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CURRENT CHALLENGES OF RISK ASSESSMENT IN LIGHT OF POPULATION PROTECTION

ABSTRACT: *The package of cardinal laws on Disaster Management, effective from 01 January 2012, has fundamentally transposed the procedures of population protection by introducing risk assessment of hazard sources concerning population protection. The system thus designed, has reliably functioned in the past six years and has ensured the hazard response planning of settlements based on real-life vulnerabilities, thus population protection planning. However, it was developed in a very different security environment. Thus, apart from natural and man-made hazard sources, it does not address the assessment of hazards concerning the population, bound to the armed defense of the country or armed operations. For the sake of the six-year operation, the changed security environment and the all-hazard approach, it is advisable to review the current system. The purpose of this study is, besides raising the problem and presenting the current "Fuzzy" logic process in Hungary, to propose a solution to expand it for the sake of an all-hazard approach.*

KEYWORDS: *hazard, risk, risk assessment, population protection*

INTRODUCTION

An important milestone of hazard response planning in Hungary was the replacement of an old-fashioned emergency planning method, taking into account all hazards at the same level, by designing a hazard response planning process meeting the requirements of the present, based on risk assessment.

Prior to the entry into force of the current system, defense/protection planning was regulated by Gov. Decree 114/1995. (IX. 27) on the rules of civil protection classification of settlements and defense/protection requirements, however, with the entry into force of the new defense and disaster management acts and their implementation decrees, this decree was repealed. Although the former civil protection classification had taken into account the vulnerability of settlements, the direct impacts; as a consequence of the public administration, infrastructure and industry center characters, as well as their role in road and rail transportation, during armed conflicts; and it had prescribed planning tasks as well, while it had not assessed risks based on the probability of their occurrence and impacts.

It was a descriptive regulation, in which, for example, settlements within a 30-km zone measured from the border, in the territory of which a plant producing, using or storing hazardous materials operated, was classified in the highest category by default and also included a safety standard for this. The biggest mistake of the regulation was that the settlements were prepared on the basis of civil protection classification and not for real risks.

The currently functioning procedure, stipulated by law[1], is a risk analysis based on the principle of the "Fuzzy" logic that I present in this article. The "Fuzzy" logic process, because of its ease of handling resulting from its matrix structure, is perfectly suited to be used without higher professional population protection qualifications, hence to group settlements in disaster management classes, but from the hazard sources relevant to population protection it does not deal with the analysis of population risks associated with armed conflicts or threats.

The security environment has considerably changed in the past three years. What shows it the best is that the NATO heads of state and government leaders at their Warsaw Conferences in July 2016 made a commitment[2] to strengthen civil preparedness, named as the central pillar of the resilience of the Alliance, and in this relation NATO determined seven baseline requirements.[3]

The current disaster risk assessment process is simple and works efficiently, however, the population and property are jeopardized not only by natural and industrial disasters. The need therefore arises, based on the all-hazard approach, to consider whether risk assessment, currently used for population protection, can be supplemented by a procedure that takes into account risks associated with armed threats. Is it possible to analyze at all the risks of various hazards in one system, including population risks associated with armed conflicts?

THE PRACTICE OF DISASTER RISK ASSESSMENT IN HUNGARY

Settlement level risk assessment

In the practice of risk assessments in Hungary, the legislation[4], describing the disaster management classification of settlements, is the first legislation, in which the grouping of hazard sources is listed, relevant from the aspect of population protection. They are as follows:

1. Natural disasters and hazard sources

- a) Flood,
- b) Inland water,
- c) Extreme weather,
- d) Geological hazard sources:
  - da) earthquake,
  - db) landslide,
  - dc) rupture,
  - de) soil subsidence,
  - df) wall collapse.

[1] Gov Decree 234/2011. (XI. 10.) on the Government implementing Act No. CXXVIII of 2011 concerning disaster management and amending certain related acts. http://njt.hu/cgi_bin/njt_doc.cgi?docid=140039.349975, Accessed on 12 January 2018.

[2] "Fact Sheet of Warsaw Summit Key Decisions". NATO. February 2017. https://www.nato.int/nato_static_fl2014/assets/pdf/pdf_2017_02/20170206_1702-factsheet-warsaw-summit-key-en.pdf, Accessed on 12 December 2017.

[3] NATO Seven Baseline Requirements. See: Shea, J. "Resilience: a core element of collective defence". *NATO Review.* 2016. https://www.nato.int/docu/Review/2016/Also-in-2016/nato-defence-cyber-resilience/EN/index.htm, Accessed on 29 December 2017.

[4] Gov Decree 234/2011.

2. Industrial accidents and man-made hazards

a) Plants under Chapter IV of the Act on Disaster Management,

b) Impacts by other establishments (industrial, agricultural), the risk of release of hazardous materials,

c) Distance from nuclear establishments:

ca) nuclear power plant,

cb) research reactor.

d) Traffic routes and junctions:

da) transportation of hazardous materials,

db) considerable traffic.

e) Plants and other establishments involving hazardous materials not under Chapter IV of the Act on Disaster Management, operated for military purposes.

3. Hazards of other origin

a) The vulnerability of surface and subsurface water (mainly drinking water bases),

b) Human epidemics or the danger of epidemics, and animal epidemics,

c) Air pollution reaching the alert threshold.

4. Risks relating to critical infrastructures

a) The vulnerability of infrastructures providing basic supply of the population,

b) The vulnerability of transportation/traffic,

c) The vulnerability of public administration and infrastructures indirectly providing the supply of the population.

The codification of the above listing was necessary to identify risks in a uniform way in Hungary, in 3,177 settlements or districts of the capital. In the settlement risk assessment procedure, risk identification is performed by checking the compliance according to a grouped list. Undoubtedly, non-definable risks concerning a particular settlement are excluded. For example, in the case of the vast majority of settlements in the southern part of the Great Hungarian Plain, items 1. d. db) – df) do not have to be included in the risk analysis as these hazard sources cannot be detected there.

Risk identification is performed on the basis of regulation; it means the examination of the related threat effect is possible if it appears in that particular settlement. The risks thus identified are analyzed in terms of the probability of occurrence and the severity of the triggered effect.

The probability of occurrence is the definition of the occurrence frequency of the hazard relevant to the given settlement, based on historical-statistical data, there is a formalized probability estimate. The other is the assessment of the consequences of the occurrence of a risk or risks, or the definition of the *severity* thereof. The frequency of occurrence and the impact assessed together, depicted on a so-called risk matrix that gives the result of the risk assessment method, that is, a disaster management classification. A hazard response plan is based on a disaster management classification, including the alert of the population, the method of population protection, the funds needed to initiate protection, as well as planning the involvement of special equipment and trained experts (voluntary rescue organizations). The establishment of civil protection organizations, forming the backbone of the self-defense capabilities of settlements, their organizational structure and their minimum number are also connected to classification.

We can see the structure of the risk matrix in the figure below:

Impact	Frequency of occurrence			
	Rare	Not frequent	Frequent	Very frequent
Very severe	Class II	Class II	Class I	Class I
Severe	Class III	Class II	Class II	Class I
Not severe	Class III	Class III	Class II	Class II
Low	Class III	Class III	Class III	Class III

Figure 1: *Risk matrix*
Source: *Annex 2 of Gov. Decree 234/2011.*

The logic used for compliance with dual conditions is the Fuzzy logic[5] therefore literature calls the relationship of severity and probability conditions in relation to each other as Fuzzy matrix, assessing the matrix as above.

In my opinion, the only weakness of this matrix is that it only distinguishes three risk classes. In a country where there are 3,177 settlements and districts of the capital, characterized by very different natural conditions, the scissors are very narrow, which shows the differences, so the inaccuracy of the risk assessment is higher.

Another feature of the Hungarian disaster risk assessment system is that it establishes a special regulation for industrial vulnerabilities, based on which settlements that are directly threatened in the 3-kilometer radius of the nuclear power plant and in the 1-kilometer radius of the research reactor shall be classified in Class I, or are threatened by a plant under the effect of Chapter IV of Act CXXVIII of 2011 on Disaster Management and on the amendment of certain acts in relation (Act on Disaster Management) and are bound to draft an off-site protection plan. Settlements that are indirectly threatened by the nuclear power plant (located in the 3 to 30-kilometer radius) shall be classified as Class II, or are threatened by a plant under the effect of Chapter IV of the Act on Disaster Management and are not bound to draft an off-site protection plan. Settlements whose territories are threatened in case of the release of hazardous materials from a plant not under the effect of Chapter IV of the Act on Disaster Management shall fall in Class III.

To be exhaustive, it should be noted that the regulation of the current industrial safety area, the general risk management factors may also be found, such as the definition of a hazard that means the identification of the possibility of a major accident determining the occurrence frequency and probability of a major accident involving potential hazardous materials; the assessment of the consequences of a major accident involving the identified hazardous materials; the presentation and evaluation of the possible domino effects, and their consequences.

For the purpose of defining individual and social risks, the regulation integrates the probability and the consequences of major accidents related to hazardous materials, affecting an area by their impacts. When calculating a social risk not only the population living in the vulnerable area, but people staying there periodically, in a significant number (e.g.,

[5] Chinho, L. and Hsieh, P. J. "A fuzzy decision support system for strategic portfolio management". *Decision Support Systems* 38/3. 2014. 383–398. https://pdfs.semanticscholar.org/ca2e/921771ce61e84197b030b9034bcfc8b6e2bf.pdf, Accessed on 18 December 2017.

workplace, shopping center, school, entertainments, etc.) are also taken into account. The more people can be affected by lethal impacts, the less acceptable a social risk is. Thus, contrary to the constant values of individual risk levels, the level of social risk can only be defined[6] as a function of the expected number of victims (deaths).

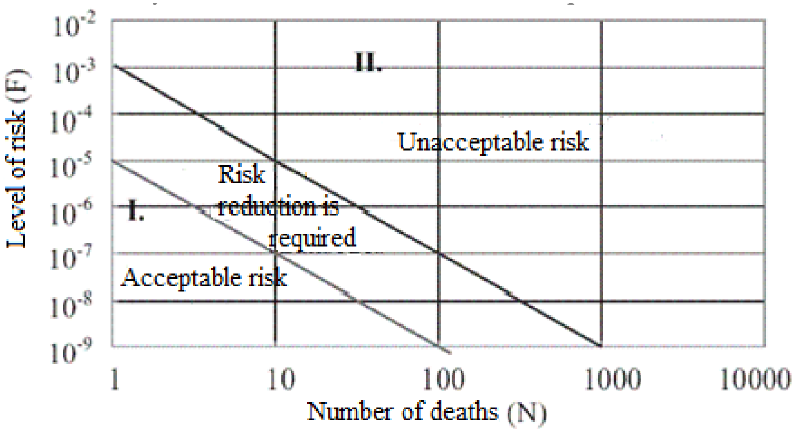

Figure 2: *Industrial Safety Social Risk. Matrix Risk level (F) Acceptable risk Risk reduction necessary Unacceptable risk Number of deaths (N)*

Source: *Annex 7 of Gov. Decree 219/2011.*

The X-axis of the F-N curve indicates the number of deaths (N). The number of deaths must be displayed on a logarithmic scale and the smallest displayed value is 1. The Y-axis of the F-N curve represents the aggregate frequency of accidents involving the death of N or more people. This accumulated frequency should be displayed on a logarithmic scale and the smallest displayed value is 10^{-9} 1/year.

The industrial safety risk analysis is a quantitative risk analysis process, a part of which is the definition and analysis[7] of possible accident series of incidents. To analyze the consequences of an incident software procedures or guidelines internationally accepted are available.

For population protection it is especially important that the consequences of a particular hazardous industrial accident stay within the establishment or affect the population living in its surroundings, directly or indirectly, via other intermediary means.

During an official authorization process, the above risk analysis procedures – which are prepared by the operator in a safety report and safety analysis – and during their review, the authority decides if the given plant is obliged or not to draft an off-site protection plan, due to its hazard impacts.

For the protection of the population it is especially important that the consequences of a particular hazardous industrial accident remain within the establishment or reach a population living in its surroundings, directly or indirectly via other intermediary medium.

6 Gov. Decree 219/2011. (X. 20.) on the protection against major accidents involving dangerous substances. http://njt.hu/cgi_bin/njt_doc.cgi?docid=139993.347708, Accessed on 02 January 2018.

7 Kátai-Urbán, L. "Evaluation and development of the conditions of application of the protection measures against the transboundary effects of industrial accidents". Thesis presented for the degree of PhD. Miklós Zrínyi National Defense University, Military Technical Doctoral School, Budapest, 2006.

During the course of the official authorization, the above risk analysis procedures – which are prepared by the operator during the safety report and the safety analysis – and during their review, the authority decides whether the given plant is obliged or not to have a threatening effect to draft an off-site protection plan.

Hungary's national level risk assessments

It is important to mention that besides the hazard source categorization used at settlement level, in practice, one can find other groupings as well. In 2011 and 2014, national level disaster risk assessments of Hungary were drafted.

The 2011*"National Disaster Risk Assessment"*[8] was elaborated by six working groups. Separate working groups dealt with the analysis of (1) flood and inland water hazards, (2) effects of extreme weather, (3) social risks, (4) forest fires, (5) earthquakes, (6) industrial accidents and risks, identifying them as the "main disaster hazards". As a result, it was established that flood and inland water hazards are regarded as the highest vulnerabilities in Hungary under those circumstances.

The 2014 risk assessment, as opposed to the previous one, identified 12 risk areas broken down into 3 groups:

1. Natural risk area
- a) Extreme weather,
- b) Floods,
- c) Geological risks,
- d) Epidemics,
- e) Space weather.

2. Major accidents risk area
- a) Hazardous materials,
- b) Road accidents,
- c) Nuclear accident.

3. Deliberate incidents
- a) Terrorism,
- b) Cyber-attack,
- c) Security policy crisis,
- d) Energy supply crisis.

Compared to the previous national assessment, hazard sources originating in cosmic and solar sources have appeared as novelties, and the consideration[9] of the risks caused by deliberate human activity. Based on the assessment, in Hungary extreme weather; invasive, allergenic or toxic plants; migration (due to climate change); droughts; and severe storms are the greatest threat to the population in Hungary. However, according to the above described points based on the regulations in force, settlement classification is a decisive factor from the aspect of population protection.

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[8] Gyenes, Zs. "Nemzeti Katasztrófa Kockázat Értékelés". Veszprém Megyei Katasztrófavédelmi Igazgatóság. 2011. http://vmkatig.hu/KEK.pdf, Accessed on 24 January 2017.

[9] Gov. Decree 1384/2014. (VII. 17.) Report of Hungary's national catastrophe risk assessment methodology and its results. 2014. http://www.katasztrofavedelem.hu/letoltes/szervezet/20140718-katasztrofakockazat-ertekelesrol-jelentes.pdf, Accessed on 28 December 2017.

ALL-HAZARD APPROACH OF POPULATION AND PROPERTY PROTECTION

It is necessary to further develop the risk assessment procedure, first of all, to introduce an all-hazard assessment of hazard factors affecting the population and property. To this end, it is expedient to group the hazard sources by their origin. Considering the above, in my opinion, hazard impacts are expedient to be examined in the following three large groups:

1. Natural disasters (hydrological, geological, meteorological, biological, extraterrestrial, etc.).
2. Technological disasters (industrial, nuclear, traffic disasters, non-natural fires, etc.).
3. Social disasters (wars, riots, terrorist threats, etc.).

A possible grouping of natural hazard sources of Hungary

Hazard sources that are obviously irrelevant of human activity or the absence thereof belong to this group. They have the peculiarity that we are inherently unable to prevent their development, but we can mitigate their effects. Natural hazard sources mainly affect safety and security in the field of society and the economy.

In Hungary, natural hazard sources may be:

1. Hydrological

a) Flood,
b) Inland water,
c) Limnological,
d) Hydrogeological,
e) Hydro-chemical and hydro-biological.

2. Meteorological

a) Extreme heat,
b) Extreme cold,
c) Effects of winds,
d) Hydro-meteorological hazards (droughts, forest and vegetation fires, cloudbursts),
e) Thunderstorms, supercells.

3. Geological

a) Earthquake,
b) Slope slide,
c) Soil collapse,
d) Subsidence,
e) River bank, mountain and rock falls,
f) Volcanic eruption.

4. Biological

a) Human epidemics,
b) Animal and plant health epidemics,
c) Spread of invasive allergenic or toxic plants,
d) Proliferation of invasive animal species.

5. Cosmic
a) Solar radiation,
b) Other cosmic radiations,
c) Collision with asteroids, minor planets or comets, or with cosmic artificial objects,
d) Supernova explosion,
e) Black holes.

My classification proposal described above lists both cosmic and biological hazards as natural hazards, similarly to the 2014 national risk assessment, based on the principle that active or negligent human activities are not necessary for their appearance. With regard to human epidemics, long discussions could continue on the issue, but in my opinion, the natural classification of epidemics is also justified by pathogens that enter human body as viruses or bacteria. The emergence of these microorganisms is not exclusively related to humans even though, in most cases, they can only survive for longer time in other living organisms such as humans.

At geological hazards, I mention volcanic eruptions, the probability of which in Hungary is low, since the basaltic volcanoes in the Balaton Uplands usually only have one outbreak cycle. At the same time, the temperature of the mantle on the Great Hungarian Plain is 200°C, which warms the sediment layer above it, so basaltic magma could break into the surface in this area just in a few days. In addition, throughout the entire territory of the Carpathian Basin, the rock mantle is thin (about 70 km). Thus, the malleable material of the upper mantle of the Earth can easily flow here, which can lead[10] to the melting of the covering rocky substance. However, it must be seen that a volcanic eruption can have implications to everyday life even from a long distance. For example, during the eruption of the Eyjafjallajökull Volcano in 2010, aviation was interrupted in many countries, thus their impacts reached Hungary as well.

A possible grouping of Hungary's technological hazards

Hazard sources that appear as a consequence of human activity or as that of the lack of human activity i.e. negligence have been included in this group. They have a peculiarity that their development could be prevented by authoritative rules.

1. Originating in industry
a) Release of toxic, carcinogenic chemical/biological, flammable and explosive substances,
b) Nuclear, radiological accidents,
c) Air pollution,
d) Extensive fires,
e) Accidents originating in planning or implementation.

2. Traffic, transportation hazards
a) By land
b) By air
c) By water

[10] Harangi, Sz. *Vulkánok: a Kárpát-Pannon térség tűzhányói*. Szeged: SZTE TTIK, 2011. 440.

3. Disruptions of essential systems
a) Water supply,
b) Electric energy supply,
c) Info-communication systems,
d Defects of supply of fossil energy sources,
e) Communal service providers.

A possible grouping of Hungary's social hazards

Social hazard sources are mentioned together by several terms of references as technological hazard sources, a civilization-based hazard source. At the same time, if we start out that, in the case of natural hazard sources, human activity is irrelevant, while at the grouping of technological hazard sources described above, it was stated that they derive from active or negligent human activity. Thus, the social hazard sources group used in the article is distinct from these, since it is based on the typically deliberate human activity. Given the fact that harmful human behavior brings these hazard sources to life, their management is also different from the hazard sources discussed above. Sometimes, it involves the legitimate use of armed force as well. Due to this striking difference, I find it justified that social risks should form a separate large group.

Starting from this approach, we should first look at what social hazard sources can be identified in our legal system. Hungary's Fundamental Law distinguishes[11] six types of special legal orders in light of threats to the population:

1. State of national crisis in the event of the declaration of a state of war or an imminent danger of armed attack by a foreign power (danger of war);

2. State of emergency in the event of armed actions aimed at subverting the lawful order or at exclusively acquiring power, or in the event of serious acts of violence endangering life and property on a massive scale, committed with arms or with objects suitable to be used as arms;

3. State of preventive defense in the event of a danger of external armed attack or in order to meet an obligation arising from an alliance (NATO);

4. State of terrorist threat in the event of a significant and direct threat of a terrorist attack or in the event of a terrorist attack;

5. Unexpected attack to repel the attack of external armed groups penetrated into the territory of Hungary;

6. State of danger in the event of a natural disaster or industrial accident endangering life and property, or in order to mitigate the consequences thereof.

Based on the above listing, a triple grouping can be noticed. The scope of hazard sources originating in war or armed conflict (1), from which the danger of a terrorist attack is separated (2), however, a jeopardizing factor, supposing an internal social crisis, intended for the violent overthrow of the constitutional order (3) appears as well. These three hazards should be complemented by migration, based on international political relations and processes nowadays witnessed, and cyber security risks. Based on the above, social hazard sources, in my opinion, may include the following:

[11] The Fundamental Law of Hungary. Articles 48–54. http://www.njt.hu/cgi_bin/njt_doc.cgi?docid=140968, Accessed on 20 December 2017.

1. Internal political crisis
2. Migration, flow of refugees
3. Cyber security
4. Terrorism
5. War, armed conflict

A POSSIBLE EXPANSION OF RISK ASSESSMENT

The assessment of risks of natural and technological hazard sources has already been integrated into the current procedure, so it is required to incorporate it in the social hazard sources listed in the previous subtitle.

The most obvious solution would be if the defense sector developed a special procedure similar to the industrial safety procedure. Paragraph (6) of Section 11 of Act CXIII of 2011 on national defense and the Hungarian Defense Forces and on the measures that may be taken in special legal order states that *"...the detailed requirements for the preparation, execution and stock building tasks related to civil protection obligations during the period of an armed conflict are contained in the armed defense plan of the country."* Accordingly, critical infrastructures of paramount importance for defense purposes as well as strategically or operationally significant traffic junctions, traffic corridors, waterway crossing points, or, in the case of fulfillment of other aspects of armed defense required by the defense sector, such as the distance from the border, they all would be included in the classification of settlements on a descriptive basis. Before doing so, however, it is expedient to review the current matrix system as well, since I have mentioned it earlier that its three outcomes do not show significant alterations among settlements.

Another solution could be if, by reviewing the matrix, an integrated method were developed. As an example, I use the risk matrix[12] elaborated by the US Army, which I have complemented with a numbering system.

			Probability				
			Frequent	Likely	Occasional	Seldom	Unlikely
			A	B	C	D	E
Severity	Catastrophic	I	20	19	17	16	12
	Critical	II	18	15	14	11	7
	Moderate	III	13	10	9	6	5
	Negligible	IV	8	4	3	2	1

Figure 3: *Risk assessment matrix*
Source: *Addition to DD Form 2977*

A separate hazard source relevant to all settlements could be analyzed with this matrix. Based on the analysis, using the classification described above, the subgroups would get the number of the hazard source receiving the highest score, and the numbers of the subgroups would be accumulated.

[12] "DD Form 2977: Deliberate Risk Assessment Worksheet". Department of Defense. January 2014. http://www.benning.army.mil/RangeOps/content/blank_forms/DD2977_DeliberateRiskAssessmentWorksheet_Apr14.pdf, Accessed on 17 December 2017.

For example, within natural hazard sources, in the subgroup of hydrological hazards, a settlement would receive 15 points for flood hazards and would receive less for all other threatening impacts. In this case, the metric of the hydrological subgroup would be 15. The metric of the other four natural hazard source subgroups (meteorological, geological, biological, cosmic) would be added to this. Thus, in extreme cases, a settlement could receive a maximum of 100 points for natural hazard sources, in the case of technological hazard sources, 60 points could be received, while in the case of social hazard sources, it could also receive 100 points; a minimum of 3 points in the reverse approach.

Of course, the probability of the two extremes is extremely low. The assessment of an armed threat could be supplemented by additional compensation procedures; for example, a city with a Tisza River crossing could receive a higher value than a settlement of the same parameter, but not as decisive in terms of freedom of movement of military force, based on a calculated multiplier, until reaching the maximum point. Resources necessary for the management of risks could be assigned to the cumulative numbers thus received.

For example, it could be the case that only municipal rescue teams could apply for support from the government to voluntary civil protection rescue organizations, in the case of which a settlement has received 120 or more points. For district and territorial rescue teams, the scores could be averaged. Another such source of support could be at the cost of increasing defense-related budget expenditures to the ratio of 2% of the GDP in order to meet the requirements of NATO's resilience. For example, in settlements having received 150 points at the assessment, an increase in the investment in resilience and civil preparedness would be possible.

Of course, the ratios given here only serve as examples; for the elaboration of the system detailed inter-ministerial consultations, impact assessments and expert analyzes are required.

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