyunik, V. V., Shevchenko, R. I., & Tyutyunyk, O. V. (2009). Assessment of individual danger of the population of the regions of Ukraine in emergency situations. *Problems of emergencies Coll. Science. wash.* Kharkov, University of Civil Defense of Ukraine, Vol. 9, 146-157.
11. Chub, I. A., & Popov, V. M. (2012). Modeling of the monitoring system of technogenic safety of the region. *Open information and computer integrated technologies*, Vol. 56, 157-161.
12. Kotovenko, O. A., Sobolevskaya, L. I., & Miroshnichenko, O. Y. (2014). Stochastic modeling in the study of processes under the influence of nature management in the region. *Eastern European Journal of Advanced Technology*, Vol. 2/14, 37-41.
13. Prikhodko, M. M. (2013). Ecological safety of natural and anthropogenic modified geosystems. Ivano-Frankivsk National Technical University of Oil and Gas. *Center for Environmental Education and Information*, 201 p.
14. Belyaev, N. N., Gunko, E. Yu., & Mashikhina, P. B. (2013). Mathematical modeling in the problems of environmental safety and emergency monitoring. Dnieper, Accent PP, 158 p.
15. Tyutyunik, V. V. (2015). Estimation of relative intensity between natural and man-made emergencies in the regions of Ukraine. *Problems of emergencies*. Kharkov, National University of Civil Defense of Ukraine, Vol. 21, 112-120.
16. Ivanets, H. V., Gorelyshev, S. A., & Ivanets, M. G. (2019). Statistical method of assessing threats to the territories and population of administrative-territorial units of the state. *Collection of scientific works of the National Academy of the National Guard of Ukraine*. Kharkov, Vol. 2(34), 51-67.