

APPLICATION OF THE AHP-VIKOR HYBRID MODEL IN MEDIA SELECTION FOR INFORMING ABOUT THE ENDANGERED IN SITUATIONS OF EMERGENCY

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Abstract: *A distribution of information in situations of emergency represents a serious challenge for the expert services engaged in protection and rescue. The number of the people who need help in situations of emergency is rather large and the number of those who can really be helped depends on their availability to expert services. A large number of people, especially endangered groups, can be saved with the help of timely and qualitative information. In the conditions determined by a lack of time, the staff in charge of situations of emergency have to make a decision on informing the population about the incoming danger. In the paper, a hybrid model based on the analytic hierarchy process (AHP) and multi-criteria compromise ranking (VIKOR) is presented, as applied through the selection of the best medium for informing the population in situations of emergency. The AHP method is used to determine criteria weight coefficients, while the VIKOR method is applied in order to find the best media by means of making a selection amongst numerous concrete options – i.e. alternatives.*

Key words: *media, situations of emergency, AHP method, VIKOR method.*

1. Introduction

Situations of emergency represent the state of the high endangerment of a social community. The consequences of situations of emergency are manifold and have far-reaching effects. Considering the size of a danger from various natural disasters and other accidents, and different categories of the endangered population, timely warning and informing are of great significance. Preventive acting through informing and alerting the population is the basis for reducing the consequences of situations of emergency. There are various population categories that need be informed about the incoming danger. The most endangered are persons with special needs, only to be followed by women and children, and, in the end, the persons who are able to save themselves on their own.

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In a situation of emergency, the problem of the functionality of the media may occur due to their territorial prevalence and the signal reception (for the television and the radio) or equipment supply and functionality (the internet). Informing by emergency sirens could be a solution in the areas with good coverage and a high population density. Otherwise, the effect of emergency sirens can be very small. Depending on the type of the situation of emergency, electricity supply can also be problematic (Komazec et al. 2014).

The manner in which people should be informed is mostly restricted by the effects of a situation of emergency and its diffusion, and very frequently, the availability of information to certain groups of people is the only criterion (Акимов & Порфирьев, 2004). However, by carrying out a thorough analysis of the relevant factors, conclusions can be drawn which refer to the selection of the optimal medium (or media) for the purpose of informing as many people as possible in order to select those media that meet the created needs. In this paper, the Analytic Hierarchy Process (AHP) and the Multi-Criteria Compromise Ranking (VIKOR) methods are applied to problem solving. The contribution of the paper reflects in the enhancement of the evaluation and selection methodologies regarding the media for the purpose of informing the population in situations of emergency through a new approach to the treatment of imprecision due to the fact that the application of this model or similar models in situations of emergency has not been reviewed in the existing literature.

2. Problem Description

The paper is focused on finding out the hybrid model which will enable the optimal selection of the media for informing the population in situations of emergency.

The occurrence of the need for informing the population in the situations of natural disasters and technical-technological accidents depends on the level of the endangerment of the social community. The alert signal announcing a danger is activated by the authorities according to the law. The level of the danger, i.e. the endangerment, is the basis for the proclamation of a situation of emergency (Karovic & Komazec, 2009). A situation of emergency is proclaimed by the staff in charge of situations of emergency when risks and threats, or the resulting consequences are on such a scale and of such an intensity that they cannot be stopped or diminished by conducting the authorities' regular activities, for which reason it is necessary that special measures, additional strengths and the means with an enhanced operation mode should be taken for the purpose of their mitigation and removal (Zakon o smanjenju rizika od katastrofa i upravljanju vanrednim situacijama [Law on Disaster Risk Reduction and Emergency Management], 2018; Pamucar et al. 2016).

The proclamation of a situation of emergency follows immediately after becoming aware of the danger. This moment is a milestone in the protection and salvation of the endangered population, material goods and the environment. Namely, as long as the staff in charge of situations of emergency are unaware of a danger, they cannot proclaim a situation of emergency, nor can they inform the endangered population about it; competent services (Republic Hydrometeorological Service of Serbia (RHMS), Republic Geodetic Authority (RGA), etc.) are, however, responsible for informing the population. The competent services usually inform people through the media (the television and the radio) and via the internet (posting warnings on relevant websites). In that period of time, the staff in charge of situations of emergency collect pieces of

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information and may perform such informing through local communities and responsible individuals.

In some special situations, the electric-power industry, the water industry and the other business associations using hydro-accumulations and landfills are obliged to ensure that the population is timely informed about the incoming danger (Zakon o smanjenju rizika od katastrofa i upravljanju vanrednim situacijama [Law on Disaster Risk Reduction and Emergency Management], 2018).

The members of the staff in charge of situations of emergency may use local radio and television stations. The transmission of information to the endangered population carried out by the Republic staff in charge of situations of emergency. The law also envisages the obligation of mobile companies to transfer information to endangered people. All mass-media means are applicable when informing the population is concerned, even before situations of emergency occur (Petrovic et al. 2017). A special problem is a situation of emergency when a danger to the population, material goods and the environment has arisen. The conditions of all the people inside the endangered territory are such that they all fear for themselves, for their families, and for their material possessions. There is a similar situation in business companies which, simultaneously having to protect their own assets, also need to engage the employees whose families are jeopardized at that moment as well. In the case of a concrete problem, persons with special needs, the elderly, women and children are considered as special and specific groups of people.

In the case of a particular problem, the means of mass communications are restricted to a segment of the mass media (the television, the radio and the internet – especially social networks and mobile communications)¹ (Radojkovic & Miletic, 2005). There is a possibility of using print media, but this way of communication is restricted by the type and level of the influence of the concrete danger.

2.1 Informing in Situations of Emergency

The practical usage of effective informing is the basis for effective management (Moriarty et al. 2012). Informing in situations of emergency (and alerting, too) is an activity of great significance with respect to decreasing human casualties and mitigating damage to material goods and the environment. Namely, timely information provides a quick and right reaction of the endangered population to the danger. Timelessness depends on the type of danger (Dey, 2001). Situations of emergency and other accidents which may occur suddenly and develop rapidly are more complex to announce. Practically, their announcement is conducted after the moment of their occurrence. The possibility that the majority of the population will not receive information on time is most likely (Komazec et al. 2018). The dangers that occur in a longer period of time and develop gradually are much easier to announce, along with the appearance of the first indicators.

The staff in charge of situations of emergency and the authorities' specialized institutions (RHMS, RGA, etc.) have the legal obligation to provide information in situations of emergency. This approach is essential for controlling the information flow, the types of information, and the process of receiving information to as many

¹The presence of social media is generally implied, due to the fact that they include mobile companies and their ability to transfer information as well.

people as possible. For the purpose of informing effectively and efficiently, the staff in charge of situations of emergency have several instruments at their disposal, namely:

1. the television and the radio;
2. the Internet-social networks;
3. the early warning, informing and alerting system;
4. print media and
5. mobile telecommunications.

The television and the radio belong to a group of highly widespread and available media. It is to be assumed that every single home has the ability to access them. The main issue in the usage of such media is the ability of the municipality staff in charge of situations of emergency to send information through the national television and radio network due to the fact that the national services are watched/listened to by a large number of individuals. Also, there is a problem in local services in the territory of the municipality and their availability throughout that territory.

The Internet is also a widely applicable instrument for the transmission of information. There is a certain limitation when access to the internet is in question. It is possible to quickly transfer information to a large number of people throughout social networks, but the availability of those individuals to the staff in charge of situations of emergency may be an issue. A special problem implies those elderly ones who do not use the internet at all, or use it poorly.

The early warning, informing and alerting system is directly available to the staff in charge of situations of emergency. The limitation lies in the operational correctness of the system, the territorial coverage and the ability of all endangered groups to understand the sent signals.

Print media belong in the group of slower and mass means of information transfer. The limitation of their application lies in the fact that, in a situation of emergency, the distribution of such media may be stopped. Also, not every municipality owns its own print media, which may refer to the dependence on a publishing house, its distance and capacity.

Mobile telecommunications represent a powerful, widespread and easily accessible medium for information transfer. A large number of people in all endangered groups own a mobile telephone. The main issue is the development of a database of telephone numbers, especially of the numbers of the endangered groups of individuals responsible for them.

2.2. Description of the Media Selection Criteria

In order to successfully apply the AHP and VIKOR methods to solving the research problem, it is necessary to identify the criteria common to all the listed and considered media of mass communications and among which a selection of the best media for informing the population in situations of emergency will be conducted. (Nenadovic et al. 2016). Taking this into account, the following criteria are identified:

K_1 – The frequency of informing – This criterion is expressed by the number of the repetitions of informing through the amount of time in order to achieve as good reception as possible by as many individuals as possible.

K_2 – Territorial coverage – This criterion is expressed in percentages and represents the ability to receive information in real time throughout the territory of the municipality.

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K₃ – Presence in a target group– This criterion is expressed in percentages and reflects the presence of a concrete medium in a concrete target group, or the other way round – it reflects the percentage of the target group ‘consuming’ a particular medium.

K₄ – The availability of the medium – This criterion represents the coverage of the Republic of Serbia’s territory (by broadcasting or by distribution)² and it is described by linguistic descriptors given in Table 1.

Table 1. The descriptive scale of the linguistic criteria

Linguistic descriptors	Very poor	Poor	Medium	Good	Excellent
Assigned numerical value	1	2	3	4	5

K₅ – The medium access price – This criterion is expressed by cash units and accounts for the amount which is necessary to pay in order to make the content of a particular medium available.³

The characteristics of the listed criteria are presented in Table 2.

Table 2. The criteria characteristics

	<i>ben</i> ⁴ .	<i>cost</i> ⁵	Qualitative	Quantitative
K ₁	+			+
K ₂	+			+
K ₃	+			+
K ₄	+		+	
K ₅		+		+

3. Applied Methods

The hybrid model used for the selection of the best media for informing the population in situations of emergency consists of the AHP and VIKOR methods. The AHP method is used to determine the weight coefficients of the identified criteria, while the VIKOR method is used to find a compromise solution, specifically for the selection of the optimal informing medium.

² When electronic media (the television and the radio) are concerned, it is significant whether they are the media with a national frequency or the media covering only a certain region in Serbia, whereas when the press (newspapers) is concerned, it is essential whether they are the media distributed throughout the territory or the media distributed locally.

³ When speaking about electronic media, the total amount represents the sum of all expenses, such as purchasing a television set or a radio receiver, the costs of electricity, broadcasting costs, a special fee for using a public service, etc., whereas in the case of the press, it accounts for the amount which has to be paid for certain newspapers, magazines and so forth. For the internet and mobile communications, it is the price for those services.

⁴ The subset of the criteria with the *benefit* characteristics, which means that a higher value of the criterion is preferable, i.e. better.

⁵ The subset of the criteria with the *cost* characteristics, which means that a lower value of the criterion is preferable, i.e. better.

3.1. AHP

The AHP method developed by Thomas Saaty at the beginning of the 1970s is a tool used in decision analysis, created for the purpose of providing assistance to decision-makers in resolving complex decision-making problems in which many decision-makers participate, numerous criteria and in various time periods. This process is based on the balance concept used in order to determine the overall significance of the set of relative attributes, activities or criteria, and relates to the analyzed decision-making problem (Cupic & Suknovic, 2010). In the paper, this method is applied so as to determine the criteria weight coefficients regarding the selection of the media for informing the population in situations of emergency. Saaty’s standard nine-level scale presented in Table 3 is applied in order to carry out a pairwise comparison (Saaty, 1980). Saaty’s scale is applied by the decision-makers or the analysts performing comparisons in pairs on the basis of the semantic preferences from the left-hand column of Saaty’s scale or by direct association. The numerical values stated in the columns 2 or 3 of Table 3, which correspond to the semantic preferences in the left-hand column, are entered into the square comparison matrix, Equation (1).

Table 3. Saaty’s pairwise comparison scale

Definition	Standard values	Reciprocal values
Equal importance	1	1
Weak importance of one over another	3	1/3
Essential or strong importance	5	1/5
Demonstrated importance	7	1/7
Absolute importance	9	1/9
Intermediate values between the two adjacent judgments	2,4,6,8	1/2, 1/4, 1/6, 1/8

$$A = \begin{matrix} & C_1 & C_2 & \dots & C_n \\ \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} & \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} \end{matrix} \quad (1)$$

Since it is true that $a_{ij} = 1/a_{ji}$ and $a_{ii} = 1$ for every $i, j = 1, 2, \dots, n$, the matrix A is positive, symmetrical and reciprocal. When applying Saaty’s classical scale, the relations in a pairwise comparison are strictly defined (Pamucar et al, 2016).

3.2. VIKOR

The VIKOR method was developed by Opricovic Serafim (Opricovic, 1998) based on the elements from compromise programming with the beginning at the “border” forms of Lp-metrics. These metrics represent the distance between the ideal point F^* and the point $F(x)$ in the space of the criteria functions (Petrovic et al. 2017).

The first step in the VIKOR method is the initial decision matrix:

$$\begin{matrix} X_1 & X_2 & X_3 & \dots & X_n \\ W_1 & W_2 & W_3 & \dots & W_n \end{matrix}$$

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$$D = \begin{matrix} A_1 \\ A_2 \\ A_3 \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} X_{11} & X_{12} & X_{13} & \cdots & X_{1n} \\ X_{21} & X_{22} & X_{23} & \cdots & X_{2n} \\ X_{31} & X_{32} & X_{33} & \cdots & X_{3n} \\ \cdots & \cdots & \cdots & \ddots & \vdots \\ X_{m1} & X_{m2} & X_{m3} & \cdots & X_{mn} \end{bmatrix} \quad (2)$$

By the decision matrix, the m alternatives and the n criteria are defined. Every criterion is associated with its weight coefficient w_i . The weight coefficients of the criterion should follow the next condition:

$$\sum_{i=1}^n w_i = 1 \quad (3)$$

After defining the decision matrix, the method is to be applied. The next step in the VIKOR method is the determination of x_i^* and x_i^- , which is conducted by the following equations:

$$x_i^* = \max (x_1, x_2, \dots, x_n); i=1,2,\dots, n; \quad (4)$$

$$x_i^- = \min (x_1, x_2, \dots, x_n); i=1,2,\dots, n; \quad (5)$$

The next step in the VIKOR method is the determination of the pessimistic (S_j) and the anticipated (R_j) solutions.

$$S_j = \sum_{i=1}^n w_i (x_i^* - x_{ij}) / (x_i^* - x_i^-); j = 1,2, \dots, m \quad (6)$$

$$R_j = \max_i [w_i (x_i^* - x_{ij}) / (x_i^* - x_i^-)]; j = 1,2, \dots, m \quad (7)$$

After that, the next step is finding a compromise solution Q_j :

$$Q_j = \nu \frac{S_j - S^*}{S^- - S^*} + (1-\nu) \frac{R_j - R^*}{R^- - R^*}; j=1, 2, \dots, m \quad (8)$$

where

$$S^* = \min S_j \quad (9)$$

$$S^- = \max S_j \quad (10)$$

$$R^* = \min R_j \quad (11)$$

$$R^- = \max R_j \quad (12)$$

ν - the weight of the strategy satisfied according to the majority of the criteria, $\nu \in \{0.25, 0.5, 0.75\}$.

The last step in the VIKOR method is the ranking of alternatives. A set of alternatives can be ranked by the value of the function of the criteria assigned to each alternative Q_j . The best alternative is the one that is the least distanced from the ideal value, i.e., the one that has the minimal Q_j value, and vice versa. As relevant, the rank list is taken for the value $\nu = 0.5$, but even though it is the first on the list, that action has to meet two more conditions (Petrovic et al. 2017), namely:

1) There has to be sufficient advantage (more than the “minimum sufficient advantage”) related to the 2nd, 3rd, and other alternatives), which is established by applying the following expression:

$$Q(a') - Q(a'') \geq DQ \tag{13}$$

where:

$$DQ = \min(0.25, \frac{1}{m-1}) \tag{14}$$

where a' and a'' represent the values of the 1st and the 2nd alternatives, respectively, by $Q_j(\nu=0.5)$, and m represents the number of the alternatives. The minimum sufficient advantage is to be 0.25 in the cases when there is a small number of alternatives.

2) It has to have a sufficiently stable position, i.e. position no. 1, according to the rank list QS_j , or according to QR_j , or according to Q for $\nu = 0.25$ and $\nu = 0.75$ where (Petrovic et al. 2017):

$$QS_j = \frac{S_j - S^*}{S^- - S^*}; j = 1, 2, \dots, m \tag{15}$$

$$QR_j = \frac{R_j - R^*}{R^- - R^*}; j = 1, 2, \dots, m \tag{16}$$

4. Presentation of the Application of the Hybrid Model

As already stated, the hybrid model consists of the AHP and VIKOR methods. The weight coefficients of the criteria are calculated by applying the AHP method in the Expert Choice program package and the results of that process are shown in Tables 4 and 5.

Table 4. The criterion pairwise comparison according to Saaty’s scale

	K ₁	K ₂	K ₃	K ₄	K ₅
K ₁	1.0	3.0	1/2	9.0	2.0
K ₂		1.0	(4.0)	2.0	2.0
K ₃			1.0	5.0	3.0
K ₄				1.0	(3.0)
K ₅					1.0

CR=0.03

Table 5: The values of the criteria weight coefficients

K ₁	.300	
K ₂	.092	
K ₃	.406	
K ₄	.051	
K ₅	.151	

Inconsistency = 0.03
with 0 missing judgments.

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For the purpose of applying the VIKOR method, a total of 6 different alternatives were chosen (from A_1 to A_6), by which the initial decision matrix was defined, which is accounted for in Table 6.

The alternatives are as follows: Alternative A_1 –Local television and radio station; Alternative A_2 –National television and radio station; Alternative A_3 –Early warning, informing and alerting system; Alternative A_4 –Internet–social networks; Alternative A_5 –Print media, and Alternative A_6 –Mobile communications.

The details regarding the listed alternatives are not presented in the paper in order to avoid a decrease in their positions in the media space and favoring certain media, too.

Table 6. The initial decision matrix

Criterion	K_1	K_2^6	K_3	K_4	K_5
Alternatives	0.300	0.092	0.406	0.051	0.151
A_1	600 ⁷	50	45	5	6
A_2	300	48	60	4	5
A_3	600	5	35	3	0.3
A_4	750	4	40	2	0.35
A_5	480	22	10	4	2.4
A_6	430	18	8	1	1.8
x_i^*	750	50	60	5	0.3
x_f	300	4	8	1	6
Characteristic of criterion	max	max	max	max	min

By solving the equations from 4 to 12, the final solutions are obtained and they are presented in Table 7.

Table 7. The final values of the alternatives

Alternatives	QS _j	QR _j	Q _j (v=0.5)	Q _j (v=0.25)	Q _j (v=0.75)
A_1	0.463	0.252	0.357	0.305	0.410
A_2	0.353	0.576	0.465	0.520	0.409
A_3	0.040	0.156	0.098	0.127	0.069
A_4	0.000	0.000	0.000	0.000	0.000
A_5	0.938	0.936	0.937	0.936	0.937
A_6	1.000	1.000	1.000	1.000	1.000

According to the results obtained, the final ranking of the alternatives is as follows: **A_4 , A_3 , A_1 , A_2 , A_5 and A_6 .**

⁶ According to the last analysis of the media market in Serbia, conducted by Ipsos Strategic Marketing Agency in 2015 (Regulatory Body for Electronic Media, 2015), the television is the leading medium, with a market share of 53%, the press accounts for 20%, and the radio accounts for 4% (the other media account for a market share of 23%).

⁷ The number of repetitions in one day (i.e. 24 hours).

5. Sensitivity Analysis

When applying methods of multi-criteria decision-making, it is crucial to examine the sensitivity of the mathematical model applied, so that decision-makers could have some kind of guarantee according to the rationality and quality of the obtained solution (Pamucar et al. 2016). The analysis of the sensitivity of the results obtained by the hybrid model implies the examination of changes in the weights of criteria and on the consistency of the solution with respect to a change in the measurement scale (Pamucar et al. 2017).

When examining change in the weight of the criteria, a total of six scenarios were developed (Table 8) (A – the equal importance of all the criteria, B – the absolute dominance of K_1 , C – the absolute dominance of K_2 , D – the absolute dominance of K_3 , E – the absolute dominance of K_4 , F – the absolute dominance of K_5). Within the framework of the independence analysis regarding change in the measurement scale, a total of two scenarios were developed (Table 9). In the first scenario, the qualitative criterion (K_4) was given by the two different scales (S_1 and S_2) connected by a positive affine transformation ($y = 2x - 1$). In the second scenario, the quantitative criterion (K_5), which represents the media access cost, expressed in cash units is was given by the two different scales: (S_1) in RSD (Republic of Serbia’s Dinar) and (S_2) in euros.

Table 8. The sensitivity analysis of change in the weights of the criteria

Scenario	A	B	C	D	E	F
Alternatives	Alternatives rank					
A ₁	4	4	3	5	3	2
A ₂	1	2	5	3	4	3
A ₃	5	6	2	4	1	6
A ₄	3	1	1	1	5	1
A ₅	6	3	6	6	6	4
A ₆	2	5	4	2	2	5

Table 9. The independence analysis of change in the measurement scale

Scenario	Scenario 1		Scenario 2	
	S ₁	S ₂	S ₁	S ₂
Alternatives	Alternatives rank			
A ₁	5	5	5	5
A ₂	3	3	3	3
A ₃	2	2	2	2
A ₄	1	1	1	1
A ₅	5	5	5	5
A ₆	6	6	6	6

6. Discussion and Conclusion

According to the results obtained by conducting a sensitivity analysis of the developed hybrid model for the purpose of the selection of the best medium for informing the population in situations of emergency and with respect to the research studies (Pamucar et al. 2018), a conclusion can be drawn that the hybrid AHP-VIKOR

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model is completely applicable in the cases of solving the treated problem and satisfies the set goal. The sensitivity analysis of change in the weights of the criteria shows that the hybrid model is sufficiently sensitive and that it keeps alternative priorities (in this particular case, Alternative A₄ is favored). Furthermore, checking the consistency of the solution by changing the measurement scale shows that the model is stable and that it generates sustainable solutions. By an analysis of all of the results obtained, it is possible to conclude that the application of the AHP and VIKOR methods can significantly help decision-makers to come to the necessary solution.

The proposed model examined in the paper represents an integration of the AHP and VIKOR methods, where the AHP method is used to determine the weight coefficients of criteria within the process of the selection of the best medium for informing the population in situations of emergency, whereas the VIKOR method is used to rank the obtained alternatives and find the optimal solution. The model has been verified through the media selection process inside the territory of a certain municipality by six different alternatives. The results obtained by the application of the model show that Alternative no. 4 is the best solution in all the scenarios with different values of the criteria. In comparison with the hybrid model, Alternative no. 4 has a priority engagement. Taking into consideration the fact that situations of emergency are concerned in this case, it is not only enough to depend on one single medium, but the competent staff in charge of situations of emergency will engage all available media. This means that informing the population would certainly be performed through the television, the radio, print media, and mobile communications. The early warning, informing and alerting system would be used for signal transmission. The sensitivity analysis has shown the stability of the results obtained by the application of the model in all of the considered scenarios.

The presented application of the hybrid model provides an unbiased aggregation of experts' choices by taking into consideration all the inconsistency and subjectivism of group decision-making. Apart from the expressed contribution, it is essential to emphasize the authors' attempt to apply this model in situations of emergency, which are characterized by uncertainty and a lack of time as well, the large amount of information and crisis decision making. The development of such models contributes to the literature in which the theoretical and practical application of multi-criteria techniques is subjected to review. The suggested model enables the evaluation of alternatives despite the imprecision and lack of quantitative information in the decision-making process. By applying the developed approach, problems concerning multi-criteria decision-making and the evaluation and selection of a medium for informing the population in situations of emergency can easily be dealt with. The model can be applied to making various decisions. It is also applicable in the process of decision-making within the staff in charge of situations of emergency in situations of emergency. The flexibility of the model is proven by the fact that its verification can be performed by applying any type of multi-criteria decision-making methods.

Further research studies regarding this paper should refer to the application of this and similar models in combination with other methods and the development of a new method, which would lead to the enrichment of this highly applicable scientific area.

Situations of emergency are the state of the endangerment of social stability with great implications for the life and health of people, the state of material goods and the environment. Therefore, every contribution to the improvement of the decision-making system of the staff in charge of situations of emergency is also a contribution to prevention and reaction in case a danger occurs.

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