Analysis of safety factors

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Abstract. An overview of the existing literature on safety factors proves that a number of variables conditioning the level of safety are extensive and very diverse. Many authors cite various determinants affecting the safety of society showing their relationship with strengthening immunity and reducing vulnerability. Accordingly, wide list of factors that can be used in research on their impact on safety is available. The author's earlier research identifies over 80 factors affecting the level of security. In the existing literature is not any scores which have attempted a comprehensive assessment of the suitability of factors in security. Due to the lack of research in this area, this article presents results of studies designed to assess the safety factors in the context of determining their hierarchy. The article presents the results of data collected in 2017 among The Main Schools of Fire Services students.

1 Introduction and purpose of research

An attempt to delineate the safety scale that allows its interpretation poses a challenge for researchers by years. All methods of risk assessment determine the risks in the form of numbers (in the case of quantitative methods), or descriptions (in the case of qualitative methods). Brings it to create diagrams, matrices and schemas, in which risk assessment takes a established scale (denoted as the quotient of impacts of the event and its probability). The risk is therefore a measure of security. The relationship between risk and security is inversely proportional in the strict sense. The lower risk, the greater the safety. Recognition of it allows to understand the security as the state of civilization and natural environment as specified by the level of its total risk [1]. Scientific studies indicate the risk, as a measure of threats assessment resulting from the possible adverse events. In addition, the risk is marked, as the layout of the three variables: probability of threats, the size of impacts and vulnerability to threats [2]. Vulnerability, in turn, can be consider with through the prism of two elements: resilience and sensitivity [3]. The resilience is affiliated with the control of the risk, with harm reduction capacity or with the ability to cope with them. The sensitivity of the affiliated with risk exposure [4]. In the methodology of the risk assessment for the purposes of crisis management system in Poland measure of vulnerability have become systemic and supplements barriers [3]. Systemic barriers are defined as systems whose task is to protect people from the threats, health protection and other protective systems. Supplement barriers in turn are defined as the sensitivity of the

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community on the threat in conjunction with resilience. In the case of systemic barriers risk 
assessment methodology authors identify two barriers relating to the efficiency of the State 
Fire Service and State Medical Service. Unspecified was, however, whether the other 
elements of the systems created by the State can be taken into account in the assessment of 
the systemic barriers. In the case of supplement barriers author evokes a number of 
indicators of vulnerability, which are reflected in the example the estimation of barriers. 
The author not points out, however, that the collection of recalled barriers is a closed 
collection.

The aim of the article is hierarchy the factors identified in previous studies, which may 
extend the number of systemic and supplements barriers used in Polish risk assessment 
methodology. In researches was used mutual comparisons methods based on Analysis 
Hierarchy Process. The list of factors, as well as the methods of their hierarchy are a test 
for the dissertation thesis of the author. For this reason, studies were carried out in two 
directions: on the one hand, efforts were made to collect proposals for changes in the 
methodology, on the other to make a preliminary analysis of received results in the test 
group.

2 Factors determinants of security

The first element of the test study was preliminary identification of factors based on 
a qualitative analysis of the literature sources. The process of identifying factors is an 
important piece of research, without which there would be a chance to go to further 
deliberations. It is also pointed out as a broad look at the factors approach to security in the 
international literature. During factors identification special attention was given to their 
subsequent usefulness to assess the level of safety and to build resistance to the crisis in a 
society. To this end, the selected factors pose to the universal base, which can be used at 
different levels of the administration of the country, in enterprises, scientific research, etc.
In the following chapter the author focuses on the identification of factors, leaving aside at 
this stage of research, quantitative assessment of individual factors (e.g. saying that the age 
of the community affects the crisis situation is omitted numeric value people in the age 
group, which is more sensitive to the occurrence of a crisis situation).

In the literature can find factors that are closely correlated with the phases of crisis 
management. Part of the factors refers to the phase before the onset of threats and relates 
largely to issues related to the preparation to the crisis situation, others are related to the 
phase after the crisis and is reflected in the reconstruction after the crisis. The initial group 
of factors, used in polish risk assessment methodology, based on the categories of people 
and the tangible and intangible values [3]. Categorized and indicated more specifically 
factors have helped in the completion of the literature review, to compose a list of 80 
factors (see Table). Listed in table 1 factors were divided into seven groups of influence:
- systemic factors (5 elements),
- area of operation services (6 elements),
- area of infrastructure (11 elements),
- life quality area (12 elements),
- group characteristic area (18 elements),
- individual features area (18 elements),
- region characteristic area (10 elements).
| Factor                                                                 | Source                                                                 |
|----------------------------------------------------------------------|----------------------------------------------------------------------|
| **(A) Group of systemic factors**                                     |                                                                      |
| Legal norms                                                           | Parson et al. 2017-2021 [5], Martin 2014 [6]                         |
| Spatial planning                                                      | Parson et al. 2017-2021 [5]                                          |
| Political involvement                                                | Parson et al. 2017-2021 [5], Martin 2014 [6], Cutter et al. 2008 [7]|
| Well prepared plans for crisis management                             | Martin 2014 [6], Skomra et al. 2015 [3]                               |
| Access to the service                                                | Martin 2014 [6], Skomra et al. 2015 [3]                               |
| **(B) Area of operation services**                                   |                                                                      |
| Internal monitoring                                                  | Bolin 1993 [8]                                                       |
| External monitoring                                                  | Bolin 1993 [8]                                                       |
| Alarming                                                             | Bolin 1993 [8]                                                       |
| Services Reliability                                                 | Skomra et al. 2015 [3]                                               |
| Material resources                                                   | Skomra et al. 2015 [3], Cutter et al. 2008 [7]                       |
| The crime                                                            | Parson et al. 2017-2021 [5]                                          |
| **(C) Area of infrastructure**                                       |                                                                      |
| The presence of schools, kindergartens and nurseries                 | Skomra et al. 2015 [3]                                               |
| Media                                                                | Cutter et al. 2003 [9]                                               |
| Critical infrastructure                                              | Skomra et al. 2015 [3]                                               |
| Shopping areas                                                       | Skomra et al. 2015 [3]                                               |
| Air routes                                                           | Cutter et al. 2003 [9]                                               |
| Water routes                                                         | Cutter et al. 2003 [9]                                               |
| Sports facilities                                                    | Skomra et al. 2015 [3]                                               |
| Objects of cultural heritage                                         | Cutter et al. 2003 [9]                                               |
| Religious objects                                                    | Skomra et al. 2015 [3]                                               |
| The presence of hospitals                                            | Parson et al. 2017-2021 [5], Cutter et al. 2008 [7], Skomra et al. 2015 [3] |
| Railway routes                                                       | Cutter et al. 2008 [7]                                               |
| **(D) Life quality area**                                            |                                                                      |
| Access to insurance                                                  | Martin 2014 [6], Cutter et al. 2003 [9]                              |
| Access to your own car                                               | Parson et al. 2017-2021 [5], Martin 2014 [6]                         |
| Access to daily service                                              | Martin 2014 [6]                                                     |
| Access to drinking water                                             | Cutter et al. 2003 [9]                                               |
| Access to medicines                                                  | Parson et al. 2017-2021 [5]                                          |
| Access to food                                                       | Martin 2014 [6]                                                     |
| Access to hygienic measures                                          | Martin 2014 [6]                                                     |
| Access to health centers                                             | Martin 2014 [6]                                                     |
| Access to banking services                                           | Martin 2014 [6]                                                     |
| Access to shelters                                                   | Bolin 1993 [8]                                                      |
| Access to media                                                      | Parson et al. 2017-2021 [5]                                          |
| Access to public transport                                           | Parson et al. 2017-2021 [5], Martin 2014 [6]                         |
| **(E) Group characteristic area**                                    |                                                                      |
| The composition of the family                                        | Cutter et al. 2008 [7]                                               |
| The level of literacy                                                | Parson et al. 2017-2021 [5]                                          |
| Cooperation                                                          | Parson et al. 2017-2021 [5]                                          |
| Social norms                                                         | Cutter et al. 2008 [7]                                               |
| Communication                                                        | Bolin 1993 [8]                                                      |
| Household composition                                                | Parson et al. 2017-2021 [5], Martin 2014 [6], Cutter et al. 2008 [7]|
| Resident of the town / village                                       | Cutter et al. 2008 [7], Cutter et al. 2003 [9]                      |
| The activities of social organizations                               | Parson et al. 2017-2021 [5]                                          |
| Monthly per capita income                                            | Parson et al. 2017-2021 [5], Cutter et al. 2003 [9], Cutter et al. 2008 [7] |
### 3 Methodology

The aim of the research is to get an ordered list of the factors listed in table 1 according to the impact to assess the safety. It is assumed that the hierarchy list will give the possibility of statistical analysis of the results for subsequent analysis and further research. In studies, the mutual comparison method is used, which is based on the Analytic Hierarchy Process [11]. AHP method checks in the situations when a group of persons is limited to a few-
dozen people, and when the person carrying out the examination using this method are able to control the actions of people filling the questionnaire (for example, through willingness to answer questions at the evaluation time [12]. In the case of the test in question was necessary to make simplifications in the AHP method applied. This was dictated by:

Plenty of factors evaluated in the framework of one group (up to more than 20 factors) in relation to proposed in the literature for the maximum number of 9 elements in the comparator.

- A large sample of the research, which was getting results in a test group of students,
- The premise for the presentation of final results each filled questionnaire.

For this purpose, it was decided on the following changes to the terms of the original AHP method:

- Replace nine-point fundamental scale to the three-point scale, in which factors were judged by taking of the decision or of the factor A has a greater impact on a security, than factor B; If both factors were judged as equal then they receive the value of A/B.
- Changed the way to enter data into a matrix. No further assessing questions, which will be reflected in subsequent cells in the matrix. Shall fill the matrix values letter, which are a reflection of the following rated factors (A or B).

A thorough overview of the assumptions in the present pre-research, can be traced in the following example.

**EXAMPLE:**

It must be assumed that the preferences are reviewed, which of the identified factors is assessed as a factor of greater importance in the safety assessment. To this the matrix was developed to compare the factors in a given group, as in Fig. 1.

In cell with coordinates AB are compared factors “legal norms” and “spatial planning” (See Fig. 2). If a bigger impact on the level of security have a factor "legal norms" is in cell AB had to be enter the value "A", if the above is assessed factor "spatial planning" is in cell AB had to be enter the value of "B". If a respondent evaluates both factors as equally valuable in assessing the impact on the level of safety or there is no sentence which factor should get more value, in the cell AB should be put the value of A/B. Similar steps must be performed for evaluation of other factors, until the complete complement of the matrix. All evaluations shall be made in based on subjective assessments of respondents.

**Fig. 1.** Matrix for factors assessment in systemic factors group.
Then need to be sum all the cells with letters corresponding to the given factors (action performed on the stage of calculating the surveys). If the letter is in the cell is alone takes the value \(1\) if the value in the cell takes the form \(A/B, C/D,\) etc., the value for both letters (both factors) is counted as \(0.5\). For example:

**The final value factor spatial planning** 
\[
\frac{A}{C} + C + \frac{C}{D} = 0.5 + 1 + 0.5 = 2
\]

Similarly, for the other factors. The matrix takes the form as in Fig. 3. The following values were obtained from mutual comparisons methods: legal norms - \(1,5\); spatial planning - \(0\); political involvement - \(2\); well prepared plans for crisis management - \(3\); access to services - \(3,5\). It follows that the factor of the highest importance in assessing the level of security is "access to services".

This example illustrates how an assessment should be made of the individual factors indicated in the matrix. To carry out research using the method indicated above, uses paper questionnaire, which collected and grouped all the identified factors in the form of matrix. For each group of factors was created a separate matrix. In addition, the matrix was created, in which respondents have to assess which of the groups should to the greatest extent affect the level of security. This was dictated by the purpose, enables in the article, creating a ranking list of all factors without division into groups.
4 Results

In order to be able to compare between the factors of the various groups, it was decided to apply the methods of comparison in relation to specific areas (groups) identified factors. This allows you to organize the factors on the one hand, in the framework of the group, as well as on the other parties within the meaning of the whole group in the evaluation system (Table 2.).

Table 2. Group value rating.

| Group name                  | Group value rating |
|-----------------------------|-------------------|
| Systemic factors            | 0.1382            |
| Area of operation services  | 0.2462            |
| Area of infrastructure      | 0.1949            |
| Life quality area           | 0.1151            |
| Group characteristic area   | 0.1081            |
| Individual features area    | 0.0930            |
| Region characteristic area  | 0.1045            |

Weight obtained in the framework of the particular groups are the basis to determine the weight of individual factors, according to the assumptions:

\[ V_e = V_f V_g \quad (V_e, V_f, V_g \rightarrow 1) \quad (1) \]

where:
- \( V_e \) - the final weight of the assessed factor,
- \( V_f \) - factor rating obtained in the group,
- \( V_g \) - the weight of the group, in which the assessed factor

The value \( V_f \) and \( V_g \) are based on the quotient of the sum of the ratings obtained by factors in subsequent questionnaires (\( F_i \)) and the sum of the factors value in a given group (\( G_s \)).

\[ V_f = \frac{F_s}{G_s} \quad (2) \]

The following table shows the ranking of the factors which, in the opinion of the responders, can most likely to have an impact on the assessment of the level of security (see column 5 and 7 in Table 3.). There is a dependency in the factor system that factors related to the operation of the services have been assessed as those that can determine the level of security to the greatest extent. may be justified by the greatest confidence that rescue services have and that the threats are associated mainly with the activities of the services. Next, it is worth paying attention to the fact that the group of systemic factors is high. Their choice may be justified by the awareness of the impact of the politicians on the general appearance of the State, including the rescue efforts. Big disasters are associated also with the help of State in the financial sphere. The third group of factors, according to the criterion of validity, is a group of infrastructure. Critical infrastructure protection activities carried out by the public authorities to increase awareness of the problem of downtime of these objects, and how big the economic effects this may cause. What's more, a group of infrastructure can be associated not so much with critical infrastructure as key objects of local infrastructure (KOLI). As KOLI should be understand the objects that meet a significant role in the context of services, which should provide the residents of the administrative unit (sewage treatment plants, water supply, electricity distribution and other similar objects). The aforementioned approach, as well as the table 3 provide can about setting priorities to strengthen the individual factors.
Table 3. Methods to sorting out the factors that affect the level of safety used in research.

| Factor                                                                 | 1   | 2                      | 3                      | 4                      | 5                      | 6                      | 7               |
|------------------------------------------------------------------------|-----|------------------------|------------------------|------------------------|------------------------|------------------------|-----------------|
| The sum of ratings $F_i$                                               | 283 | 0,1343                 | 0,1382                 | 0,018553584            | 14                     |                        |                 |
| The sum of group ratings $G_i$                                         | 419 | 0,2915                 | 0,2462                 | 0,040280808            | 5                      |                        |                 |
| Factor rating in group $V_f$                                           |     |                        |                        |                        |                        |                        |                 |
| Group rating $V_G$                                                     |     |                        |                        |                        |                        |                        |                 |
| Factor total rating $V_e$                                              |     |                        |                        |                        |                        |                        |                 |
| Hierarchy ordinal number                                              |     |                        |                        |                        |                        |                        |                 |
| Legal norms (A)                                                        | 38,0| 0,1343                 | 0,1382                 | 0,018553584            | 14                     |                        |                 |
| Spatial planning (A)                                                   | 41,0| 0,1449                 | 0,1494                 | 0,020018341            | 12                     |                        |                 |
| Political involvement (A)                                              | 33,0| 0,1166                 | 0,1211                 | 0,016112323            | 17                     |                        |                 |
| Well prepared plans for crisis management (A)                          | 82,5| 0,2915                 | 0,2462                 | 0,040280808            | 5                      |                        |                 |
| Access to the service (A)                                              | 88,5| 0,3127                 | 0,3250                 | 0,043210321            | 4                      |                        |                 |
| Internal monitoring (B)                                                | 47,0| 0,1122                 | 0,1293                 | 0,027620701            | 8                      |                        |                 |
| External monitoring (B)                                                | 45,0| 0,1074                 | 0,1208                 | 0,026445352            | 9                      |                        |                 |
| Alarming (B)                                                           | 97,5| 0,2327                 | 0,2462                 | 0,057298262            | 2                      |                        |                 |
| Services reliability (B)                                               | 111,0| 0,2649                 | 0,2711                 | 0,065231867            | 1                      |                        |                 |
| Material resources (B)                                                 | 87,5| 0,2088                 | 0,2151                 | 0,051421517            | 3                      |                        |                 |
| The crime (B)                                                          | 31,0| 0,0740                 | 0,0775                 | 0,018217909            | 15                     |                        |                 |
| The presence of schools, kindergartens and nurseries (C)              | 87,0| 0,0566                 | 0,0596                 | 0,011026378            | 28                     |                        |                 |
| Media (C)                                                              | 136,0| 0,0885                 | 0,0923                 | 0,017236636            | 16                     |                        |                 |
| Critical infrastructure (C)                                            | 229,5| 0,1493                 | 0,1536                 | 0,029086824            | 6                      |                        |                 |
| Shopping areas (C)                                                     | 92,0| 0,0598                 | 0,0630                 | 0,011660078            | 25                     |                        |                 |
| Air routes (C)                                                         | 169,0| 0,1099                 | 0,1142                 | 0,021419056            | 11                     |                        |                 |
| Water routes (C)                                                       | 157,5| 0,1024                 | 0,1065                 | 0,019961546            | 13                     |                        |                 |
| Sports facilities (C)                                                  | 84,5| 0,0550                 | 0,0588                 | 0,010709528            | 30                     |                        |                 |
| Objects of cultural heritage (C)                                       | 87,5| 0,0569                 | 0,0607                 | 0,011089748            | 26                     |                        |                 |
| Religious objects (C)                                                  | 82,5| 0,0537                 | 0,0573                 | 0,010456048            | 32                     |                        |                 |
| The presence of hospitals (C)                                          | 227,5| 0,1480                 | 0,1523                 | 0,028833344            | 7                      |                        |                 |
| Railway routes (C)                                                     | 184,5| 0,1200                 | 0,1245                 | 0,023383525            | 10                     |                        |                 |
| Access to insurance (D)                                                | 41,5| 0,0224                 | 0,0265                 | 0,002583706            | 77                     |                        |                 |
| Access to your own car (D)                                             | 81,5| 0,0441                 | 0,0482                 | 0,005074026            | 61                     |                        |                 |
| Access to daily service (D)                                            | 122,0| 0,0660                 | 0,0704                 | 0,007595474            | 49                     |                        |                 |
| Access to drinking water (D)                                           | 257,0| 0,1390                 | 0,1433                 | 0,016000303            | 19                     |                        |                 |
| Access to medicines (D)                                                | 228,0| 0,1233                 | 0,1277                 | 0,014194821            | 21                     |                        |                 |
| Access to food (D)                                                     | 252,5| 0,1365                 | 0,1410                 | 0,015720142            | 20                     |                        |                 |
| Access to hygienic measures (D)                                        | 178,0| 0,0962                 | 0,1007                 | 0,011081922            | 27                     |                        |                 |
| Access to health centers (D)                                           | 215,0| 0,1162                 | 0,1209                 | 0,013385467            | 22                     |                        |                 |
| Access to banking services (D)                                         | 77,5| 0,0419                 | 0,0462                 | 0,004824994            | 63                     |                        |                 |
| Access to shelters (D)                                                 | 210,5| 0,1138                 | 0,1186                 | 0,013105306            | 23                     |                        |                 |
| Access to media (D)                                                    | 89,5| 0,0484                 | 0,0529                 | 0,005572090            | 57                     |                        |                 |
| Access to public transport (D)                                         | 96,5| 0,0522                 | 0,0564                 | 0,006007896            | 54                     |                        |                 |
| The composition of the family (E)                                      | 231,5| 0,0543                 | 0,0587                 | 0,005872976            | 55                     |                        |                 |
| The level of literacy (E)                                              | 122,0| 0,0286                 | 0,0329                 | 0,003095046            | 75                     |                        |                 |
| Cooperation (E)                                                       | 316,0| 0,0742                 | 0,0795                 | 0,008016676            | 46                     |                        |                 |
| Social norms (E)                                                       | 178,0| 0,0418                 | 0,0462                 | 0,004515723            | 67                     |                        |                 |
| Communication (E)                                                      | 326,5| 0,0767                 | 0,0821                 | 0,008283053            | 43                     |                        |                 |
| Household composition (E)                                              | 182,5| 0,0428                 | 0,0474                 | 0,004629884            | 65                     |                        |                 |
| Resident of the town / village (E)                                     | 180,5| 0,0424                 | 0,0474                 | 0,004579146            | 66                     |                        |                 |
| The activities of social organizations (E)                             | 217,0| 0,0509                 | 0,0550                 | 0,005505123            | 58                     |                        |                 |
| Monthly per capita income (E)                                          | 159,5| 0,0374                 | 0,0406                 | 0,004046392            | 69                     |                        |                 |
| Diversity (E)                                                          | 107,5| 0,0252                 | 0,0272                 | 0,002727192            | 76                     |                        |                 |
| Working conditions (E)                                                 | 203,0| 0,0477                 | 0,0525                 | 0,005149953            | 60                     |                        |                 |
5 Conclusion

History has shown that socially vulnerable populations are disproportionately impacted by disasters. These groups experience disproportionate suffering, particularly from public health and safety impacts such as injuries, death, and a decreased likelihood of recovery [6]. In this case importance is of gaining accurate and detailed assessment of the level of security, taking into account the characteristics of the society (its sensitivity and resistance to threats), and of obstacles resulting from existing infrastructure or efficiency of systems
created by the State in charge of security. The list of identified factors, as well as the proposed method of assessing their suitability in assessing the level of security, may be useful in the implementation of this assumption. At this point, needs to be pay attention to several practical issues related to the method used:

- the time of completing the questionnaire by respondents is about 2 hours, which translates into the problem of its reliable completion,
- entering marks into matrix cells often resulted in a number of errors, especially in the case of matrices in which a large number of factors were evaluated,
- the time of summarizing the results by research is about 30 minutes per questionnaire, which in the case of large sample tests requires a lot of time for the technical side of the research,
- it would be a good idea to use a computer tool to assess the identified factors using the method indicated in the article.

Indicated in article approach is an evidence by the possibility to hierarchisation of factors that affect the level of safety in a large research sample. The results obtained determine how, and to what extent to utilize individual factors in the assessment of the level of security. On the other hand they are a valuable source of information for policy makers about what should be a start setting priorities for action to strengthening the individual factors. These results may be a signal to treat some factors as unnecessary in assessing the level of security too. In addition, the results provide possibility to further statistical analysis in order to obtain a deeper and more accurate conclusions. This is an important contribution to the understanding of social sensitivity in order to promote the building of social resilience.

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