Journal of Electronic Research and Application, 2024, Volume 8, Issue 6
http://ojs.bbwpublisher.com/index.php/JERA
ISSN Online: 2208-3510
ISSN Print: 2208-3502

# A Method for Determining the Importance of Critical Emergency Indicators Based on Multi-granularity Uncertain Language

**Yongguang Yi**[1]*, **Zengqiang Wang**[2]

[1]China Construction Third Engineering Division Second Construction Engineering Co., Ltd., Wuhan 430000, Hubei Province, China
[2]School of Management, Xihua University, Chengdu 610000, Sichuan Province, China

***Corresponding author:*** Yongguang Yi, wzqlinger@163.com



**Abstract:** In view of the complexity of emergencies and the subjectivity of decision-makers, a method of determining key emergency indicators based on multi-granularity uncertainty language is proposed. Firstly, decision members use preferred uncertain language phrases to represent the importance of each key indicator and use transformation functions to carry out the consistent transformation of this multi-granularity uncertain language information. Secondly, the group evaluation vector is obtained by using the extended weighted average operator of uncertainty, and then the weight vector of each key index is obtained by using the decision theory of uncertain language. Finally, an example is given to verify the practicability and effectiveness of the proposed method.

**Keywords:** Emergency event; Multi-granularity uncertain linguistic; Key attributes

**Online publication:** November 29, 2024

## 1. Introduction

In order to promote rapid economic growth, the demand for various resources around the world has gradually increased, the living environment of human beings has been threatened unprecedentedly, and the incidence and harm degree of various natural disasters and man-made accidents have increased sharply. After the occurrence of these events, scientific emergency planning can greatly reduce the negative impact of accidents. Therefore, how to quickly respond to various emergencies and select reasonable emergency plans has attracted wide attention from people from all walks of life [1].

The decision of emergency plan under the emergency usually needs to make the right choice in the first time in the incomplete information environment. In order to make full use of limited resources, the decision-makers are required to determine the key indicators and secondary indicators that affect the decision, to determine the focus of resource investment. Generally speaking, the importance analysis of key indicators in emergency decision-making is divided into three steps [2]: (1) to obtain the influencing factors of decision-making; (2) to sort out and analyze the preliminarily collected information; (3) to determine the weight of key indicators. The factors influencing decision-making are usually obtained through case analysis and group interviews [5]. In literature, the collected information is summarized and analyzed in the form of a tree graph, and the impact indicators of emergency decision-making are sorted into clear structure graphs [6].

The research on the first two aspects has been relatively mature, so this paper will focus on how to use the limited information to determine the weight of each key indicator. The traditional weight determination method requires decision-makers to use a score such as 1-3-5 to represent the importance of an index [3]. In actual operation, decision makers usually tend to assign higher score values to multiple indicators, which increases the difficulty of the implementation of the method. Decision-makers were invited to use AHP to compare the importance of each index in pairs to improve the consistency of judgment. However, the process of determining the weight of key indicators inevitably contains a lot of fuzzy and uncertain information, so it is difficult for AHP to accurately represent the opinions of decision-making members [4]. To accurately describe the fuzziness of the information environment, the fuzzy theory was introduced into the process of determining the weight of key indicators and made good use of decision information. However, membership functions must be determined by using the fuzzy theory. Existing studies chose some commonly used functions, such as triangular fuzzy numbers or trapezoidal fuzzy numbers, without considering the accuracy and applicability of the functions. After an emergency occurs, the information that can be obtained at the first time is extremely limited. In order to deal with incomplete information effectively, decision-making members often directly reflect their own opinions with language phrases such as "important," "general" or "unimportant" [5]. In addition, limited by the fuzziness and complexity of emergencies and the difference in understanding ability and knowledge level of decision makers, decision makers often prefer to use uncertain language phrases with preference granularity to represent the importance of an indicator, which can fully reflect the fuzziness of evaluation judgment and give play to the subjective initiative of decision makers.

## 2. The weight analysis method of the critical emergency index

In the decision-making process of the emergency plan under emergencies, it is usually necessary to invite several decision-makers to evaluate the influencing factors and alternative plans of decision-making. Generally speaking, after the occurrence of an emergency, human beings' understanding and judgment of the event are vague and uncertain at the first time. Therefore, language phrases are often used to represent the preference information of key indicators and alternatives. In addition, decision-makers may prefer different language phrase sets under the influence of their own experience, knowledge structure, and cultural background. The method proposed in this paper invites decision members to use multi-granularity uncertain language phrases to give corresponding preference information.

After an emergency occurs, the person in charge should quickly select a number of personnel from relevant departments to form a decision-making team for the emergency plan. In fact, the importance of these members varies in the selection and judgment. This paper uses the compromise voting method to obtain the relative importance of each decision-making member. The decision-making team anticipates the characteristics and severity of the emergency and uses its own experience to determine the key influencing factors of the incident.

Due to the influence of subjective and objective factors such as empirical knowledge, work experience and complexity of the emergency itself, the preference information given by decision-making members is usually in the form of uncertain language phrases. In addition, due to the differences in the cultural backgrounds of these members, different decision-making members often use language phrase sets of different granularities to express their preference information. According to their characteristics, decision-making members use their preferred language phrase set to evaluate and judge the importance of key influencing factors, and then construct the initial evaluation matrix of key indicator weights. However, when determining the weight coefficient of the key indicators, the multi-granularity language phrases given by the evaluation members must be uniformly processed, and the preference information given by the decision-making members can be transformed through Equations (1) and (2) to obtain the key indicator weight evaluation matrix of the same granularity. The most frequent set of language phrases in the initial evaluation matrix is usually set as the basic phrase set, and the rest of the preference information is converted to the corresponding language phrases in the basic phrase scale.

$$f : s^{\varsigma_1}_{[-(x_1-1), x_1-1]} \rightarrow s^{\varsigma_2}_{[-(x_2-1), x_2-1]} \tag{1}$$

$$f^{\varsigma_2}_{\varsigma_1}\left(s^{\varsigma_1}_{\sigma_1}\right) = f^{-1}_{y_2}\left(\frac{\sigma_1\left(x_2-1\right)}{x_1-1}\right) = s^{\varsigma_2}_{\sigma_2} \tag{2}$$

The UEWAA operator is used to aggregate the relative importance of decision members with the key indicator weight evaluation matrix of the same granularity, and the group evaluation vector of each key indicator weight is obtained. The calculation formula is as follows:

$$f^{\varsigma_2}_{\varsigma_1}\left(s^{\varsigma_1}_{\sigma_1}\right) = f^{-1}_{y_2}\left(\frac{\sigma_1\left(x_2-1\right)}{x_1-1}\right) = s^{\varsigma_2}_{\sigma_2} \tag{3}$$

Based on the probability of uncertain language phrase comparison, the group evaluation phrases of each key index weight are compared pairwise, and the corresponding probability matrix is obtained.

The calculation formula of the weight coefficient of each key indicator is as follows:

$$\omega_{i_1} = \frac{\sum_{i_2=1}^{l} p_{i_1 i_2}}{\sum_{i_1=1}^{l}\sum_{i_2=1}^{l} p_{i_1 i_2}} \tag{4}$$

## 3. Application examples

In this part, the feasibility of the proposed method is illustrated by the decision-making problem of the emergency plan for the debris flow in a certain area. The solid matter content of the event is as high as 50%, which rushed into the construction site of a public project and a residential place, and according to statistics, a total of 4,732 people and a large number of properties were seriously threatened. To minimize the loss of life and property to the public, the decision-makers should make a reasonable choice the first time:

The local government selects relevant personnel to form a decision-making team in the shortest time. These personnel have different knowledge of the local situation and the event, and uses the improved compromise voting method to determine the relative importance vector of each decision-making member as *p*

= (0.226, 0.195, 0.211, 0.167, 0.201). In order to make an effective decision, the key influencing factors and their weights must be determined in advance. According to the specific situation of the event, the decision-making team selects the key influencing factors of the emergency plan, namely, the timeliness of the event processing, the matching degree of emergency materials, the degree of personal safety casualties, the degree of property losses and the negative influence of public opinion. Influenced by the uncertainty of emergencies and the fuzziness of human thinking, decision-makers choose their preferred linguistic variable set according to their understanding of emergencies, and then use corresponding uncertain language phrases to represent the weight information of key indicators, as shown in **Table 1**.

**Table 1.** Key indicator evaluation information given by decision-making members

| | $t_1$ | $t_2$ | $t_3$ | $t_4$ | $t_5$ |
|---|---|---|---|---|---|
| $d_1$ | $[S^4_{4/3}, S^4_3]$ | $[S^4_{1/3}, S^4_{4/3}]$ | $[S^4_{4/3}, S^4_3]$ | $[S^4_0, S^4_{1/3}]$ | $[S^4_0, S^4_{4/3}]$ |
| $d_2$ | $[S^3_{2/3}, S^3_2]$ | $[S^3_0, S^3_{2/3}]$ | $[S^3_{2/3}, S^3_2]$ | $[S^3_{-2/3}, S^3_0]$ | $[S^3_0, S^3_{2/3}]$ |
| $d_3$ | $[S^4_{1/3}, S^4_3]$ | $[S^4_{1/3}, S^4_3]$ | $[S^4_{4/3}, S^4_3]$ | $[S^4_0, S^4_{4/3}]$ | $[S^4_{1/3}, S^4_{4/3}]$ |
| $d_4$ | $[S^5_1, S^5_4]$ | $[S^5_1, S^5_2]$ | $[S^5_2, S^5_4]$ | $[S^5_{0.4}, S^5_1]$ | $[S^5_{0.4}, S^5_2]$ |
| $d_5$ | $[S^3_{2/3}, S^3_2]$ | $[S^3_{2/3}, S^3_2]$ | $[S^3_{2/3}, S^3_2]$ | $[S^3_0, S^3_{2/3}]$ | $[S^3_{-2/3}, S^3_{2/3}]$ |

Equations (1) and (2) were used to transform the multi-granularity weight information given by decision-making members to obtain the key indicator evaluation information of the same granularity, as shown in **Table 2**.

**Table 2.** Evaluative information on key metrics at the same granularity

| | $t_1$ | $t_2$ | $t_3$ | $t_4$ | $t_5$ |
|---|---|---|---|---|---|
| $d_1$ | $[S^4_{4/3}, S^4_3]$ | $[S^4_{1/3}, S^4_{4/3}]$ | $[S^4_{4/3}, S^4_3]$ | $[S^4_0, S^4_{1/3}]$ | $[S^4_0, S^4_{4/3}]$ |
| $d_2$ | $[S^4_1, S^4_3]$ | $[S^4_0, S^4_1]$ | $[S^4_1, S^4_3]$ | $[S^4_{-1}, S^4_0]$ | $[S^4_0, S^4_1]$ |
| $d_3$ | $[S^4_{1/3}, S^4_3]$ | $[S^4_{1/3}, S^4_3]$ | $[S^4_{4/3}, S^4_3]$ | $[S^4_0, S^4_{4/3}]$ | $[S^4_{1/3}, S^4_{4/3}]$ |
| $d_4$ | $[S^4_{3/4}, S^4_3]$ | $[S^4_{3/4}, S^4_{3/2}]$ | $[S^4_{3/2}, S^4_3]$ | $[S^4_{0.3}, S^4_{3/4}]$ | $[S^4_{0.3}, S^4_{3/2}]$ |
| $d_5$ | $[S^4_1, S^4_3]$ | $[S^4_1, S^4_3]$ | $[S^4_1, S^4_3]$ | $[S^4_0, S^4_1]$ | $[S^4_{-1}, S^4_1]$ |

By using the uncertain extended weighted arithmetic average operator, the relative importance of each decision member is aggregated with the evaluation information of key indicators of the same granularity, and the group evaluation vector of key indicator weights is obtained by Equation (3) as $\theta = \{[0.893, 3.000], [0.472, 1.983], [1.229, 3.000], [-0.145, 0.683], [-0.081, 1.229]\}$.

Based on the probability of uncertain language phrase comparison, the corresponding probability matrix is obtained as:

$$P = \begin{bmatrix} 0.500 & 0.699 & 0.457 & 1.000 & 0.902 \\ 0.301 & 0.500 & 0.230 & 0.910 & 0.732 \\ 0.543 & 0.770 & 0.500 & 1.000 & 1.000 \\ 0.000 & 0.090 & 0.000 & 0.500 & 0.357 \\ 0.098 & 0.268 & 0.000 & 0.643 & 0.500 \end{bmatrix}$$

The possibility matrix is processed by Equation (4), and the weight vector of each key indicator is $\omega$ = (0.284, 0.214, 0.305, 0.076, 0.121).

## 5. Conclusion

The fuzziness, uncertainty and uncontrollability of emergencies increase the difficulty of emergency response. Aiming at this characteristic, this paper proposes a method to determine the importance of emergency key indicators based on multi-granularity uncertain language phrases. The weight determination method of key indicators based on multi-granularity uncertain language phrases proposed in this study effectively reflects the incomplete information environment, and makes full use of the judgment information given by decision makers, so as to obtain the importance of each key indicator, so as to facilitate the team to design alternative plans for emergency decision-making.

## Disclosure statement

The authors declare no conflict of interest.

## References


[1] Wang ZQ, Chen ZS, Garg H, et al., 2022, An Integrated Quality-Function-Deployment and Stochastic-Dominance-Based Decision-Making Approach for Prioritizing Product Concept Alternatives. Complex & Intelligent Systems, 8(3): 2541–2556.

[2] Hosseinzadeh A, Karimpour A, Kluger R, et al., 2022, Data Linkage for Crash Outcome Assessment: Linking Police-Reported Crashes, Emergency Response Data, and Trauma Registry Records. Journal of Safety Research, 81(6): 21–35.

[3] Rahman K, 2021, Mathematical Calculation of the COVID-19 Disease in Pakistan by Emergency Response Modeling Based on Intuitionistic Fuzzy Decision Process. New Mathematics and Natural Computation, 18(2): 407–447.

[4] Fei L, Feng Y, Wang H, 2021, Modeling Heterogeneous Multi-Attribute Emergency Decision-Making with Dempster-Shafer Theory. Computers & Industrial Engineering, 161(11): 107633–107646.

[5] Wang Z, Fung RYK, Li YL, et al., 2018, An Integrated Decision-Making Approach for Designing and Selecting Product Concepts Based on QFD and Cumulative Prospect Theory. International Journal of Production Research, 56(5): 2003–2018.