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Using Fuzzy Comprehensive Evaluation to Assess the Competency of Full-Time Water Conservancy Emergency Rescue Teams

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Abstract: Drought and flood disasters are common events threatening the safety of human lives, and full-time water conservancy emergency rescue teams play an important role in fighting against these disasters. In this paper, a competency assessment indicator system full-time water conservancy emergency rescue teams was first constructed by the Delphi Method. Four first-level, seventeen second-level and sixty third-level competency assessment indicators are proposed. Secondly, the weights of assessment indicators for a full-time water conservancy emergency rescue team at all levels were obtained by an analytic hierarchy process. Thirdly, based on that established assessment indicator system, the competency of the water conservancy emergency rescue team in Province A was assessed using a fuzzy comprehensive evaluation. Finally, the assessment results for the full-time water conservancy emergency rescue team in Province A were obtained. This study concludes by noting some practical implications of the results.

Keywords: full-time water conservancy emergency rescue team; assessment indicator system; analytic hierarchy process; fuzzy comprehensive evaluation; emergency management

MSC: 90-08; 90B50

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1. Introduction

In the process of further promoting the emergency management of water availability, China still faces certain problems. Natural risks such as floods have increased, prevention and control have become more difficult, and emergencies are prone to occur. The COVID-19 epidemic and the "July 20" Catastrophic Rainstorm Disaster in Zhengzhou, Henan Province in 2021 are examples of this. Therefore, as the final barrier to for preventing and controlling major risks, emergency rescue is of great importance to resist disasters, reduce losses and protect lives. China's emergency rescue teams are mainly composed of full-time, military and part-time emergency rescue teams [1,2]. Among these, full-time emergency rescue teams, including comprehensive fire rescue teams and various professional emergency rescue teams, are responsible for risk prevention, response and emergency rescue during various natural disasters and accidents [3]. The full-time water conservancy emergency rescue team is one of the key forces in charge of flood and drought control.

In recent years, several studies on the construction and management of full-time emergency rescue teams and the optimization of competency systems have emerged [4–6]. Scholars have been looking for new perspectives in the study and discussion of the organizational competency of full-time emergency rescue teams [7,8], including mine rescue [9], coal mine rescue [10,11] and emergency healthcare teams [12]. Other scholars have studied the organizational competency of emergency rescue teams in the face of highly uncertain, complex and dynamic crisis emergencies, by tracking and comparing the behaviors and characteristics of high-performance teams and low-performance teams during different stages of emergency management [13]. In the process of emergency rescue, the connection between each link and the deployment of various elements should be managed and promoted by full-time rescue teams, including the formulation, promotion and implementation of rescue plans and regulations, as well as the reasonable operation of rescue materials and information [14], covering all periods of rescue [15]. Therefore, the state needs to continuously improve emergency management forces at different levels, promote the adjustment of institutional functions, and strengthen the comprehensive coordination of emergency management [16]. Meanwhile, rescue teams need to select optimal rescue schemes according to the emergency rescue time [17], their own competency [17,18], available resources and other conditions [19,20]. Therefore, attention should be paid to the training of emergency personnel; at the same time, the emergency abilities and technical proficiency of all kinds of emergency personnel need to be further improved [21].

Methods of emergency rescue measures and competency assessments include the analytic hierarchy process (AHP) [22,23], fuzzy comprehensive evaluation [24,25], TOPSIS comprehensive evaluation [9,26], the catastrophe progression method [27], cloud model [28], multiple correspondence analysis [29], etc. Among these, AHP and fuzzy comprehensive evaluation have been used to study emergency rescue in more detail. For example, Zhang et al. [30] used AHP and fuzzy comprehensive evaluation to establish an assessment indicator system of emergency plans for business production safety accidents. Jing et al. [31] used AHP and fuzzy comprehensive evaluation to build a competency model of railway earthquake emergency rescue personnel. Ruan et al. [32] used fuzzy comprehensive evaluation to calculate subjective indicator scores, and AHP to estimate weight distribution, in the process of establishing a comprehensive assessment indicator system for the containment rescue measures of the national nuclear emergency engineering rescue team. The combination of these two methods [33] makes the results more accurate, because a single assessment method often cannot obtain accurate assessment results [34]. It also makes the system stronger and can better solve fuzzy and unquantifiable problems.

The full-time water conservancy emergency rescue team in Province A has gradually improved, but there are still some problems. For example, in the preparation process, material reserves have been insufficient; in the response process, the team is not efficient; in the execution process, command and coordination need to be enhanced. However, there is no suitable system or model to clarify these issues. Although scholars have made many contributions to emergency rescues, there are still two problems that need to be handled:

(1) **There is a lack of research on the competency of full-time water conservancy emergency rescue teams**. Scholars have studied fire [35–37], safety accidents [28,30] and other emergencies. Considering the special nature of water conservancy, including factors such as seasonality and continuity, research on the competency of full-time water conservancy emergency rescue teams is very important.

(2) **There is a lack of research on the construction of an assessment indicator system using a life-cycle approach.** The life-cycle approach is a crisis management theory based on four stages of a process, and it is conducive to the management and control of a whole event [38]. However, most studies have been based on relevant documents [24,30], event characteristics [22], expert opinions [7,25], etc. Due to the lack of theoretical basis, systematization and scientificity need to be improved. Therefore, it is necessary to construct an assessment indicator system from the perspective of a life-cycle approach.

Motivated by the above problems, this study first constructed a competency assessment indicator system for a full-time water conservancy emergency rescue team using the Delphi Method. Then, we obtained the weights of assessment indicators using AHP and constructed a competency assessment model with fuzzy comprehensive evaluation. Finally, we applied the constructed assessment model to Province A to test the practical value of the model, and to identify practical implications according to the competency assessment results of the full-time water conservancy emergency rescue team in Province A.

The remainder of this study is organized as follows. Section 2 introduces the Delphi method as well as AHP, and puts them into practice to construct the competency assessment indicator system for a full-time water conservancy emergency rescue team, and to obtain the weights of evaluation indicators. Section 3 presents comprehensive evaluation results obtained through a constructed competency evaluation model of a full-time water conservancy emergency rescue team, using fuzzy comprehensive evaluation. Section 4 discusses the practical implications of this. Section 5 summarizes the main work and contributions of this paper.

2. Methods

In this section, the Delphi method and AHP are introduced. The fuzzy comprehensive evaluation results for a full-time water conservancy emergency rescue team are presented in Section 3.

2.1. Delphi Method

The Delphi method is a collective, anonymous exchange of ideas in the form of a correspondence consultation [39]. Based on the life-cycle approach and organizational competency theory, through two rounds of expert feedback using the Delphi method, this study obtained an assessment indicators database applicable to a full-time water conservancy emergency rescue team, and then constructed the competency assessment indicator system.

According to the principles of "strategic orientation with clear goals", "prominent emphasis and overall consideration", "emphasis on operation and strong applicability ", and "normative system and moderately advanced indicators" [40,41], the content analysis method was applied to select relevant competency assessment indicators. The steps for selecting competency assessment indicators were as follows:

(1) Framing the research question: The research question concerned the construction of the competency assessment indicator system for a full-time water conservancy emergency rescue team.
(2) Determining the scope of the research and samples: Specifically, references were selected from the full-text database of the China Academic Journals Network (CNKI), and the research period lasted until 10 April 2022. Overall, 171 relevant pieces of the literatures were selected.
(3) Defining the analysis unit of the study: The analysis unit of the study was full-time emergency rescue water conservancy teams.
(4) Constructing categories of competency assessment indicators and a quantitative system: Specific category standards were determined according to expert interviews, and each category item was coded.
(5) Pretesting: Reliability was verified and content was encoded according to the definition. In the process of sample testing, "1" was denoted when the two coders had the same views; if they were inconsistent, they were denoted as "0". If the consistency ratio reached over 80%, it was considered that the reliability analysis for this process had been passed. After calculation, the coders' consistency ratio reached 95.5%, indicating that the coding process passed the reliability test.
(6) Data analysis: According to organizational competency theory, through the study of the available literature, competency assessment indicators that are comprehensive, obvious, easy to measure, easy to examine and applicable were sorted. The assessment indicators can objectively and accurately reflect the reality and characteristics of full-time water conservancy emergency rescue teams.

Seventy-two competency assessment indicators of full-time water conservancy emergency rescue teams were determined after preliminary selection. These were as follows: preplan compiling, completeness of emergency plan, operation of emergency plan, risk assessment ability, laws and regulations, team-building, job qualifications, staff number, cooperation with other teams, material reserves, number/category/specification, equipment maintenance, simple equipment production, equipment procurement, training and development, physical fitness, technical knowledge, teamwork ability, research learning, amount of research, time of research, new knowledge/new methods, crisis consciousness, information acquisition ability, information access, information transfer mode, daily monitoring ability, special period search ability, task-switching ability, task-recognition ability, material equipment ability, team-building ability, goods loading time, quick delivery ability, quick configuration and startup ability, route-planning ability, time-control ability, delivery-support ability (traffic control department), parallel disposal ability, communication ability (on-site), coordinating-routes ability, technical guidance, envision-solution ability, professional technical ability, plan execution, man-machine cooperation ability, equipment start-up time, safe operation, field-warning ability, organizational motivation ability (leadership), strain ability, vigilance ability, personnel and material allocation ability, team motivation, command and coordination ability, professional advice, decision-making ability, organizing ability, comprehensive support ability, logistics ability, emergency material preparation ability (electric power), emergency shelter, emergency communication equipment, publicity ability, restoring-order ability, safe evacuation, functional recovery ability of equipment, summarizing-learning ability, post-emergency assessment ability, learning-improvement ability, summarizing learning procedures, and plan-revision ability.

Then, we invited fifteen experts from the water conservancy industry and emergency management field to form a team to use the Delphi Method. The composition of these experts is shown in Table A1 (see the Appendix A). The preliminary selected competency assessment indicator tables for the full-time water conservancy emergency rescue team were sent to all experts in the form of a letter. Then, the experts revised the assessment indicators according to their professional knowledge and work experience [39].

According to the analyzed literature mentioned above, a semi-open questionnaire was created focusing on capacity assessment indicators for full-time water conservancy emergency rescue teams. The feedback results from fifteen experts in the first round are shown in Table A2 (see the Appendix A). In Table A2, "1" and "7" mean "strongly disagree" and "strongly agree", respectively, with the degree of agreement increasing between these.

The experts completed fifteen valid questionnaires in the first round. According to the results, the average scores of all assessment indicators were more than 4.5 points and assessment indicators such as scientificity of emergency plans, emergency rescue experience and professional level (dress, technical knowledge) were added. Three assessment indicators including "risk assessment ability", "technical knowledge" and "time control ability" were deleted. In addition, suggestions regarding modifying the names of certain assessment indicators are shown in Table A2.

In the first round, seven assessment indicators were added, and thirty-five assessment indicators were modified. More than two-thirds of the experts agreed. However, some experts were not satisfied with certain assessment indicators. Therefore, according to the feedback provided by the experts in the first round, the second-round semi-open questionnaire was created. Then, the questionnaires were sent to fifteen experts by e-mail, as agreed, and experts were invited to unify the names of assessment indicators. Experts revised the assessment indicators again according to their professional knowledge and work experience, and the expert feedback is shown in Table A3 (see the Appendix A).

In the second round, experts changed the names of some assessment indicators, added nine assessment indicators regarding funds and systems, and deleted "legal compliance of emergency plan". Meanwhile, "prototype equipment design ability" and "simple equipment production" were merged into "design and production".

After two rounds of Delphi Method feedback, the competency assessment indicator database for full-time water conservancy emergency rescue teams was formed. Then, the final seventy-seven assessment indicators were processed by stratification, and the second- and third-level assessment indicators of the competency assessment indicator system were determined. Then, according to the life-cycle approach, the first-level assessment indicators were established for the competency assessment of water conservancy full-time emergency rescue teams; these indicators were organizational readiness competency, organizational response competency, organizational execution competency and organizational recovery competency. The first- and second-level assessment indicators are shown in Figure 1; C_i, C_{ij}, and C_{ijl} represent the first-, second- and third-level assessment indicators, respectively. Combined with the characteristics of the full-time water conservancy emergency rescue team and the requirements of emergency management construction, the competency assessment indicator system and spiral organizational competency model of the full-time water conservancy emergency rescue team were constructed, as shown in Table A4 (see the Appendix A) and Figure 2.

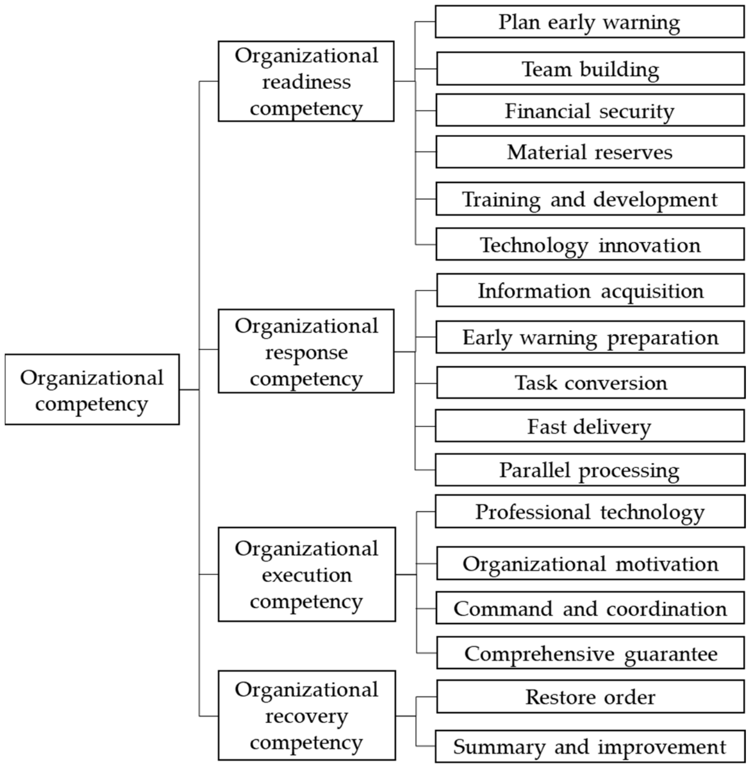

Figure 1. First-level and second-level assessment indicators of full-time water conservancy emergency rescue teams.

Then, according to the constructed assessment indicator system, using AHP we calculated the weights of the evaluation indicators for a full-time water conservancy emergency rescue team.

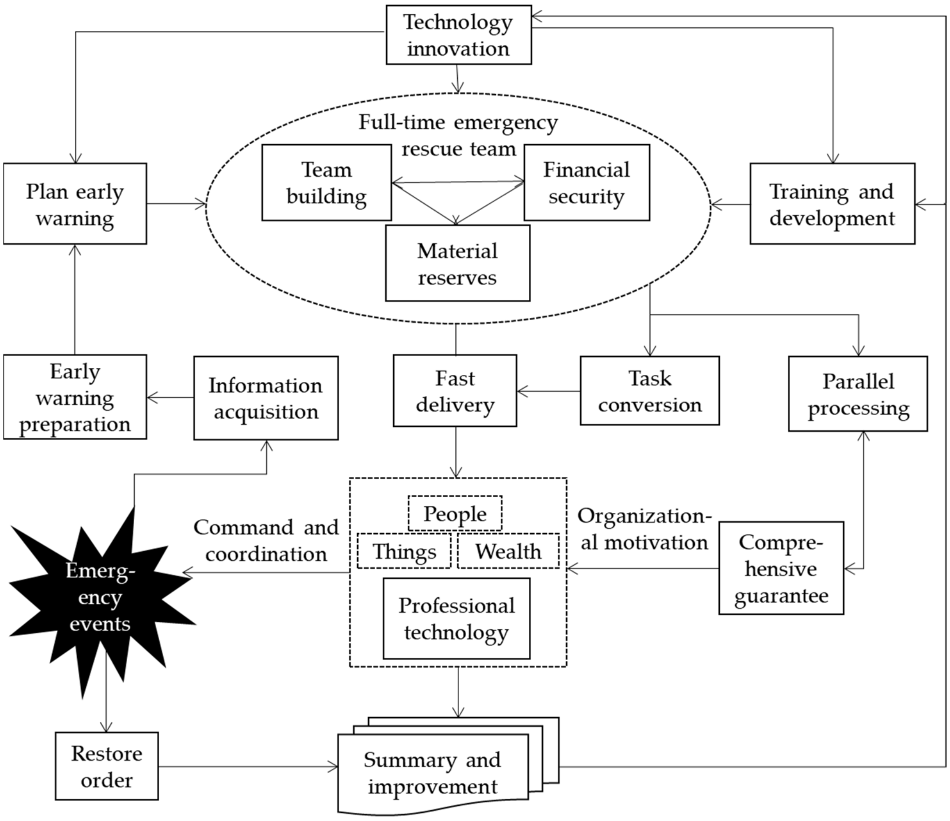

Figure 2. Spiral organizational competency model of full-time water conservancy emergency rescue teams.

2.2. Analytic Hierarchy Process

AHP is a method for decomposing the factors related to decision-making into levels of objectives, criteria, schemes, etc., and analyzing them layer by layer on this basis [42,43]. In this part of the study, AHP was used to obtain the weights of assessment indicators for a competency assessment indicator system.

(1) Determining the weights of expertise.

Due to differences in the ability and understanding of the experts, as well as their status and identity, the weighting of their expertise was set differently [44]. Various factors that can influence the weight of expertise, such as experts' social network, educational background, time spent working, etc. [45–48]. Referring to Wang et al. [47], Han et al. [46], and Zhang et al. [45], five criteria were selected in this paper to determine the weighting of expertise; the five criteria were professional title, educational background, scientific research achievements, professional relevance and working time. In the future, it will be interesting to utilize other approaches to determine the weighting of expertise.

Let m represent expert m: A_m, B_m, C_m, D_m and E_m represent the assessment values of the professional title, educational background, scientific research achievements, professional relevance and working time of expert m, respectively. G_m represents the assessment value for the five criteria of expert m; $\alpha_i(i = 1, 2, \ldots, 5)$ represents the weight coefficients of different criteria; t represents the number of experts; H_m represents the weighting of expert m.

Then, H_m is given by the following:

$$G_{\mathrm{m}} = \alpha_1 A_m + \alpha_2 B_m + \alpha_3 C_m + \alpha_4 D_m + \alpha_5 E_m \quad (1)$$

$$H_m = G_m / \sum_{m=1}^{t} G_m \quad (2)$$

In this study, we assumed that α_1 = 0.1, α_2 = 0.1, α_3 = 0.5, α_4 = 0.2, and α_5 = 0.1. Then, we invited four emergency center experts and three professors of Hohai University. The information about the experts is shown in Table A5 (see the Appendix A). Based on the expert information regarding five criteria, we determined the weighting of the experts. According to the Equations (1) and (2), the weightings of the seven experts were 0.148, 0.136, 0.137, 0.142, 0.148, 0.146, 0.143 respectively.

(2) Determining the weights of assessment indicators.

The judgment matrix is the matrix form of expert assessment [49]. To determine the weights of assessment indicators using AHP, the judgment matrix was constructed by comparing the importance of assessment indicators in pairs [50]. The relative importance of each assessment indicator was quantified using a certain digital scale [51].

In the judgment matrix, the most common method is to use 1–9 and the reciprocal for comparison [34]. The degree of importance increases with the increase in number. A score of "1" means that the vertical indicator is equally important compared with the horizontal indicator, and "9" means that the vertical indicator is significantly more important than the horizontal indicator [52]. If the horizontal indicator is considered more important than the vertical indicator, it is marked "1/9"- "1". The specific rules are shown in Table A6 [51] (see the Appendix A), and the judgment matrix is shown in Table A7 (see the Appendix A). The consistency ratio (CR) is often used to test the consistency of the judgment matrix [34,53]. If $CR < 0.1$, the consistency is acceptable [52].

In Table A7, n represents the order of the judgment matrix, F_n represents assessment indicators, and $a_{ij}(i = 1, 2, \ldots, n; j = 1, 2, \ldots, n)$ represents the digital scale given by experts for the relative importance of assessment indicators according to the assessment rules. CI represents consistency index, λ_{max} represents the maximum eigenvalue of the judgment matrix, and RI represents random index [49]; CR can be obtained by:

$$CI = \lambda_{max}/(n-1) \tag{3}$$

$$CR = CI/RI \tag{4}$$

Seven experts assessed the relative importance of the assessment indicators at all levels, according to the actual situation of the full-time water conservancy emergency rescue team in Province A and their own professional knowledge. Then, the judgment matrices were formed. In this study, Expert Choice 11.5 software was used to calculate the weights of the three levels of assessment indicators. After being calculated by Equations (3) and (4), the consistency test was passed. The results from one expert are shown in Tables A8–A10 (see the Appendix A).

Let w_i^m, w_{ij}^m and w_{ijl}^m $(i = 1, 2, \ldots, 4; j = 1, 2, \ldots, 6; l = 1, 2, \ldots, 7)$ represent the weights of first-, second- and third-level assessment indicators made by the expert m, respectively. w_i^c, w_{ij}^c and w_{ijl}^c represent the collective weights of first-, second- and third-level assessment indicators, respectively.

According to Equations (1) and (2), H_m is given, then w_i^c, w_{ij}^c and w_{ijl}^c can be calculated by the following.

$$w_i^c = \sum_{m=1}^{t} H_m w_i^m \tag{5}$$

$$w_{ij}^c = \sum_{m=1}^{t} H_m w_{ij}^m \tag{6}$$

$$w_{ijl}^c = \sum_{m=1}^{t} H_m w_{ijl}^m \tag{7}$$

According to Equations (5)–(7), the weights of first-level assessment indicators were 0.43, 0.20, 0.22 and 0.15, and the other results are shown in Table A11 (see the Appendix A).

Then, based on the weights of assessment indicators, we constructed a competency assessment model for the full-time water conservancy emergency rescue team in Province A.

3. Results

This study used fuzzy comprehensive evaluation to construct the competency assessment model for a full-time water conservancy emergency rescue team in Province A.

3.1. Background

In China, Province A is a low-lying area with poor runoff. The time distribution of precipitation is uneven, and droughts and floods occur one after another. The natural conditions highlight the special importance of water conservancy work in the economic and social development of Province A. The full-time water conservancy emergency rescue team in Province A was established in 1966, and currently there are about 90 rescue team members who can be mobilized. In accordance with the requirements of "militarization of action, specialization of technology and modernization of equipment", the rescue team carries out practical training before the flood season every year. This rescue team plays an efficient, mobile and rapid emergency rescue role, and is the "main force" for flood-fighting and disaster rescue in Province A. Although the emergency rescue training in Province A has gradually been strengthened and the professional level of emergency rescue has gradually improved, there remain some problems. For example, in the preparation process, material reserves are insufficient; in the response process, the team is not efficient; in the execution process, command and coordination need to be enhanced. To solve these problems, it is necessary to study the competence of the full-time water conservancy emergency rescue team in Province A.

3.2. Fuzzy Comprehensive Evaluation

Fuzzy comprehensive evaluation is used for the overall evaluation of things or events that are restricted by multiple factors [54]. This method is objective, scientific, and can combine qualitative and quantitative indicators [55]. It has great advantages in dealing with problems that are fuzzy, uncertain, and difficult to quantify [56]. Thus, fuzzy comprehensive evaluation was used to reach the comprehensive assessment result. Firstly, assessment indicators' grades were judged; then, fuzzy membership matrices were constructed, and finally, comprehensive assessment results were obtained. The concrete steps were as follows:

(1) Obtaining third-level assessment indicator assessment information.

We invited the participation of four emergency center experts and three professors of Hohai University. These experts used a five-grade linguistic term to assess the full-time water conservancy emergency rescue team in Province A, provided as follows: Level I, Level II, Level III, Level IV and Level V, from low to high.

Based on materials and field investigation, experts considered the third-level assessment indicators of organizational competency of the full-time water conservancy emergency rescue team in Province A. The assessment information matrixes of the third-level assessment indicators given by the seven experts are shown in Table A12 (see the Appendix A).

(2) Constructing the fuzzy membership matrix.

The percentage statistical method was applied to convert the grades assessed by experts into fuzzy membership degrees. The fuzzy membership matrix was constructed using the proportion of the number of experts rated as being at a certain level for each assessment indicator, as shown in Table A12.

Let u_i^c, u_{ij}^c, u_{ijl}^c, and u^c represent fuzzy comprehensive evaluation sets of the first-, second-, third- and target levels of the assessment indicators.

Combining the weights of assessment indicators and the fuzzy membership matrix, the fuzzy comprehensive evaluation sets of the second-, first- and target levels of assessment indicator were calculated by the following:

$$u_{ij}^{c} = w_{ijl}^{c} \times (u_{ijl}^{c})^{T} \tag{8}$$

$$u_{i}^{c} = w_{ij}^{c} \times (u_{ij}^{c})^{T} \tag{9}$$

$$u^{c} = w_{i}^{c} \times (u_{i}^{c})^{T} \tag{10}$$

According to Equations (8) and (9), the second-level and first-level assessment indicator information matrixes are shown in Tables A13 and A14 (see the Appendix A). Based on the principle of maximum membership degree, the corresponding assessment grades of the largest numbers in $\begin{bmatrix} u_{ij1} & \cdots & u_{ijm} & \cdots & u_{ij5} \end{bmatrix}$, $\begin{bmatrix} u_{i1} & \cdots & u_{im} & \cdots & u_{i5} \end{bmatrix}$ and $\begin{bmatrix} u_{1} & \cdots & u_{m} & \cdots & u_{5} \end{bmatrix}$ were the comprehensive assessment results of the second-level assessment indicator, first-level assessment indicator and target layer.

According to Table A14 and Equation (10), the assessment information matrix of the target layer was $\begin{bmatrix} 0.00 & 0.05 & 0.20 & 0.45 & 0.30 \end{bmatrix}$. Therefore, the assessment grade of the full-time water conservancy emergency rescue team in Province A is level IV.

(3) Obtaining comprehensive assessment results.

There are three sections of the comprehensive assessment results as follows: (1) Importance comparison of assessment indicators: The importance of each assessment indicator to the assessment object can be determined by comparing the weight, so that strategic actions can be taken or resources can be allocated. (2) Fuzzy comprehensive evaluation set analysis: Through the analysis of fuzzy comprehensive evaluation sets, the comprehensive assessment results for the competency of the full-time water conservancy emergency rescue team were obtained, reflecting the current state of the full-time water conservancy emergency rescue team. (3) Optimization measures: The reasons for the current state of the full-time emergency water conservancy rescue team were analyzed, and optimization measures were taken according to the assessment results and for internal reasons, and systematic suggestions for the modernization of emergency management were put forward.

According to the results of the membership degree, the competency of the full-time water conservancy emergency rescue team in Province A was comprehensively assessed, as shown in Figure 3.

The competency of the full-time water conservancy emergency rescue team in Province A was found to be level IV overall, meaning that they are well-qualified for professional emergency rescue tasks. The organizational recovery competency shown by the first-level assessment indicators was very strong, reaching level V, and the organizational readiness, response and execution competency were all level IV, ahead of the construction requirements for emergency management. For the information acquisition relating to organizational response competency and comprehensive guarantee of organizational execution competency, the assessment results were level II and level III, respectively, revealing obvious shortcomings.

In addition, the figure shows that the full-time water conservancy emergency rescue team needs to further improve in the following aspects: training and development, technological innovation, financial security of organizational readiness competency, early warning preparation, parallel processing of organizational response competency, organizational motivation, command and coordination, comprehensive guarantee of organizational execution competency, etc.

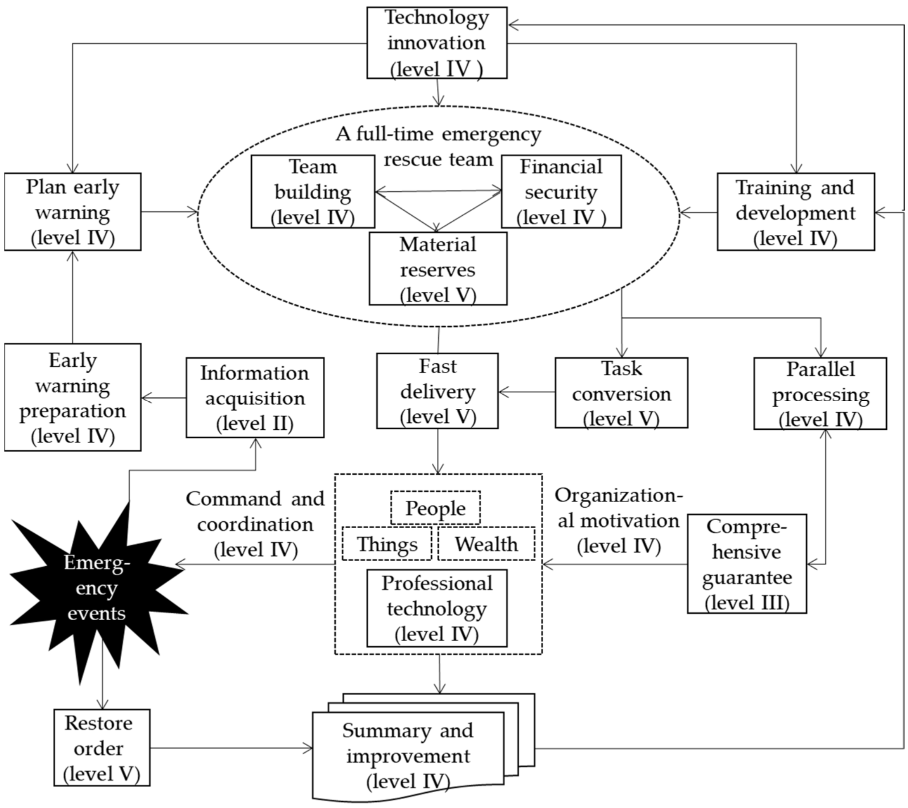

Figure 3. Spiral organizational competency model of the full-time water conservancy emergency rescue team in Province A.

4. Discussion

According to the competency assessment results for the full-time water conservancy emergency rescue team in Province A, we obtained the following practical implications:

(1) **Investigation of the construction of the water conservancy full-time emergency rescue team.** The process of the construction of a water conservancy full-time emergency rescue team requires finding the overall competency of the current team, as well as viewing the overall competency level, structure and other characteristics from different angles and levels, and then identifying the prominent problems and key tasks in the construction of water conservancy full-time emergency rescue teams, and formulating an implementation plan accordingly.

(2) **Improving the organizational readiness competency of the full-time water conservancy emergency rescue team.** In accordance with the requirements of "long-term preparation, key construction", it is necessary to focus on strengthening the basic work of emergency management, and to take precautions. First of all, the reserve management of emergency materials and equipment should be strengthened, and an emergency material support system constructed. Secondly, regular or irregular emergency drills should be carried out, including desktop drills, practical exercises and other methods to test and revise plans, and to solidify knowledge into abilities that can be called on in practice at any time. Finally, in-depth work exchanges should be carried out to promote knowledge sharing, and efforts should be made to establish a specialized, responsive and skilled full-time water conservancy emergency rescue team that is capable of preventing and managing various disasters.

(3) **Enhancing the response competency of the full-time water conservancy emergency rescue team.** In accordance with the principle of "rapid response and overall planning", a peacetime and wartime conversion mechanism should be established to continuously improve the early handling capacity of the full-time water conservancy emergency rescue team. According to the emergency plan, the full-time emergency

rescue team of water conservancy implements joint disposal mechanisms such as investigation, express delivery, information submission and parallel disposal, to prevent flood and drought disasters from a range of incidents, from a "grey rhino incident" to a "black swan incident".

(4) **Improving the execution competency of the full-time water conservancy emergency rescue team.** In accordance with the principle of "full incentives, rewards and punishments", it is necessary to implement a suitable national wage system, offer duty and overtime subsidies, make good use of spiritual incentives, and provide timely commendations at the end of rescue and disaster relief. Additionally, sound accountability mechanisms in the process of emergency rescue should be established, and incompetent behaviors penalized according to the regulations and facts. This is especially relevant for cooperation among departments, so as to reduce the weak links in water emergency operations. A post-supervision system to ensure accountability should be set up to avoid mere formality regarding accountability.

(5) **Summarizing the construction of the full-time water conservancy emergency rescue team.** Following regular assessment after disaster relief, the team's competency assessment and corresponding work should be put into practice. Problems, vulnerabilities and weaknesses existing in emergency rescue work should be quickly uncovered after the assessment of the rescue team. A rectification plan should be formed "better later than never", and a system of rectification work should be established so that the rectification can be fully implemented.

5. Conclusions

This study puts forward a new competency assessment indicator system for a full-time water conservancy emergency rescue team using AHP. It also assesses a full-time water conservancy emergency rescue team in Province A using fuzzy comprehensive evaluation. The contributions of this paper are described as follows:

(1) **This study constructed a novel competency assessment indicator system for full-time water conservancy emergency rescue teams, which can promote the standardization and refinement of emergency rescue work**. The full-time water conservancy emergency rescue team is the backbone force especially responsible for flood and drought control, and plays an important role in dealing with flood and drought disasters. The existing competency assessment indicator system is mainly focused on sudden emergency events and safety accidents, and there has been a lack of research on full-time water conservancy emergency rescue teams. In this paper, assessment indicators of full-time water conservancy emergency rescue teams have been further enriched and expanded.

(2) **This study determined competency assessment indicators of full-time water conservancy emergency rescue teams, based on a life-cycle approach, and can comprehensively and systematically reflect the rescue team both in whole and in part**. The research constructed an assessment indicator system for emergency rescue based on relevant documents, emergency features and expert opinions, providing strong subjectivity and weak systematization. The life-cycle approach can provide a clear theoretical framework for the construction of an organizational competency model, starting from the four stages of crisis management. Therefore, competency assessment indicators of water conservancy emergency rescue teams were based on a life-cycle approach.

(3) **This paper used fuzzy comprehensive evaluation to assess the competency of a full-time water conservancy emergency rescue team, and has great advantages for dealing with the complex and unquantifiable competency assessment of the rescue team**. Competency assessments of emergency rescue teams are based on precise numerical values existing research. However, the collected assessment information is often imprecise, and it is difficult for experts to assess the competency of emergency rescue teams using precise values. Fuzzy comprehensive evaluation can combine

qualitative and quantitative assessment indicators, and can deal well with complex and unquantifiable problems. Therefore, fuzzy comprehensive evaluation was used to assess the competency of the full-time water conservancy emergency rescue team.

In the future, we can improve the method and conduct further research. Big data, artificial intelligence and other means can be used to determine the assessment indicators and determine the levels of assessment indicators, to improve the accuracy of competency assessments of full-time water conservancy emergency rescue teams.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Composition of experts.

Classifications	Number	Percentage (%)
Male	13	86.7
Female	2	13.3
Sub-senior	5	33.3
Senior	10	66.7

Table A2. Results of the first round of questionnaires.

No.	Indicators	Indicators' Frequency										Indicators Modified by Experts
		1	2	3	4	5	6	7	Mean	Median	Standard Deviation	
1	Preplan compiling					1	13	1	6	6	0.37	
2	Completeness of emergency plan				1	1	12	1	5.87	6	0.62	
3	Operation of emergency plan					1	14		5.93	6	0.25	
4	Risk assessment ability				1	2	11	1	5.8	6	0.65	Delete
5	Laws and regulations					1	13	1	6	6	0.37	Legal compliance of emergency plan
6	Team-building				1	3	10	1	5.73	6	0.68	
7	Job qualifications					4	11		5.73	6	0.44	
8	Staff number					1	13	1	6	6	0.37	
9	Cooperation with other teams			1	4	1	9		5.2	6	1.05	Cooperation ability
10	Material reserves			2	3		8	2	4.87	6	1.38	
11	Number/Category/Specification				3	1	11		5.53	6	0.81	Prototype equipment design ability
12	Equipment maintenance						14	1	6.07	6	0.25	

Table A2. *Cont.*

No.	Indicators	Indicators' Frequency										Indicators Modified by Experts
		1	2	3	4	5	6	7	Mean	Median	Standard Deviation	
13	Simple equipment production						13	2	6.13	6	0.34	
14	Equipment procurement			1	4		9	1	5.33	6	1.14	Equipment purchasing suggestion ability
15	Training and development				4		10	1	5.53	6	0.96	
16	Physical fitness						14	1	6.07	6	0.25	Individual ability training
17	Technical knowledge			1	1	5	7	1	5.4	6	0.95	Delete
18	Teamwork ability				1	4	9	1	5.67	6	0.70	Team cooperation ability training (internal cooperation)
19	Research learning				4	1	8	2	5.53	6	1.02	
20	Amount of research					1	12	2	6.07	6	0.44	Research ability
21	Time of research			2	5	1	7		4.87	5	1.15	
22	New knowledge/new methods				1	3	11		5.67	6	0.60	Learning ability
23	Crisis consciousness				3	5	6	1	5.33	5	0.87	Learning consciousness (crisis)
24	Information acquisition ability				1	2	9	3	5.93	6	0.77	
25	Information access				1	2	12		5.73	6	0.57	
26	Information transfer mode					2	13		5.87	6	0.34	Information channel construction (acquisition, transmission)
27	Daily monitoring ability					1	9	5	6.27	6	0.57	
28	Special period search ability					4	5	6	6.13	6	0.81	
29	Task-switching ability					5	7	3	5.87	6	0.72	
30	Task-recognition ability					1	9	5	6.27	6	0.57	
31	Material equipment ability					3	9	3	5.67	6	0.71	
32	Team-building ability						11	4	6.27	6	0.44	
33	Goods loading time				1	1	13		5.8	6	0.54	Loading efficiency of materials
34	Quick delivery ability					3	9	3	6	6	0.63	
35	Quick configuration and startup ability				1	7	7		5.4	5	0.61	Quick configuration and start-up ability (lifting equipment)

Table A2. *Cont.*

No.	Indicators	Indicators' Frequency										Indicators Modified by Experts
		1	2	3	4	5	6	7	Mean	Median	Standard Deviation	
36	Route-planning ability						14	1	6.07	6	0.25	
37	Time-control ability					3	11	1	5.87	6	0.50	Delete
38	Delivery-support ability (Traffic Control Department)				4	1	10		5.41	6	0.88	Aid access ability (Traffic Control Department)
39	Parallel disposal ability				1	1	4	9	6.4	6	0.88	
40	Communication ability (on-site)				1	9	5		5.27	5	0.57	Route contingency ability, solution deducting ability, remote consulting ability
41	Coordinating-routes ability				1	10	4		5.2	5	0.54	
42	Technical guidance				9	2	4		5.07	4	0.96	
43	Envision-solution ability				5	4	6		5.07	5	0.85	
44	Professional technical ability				1	3	10	1	5.73	6	0.68	
45	Plan execution				3		12		5.6	6	0.80	
46	Man-machine cooperation ability					4	11		5.73	6	0.44	
47	Equipment start-up time				6		9		5.2	6	0.98	Ability to ensure proper operation of equipment
48	Safe operation						14	1	6.07	6	0.25	
49	Field-warning ability					1	12	2	6.07	6	0.44	
50	Organizational motivation ability (leadership)					1	11	3	6.13	6	0.50	
51	Strain ability			1	2	3	9		5.13	6	0.96	On-site emotional management (tension, calm), boost morale (team motivation)
52	Vigilance ability			1	2	6	6		5.13	5	0.88	
53	Team motivation				5	2	8		5.2	6	0.91	
54	Personnel and material allocation ability				2	4	9		5.47	6	0.72	
55	Command and coordination ability					3	12		5.8	6	0.40	
56	Professional advice				3	3	9		5.4	6	0.80	Ability to make professional decisions and recommendations
57	Decision-making ability			2	1	7	5		5	5	0.97	
58	Organizing ability			1		3	11		5.6	6	0.80	Organization and execution ability (coordination command)
59	Comprehensive support ability				1	3	6	5	6	6	0.89	

Table A2. *Cont.*

No.	Indicators	Indicators' Frequency										Indicators Modified by Experts
		1	2	3	4	5	6	7	Mean	Median	Standard Deviation	
60	Logistics ability					1	7	7	6.4	6	0.61	
61	Emergency material preparation ability (electric power)				1	4	9	1	5.67	6	0.70	
62	Emergency shelter				1	9	5		5.27	5	0.57	On-site emergency response ability (supplies, electricity, shelter plans, communications plans)
63	Emergency communication equipment				1	7	7		5.4	5	0.61	
64	Publicity ability					1	5	9	6.53	7	0.62	
65	Restoring-order ability						11	4	6.27	6	0.44	
66	Safe evacuation			1	2	6	6		5.13	5	0.88	
67	Functional recovery ability of equipment					1	7	7	6.4	6	0.61	
68	Summarizing-learning ability				3	4	8		5.33	6	0.79	
69	Post-emergency assessment ability					1	8	6	6.33	6	0.60	
70	Learning-improvement ability				1	3	4	7	6.13	6	0.96	
71	Summarizing learning procedures					3	6	6	6.2	6	0.75	Feedback ability (department, leader), plan making and implementation ability (plan, training program)
72	Plan-revision ability					5	8	2	5.8	6	0.65	
Added indicators		Scientificity of emergency plan, emergency rescue experience, professional level (dress, technical knowledge), training ability building (training system construction, expert database, trainer training, social force training), rectification plan implementation (whether to integrate constructive suggestions into the subsequent improved emergency plan), on-site quick guidance ability, danger judgment and prediction ability										

Table A3. Results of the second round of questionnaires.

No.	Indicators	Indicators' Frequency										Indicators Modified by Experts
		1	2	3	4	5	6	7	Mean	Median	Standard Deviation	
1	Preplan compiling					1	7	7	6.4	6	0.61	Plan early warning
2	Completeness of emergency plan					1	2	12	6.73	7	0.57	Completeness
3	Operability of emergency plan					2	2	11	6.6	7	0.71	Operability
4	Scientificity of emergency plan						1	14	6.93	7	0.25	Scientificity
5	Legal compliance of emergency plan			5	1	6	1	2	4.8	5	1.37	Delete
6	Team building					1	2	12	6.73	7	0.57	Team building

Table A3. *Cont.*

No.	Indicators	Indicators' Frequency										Indicators Modified by Experts
		1	2	3	4	5	6	7	Mean	Median	Standard Deviation	
7	Job qualifications					1	3	11	6.67	7	0.60	
8	Staff number						2	13	6.87	7	0.34	
9	Emergency rescue experience					1	2	12	6.73	7	0.57	
10	Cooperation ability					1	1	13	6.8	7	0.54	
11	Professional level						2	13	6.87	7	0.34	
12	Material reserves						1	14	6.93	7	0.25	
13	Equipment purchasing suggestion ability				1	1	1	12	6.6	7	0.88	Purchasing management, Specification scale
14	Prototype equipment design ability				1	1	6	7	6.27	7	0.85	Design and production
15	Simple equipment production					1	5	9	6.53	7	0.62	
16	Equipment maintenance						2	13	6.87	7	0.34	Maintenance, Patrol inspection
17	Training and development						1	14	6.93	7	0.25	
18	Individual ability training					1	5	9	6.53	7	0.62	Individual training
19	Team cooperation ability training					1	6	8	6.47	7	0.62	Team training
20	Training ability building					1	2	12	6.73	7	0.57	Development system
21	Research learning					1	5	9	6.53	7	0.62	Technological innovation
22	Learning consciousness						3	12	6.8	7	0.40	Scientific research consciousness
23	Research ability					1	2	12	6.73	7	0.57	
24	Learning ability				6	1	4	4	5.4	6	1.25	Innovation ability
25	Rectification plan implementation						2	13	6.87	7	0.34	Implementation of rectification
26	Information acquisition ability						4	11	6.73	7	0.44	Information acquisition
27	Information channel construction						3	12	6.8	7	0.40	Channel construction
28	Daily monitoring ability					1	4	10	6.6	7	0.61	Daily monitoring
29	Special period search ability						6	9	6.6	7	0.49	Special patrol
30	Task-switching ability						7	8	6.53	7	0.50	Task conversion
31	Task-recognition ability						4	11	6.73	7	0.44	Task identification
32	Material equipment ability						2	13	6.87	7	0.34	Material allocation
33	Team-building ability						5	10	6.67	7	0.47	Team formation
34	Loading efficiency of materials						3	12	6.8	7	0.40	Loading efficiency
35	Quick delivery ability						4	11	6.73	7	0.44	Fast delivery
36	Route-planning ability						3	12	6.8	7	0.40	Route planning

Table A3. *Cont.*

No.	Indicators	Indicators' Frequency 1	2	3	4	5	6	7	Mean	Median	Standard Deviation	Indicators Modified by Experts
37	Quick configuration and start-up ability						5	10	6.67	7	0.47	Quick configuration
38	Aid access ability						4	11	6.73	7	0.44	Aid acquisition
39	Parallel disposal ability						5	10	6.67	7	0.47	Parallel processing
40	Route contingency ability						6	9	6.6	7	0.49	Route strain
41	Solution deducting ability						7	8	6.53	7	0.50	Scheme deduction
42	Remote consulting ability						8	7	6.47	6	0.50	Remote consultation
43	Professional technical ability						6	9	6.6	7	0.49	Professional technology
44	Plan execution						3	12	6.8	7	0.40	Plan implementation
45	Man–machine cooperation ability						4	11	6.73	7	0.44	Man–machine Coordination
46	Safe operation						2	13	6.87	7	0.34	Safe operation
47	Field-warning ability						1	14	6.93	7	0.25	On-site warning
48	On-site quick guidance ability						2	13	6.87	7	0.34	Quick coaching
49	Ability to ensure proper operation of equipment						3	12	6.8	7	0.40	Operation guarantee
50	Danger judgment and prediction ability						4	11	6.73	7	0.44	Danger prediction
51	Organizational motivation ability						6	9	6.6	7	0.49	Organizational motivation
52	On-site emotional management						5	10	6.67	7	0.47	Emotion management
53	Boost morale						4	11	6.73	7	0.44	Team motivation
54	Command and coordination ability						2	13	6.87	7	0.34	Command and coordination
55	Personnel and material allocation ability						3	12	6.8	7	0.40	Resource allocation
56	Ability to make professional decisions and recommendations						1	14	6.93	7	0.25	Decision-making advice
57	Organization and execution ability						3	12	6.8	7	0.40	Organization and implementation
58	Comprehensive support ability						1	14	6.93	7	0.25	Comprehensive guarantee
59	Logistics ability						4	11	6.73	7	0.44	Logistic service
60	On-site emergency response ability						3	12	6.8	7	0.40	On-site emergency
61	Publicity ability						4	11	6.73	7	0.44	
62	Restoring-order ability						2	13	6.87	7	0.34	Restore order
63	Safe evacuation						1	14	6.93	7	0.25	Safe evacuation
64	Functional recovery ability of equipment						4	11	6.73	7	0.44	Functional recovery
65	Summarizing-learning ability					5	1	9	6.27	7	0.93	Summary and improvement

Table A3. *Cont.*

No.	Indicators	Indicators' Frequency										Indicators Modified by Experts
		1	2	3	4	5	6	7	Mean	Median	Standard Deviation	
66	Post-emergency assessment ability					1	6	8	6.47	7	0.62	Post assessment
67	Feedback ability						6	9	6.6	7	0.49	
68	Plan making and implementation ability						2	13	6.87	7	0.34	Improvement scheme
Added indicators		Reserve funds, training funds, early warning preparation, management responsibilities, management mechanism, grading system, financial security, daily funds, scientific research funds										

Table A4. Competency assessment indicator system for the full-time water conservancy emergency rescue team.

First-Level Indicator C_i	Second-Level Indicator C_{ij}	Third-Level Indicator C_{ijl}
Organization readiness competency C_1	Plan early warning C_{11}	Completeness C_{111}, Operability C_{112}, Scientificity C_{113}
	Team building C_{12}	Job qualifications C_{121}, Staff number C_{122}, Emergency rescue experience C_{123}, Cooperation ability C_{124}, Professional level C_{125}
	Financial security C_{13}	Daily funds C_{131}, Reserve funds C_{132}, Training funds C_{133}, Scientific research funds C_{134}
	Material reserves C_{14}	Specification scale C_{141}, Purchasing management C_{142}, Design and production C_{143}, Maintenance C_{144},Patrol inspection C_{145}
	Training and development C_{15}	Individual training C_{151}, Team training C_{152}, Development system C_{153}
	Technological innovation C_{16}	Scientific research consciousness C_{161}, Innovation ability C_{162}, Research ability C_{163}, Implementation of rectification C_{164}
Organizational response competency C_2	Information acquisition C_{21}	Channel construction C_{211}, Daily monitoring C_{212}, Special patrol C_{213}
	Early warning preparation C_{22}	Grading system C_{221}, Management responsibilities C_{222}, Management mechanism C_{223}
	Task conversion C_{23}	Task identification C_{231}, Team formation C_{232}, Material allocation C_{233}, Loading efficiency C_{234}
	Fast delivery C_{24}	Route planning C_{241}, Quick configuration C_{242}, Aid acquisition C_{243}
	Parallel processing C_{25}	Route strain C_{251}, Scheme deduction C_{252}, Remote consultation C_{253}
Organizational execution competency C_3	Professional technology C_{31}	Plan implementation C_{311}, Quick coaching C_{312}, Safe operation C_{313}, Man-machine cooperation C_{314}, On-site warning C_{315}, Operation guarantee C_{316}, Danger prediction C_{317}
	Organizational motivation C_{32}	Emotion management C_{321}, Team motivation C_{322}
	Command and coordination C_{33}	Resource allocation C_{331}, Decision-making advice C_{332}, Organization and implementation C_{333}
	Comprehensive guarantee C_{34}	Logistic service C_{341}, On-site emergency C_{342}, Publicity ability C_{343}
Organizational recovery competency C_4	Restore order C_{41}	Safe evacuation C_{411}, Functional recovery C_{412}
	Summary and improvement C_{42}	Post assessment C_{421}, Feedback ability C_{422}, Improvement scheme C_{423}

Table A5. The information of experts.

Experts	Professional Title	Educational Background	Scientific Research Achievements	Professional Relevance	Working Time
Expert 1	100	90	90	75	85
Expert 2	90	75	80	80	80
Expert 3	80	80	80	80	90
Expert 4	90	80	80	90	90
Expert 5	80	80	90	90	85
Expert 6	80	90	85	90	90
Expert 7	75	80	85	90	85

Table A6. Competency assessment indicators' relative importance assessment rules.

Digital Scale	Definition
1	The vertical indicator is as important as the horizontal indicator
3	The vertical indicator is slightly more important than the horizontal indicator
5	The vertical indicator is obviously more important than the horizontal indicator
7	The vertical indicator is more important than the horizontal indicator
9	The vertical indicator is extremely more important than the horizontal indicator
2, 4, 6, 8	Intermediate case of the above adjacent judgment
1/9-1	If the ratio of indicator A_i to indicator A_j is a_{ij}, the ratio of indicator A_j to indicator A_i is $1/a_{ij}$.

Table A7. Judgment matrix model.

Indicators	F_1	F_2	F_3	...	F_n
F_1	1	a_{12}	a_{13}	...	a_{1n}
F_2	a_{21}	1	a_{23}	...	a_{2n}
F_3	a_{31}	a_{32}	1	...	a_{3n}
...	...	...	...	...	...
F_n	a_{n1}	a_{n2}	a_{n3}	...	1

Table A8. Judgment matrices and weights of first-level assessment indicators.

First-Level Indicators C_i	First-Level Indicators				CR	Weights
	C_1	C_2	C_3	C_4		
Organizational readiness competency C_1	1	1/2	1/2	1/3	0.01	0.43
Organizational response competency C_2	2	1	1	1		0.20
Organizational execution competency C_3	2	1	1	1		0.20
Organizational recovery competency C_4	3	1	1	1		0.17

Table A9. Judgment matrices and weights of second-level assessment indicators.

Second-Level Indicators C_{ij}	Second-Level Indicators						CR	Weights
	C_{i1}	C_{i2}	C_{i3}	C_{i4}	C_{i5}	C_{i6}		
Plan early warning C_{11}	1	3	1/3	1	1	1/5	0.03	0.15
Team building C_{12}	1/3	1	1/7	1/5	1/5	1/9		0.49
Financial sec urity C_{13}	3	7	1	3	3	1/3		0.06
Material reserves C_{14}	1	5	1/3	1	1	1/5		0.13
Training and development C_{15}	1	5	1/3	1	1	1/5		0.13
Technological innovation C_{16}	5	9	3	5	5	1		0.04
Information acquisition C_{21}	1	5	3	1	5		0.03	0.07
Early warning preparation C_{22}	1/5	1	1/3	1/5	1			0.36
Task conversion C_{23}	1/3	3	1	1/3	3			0.16
Fast delivery C_{24}	1	5	3	1	3			0.07
Parallel processing C_{25}	1/5	1	1/3	1/3	1			0.34

Table A9. *Cont.*

Second-Level Indicators C_{ij}	Second-Level Indicators						CR	Weights
	C_{i1}	C_{i2}	C_{i3}	C_{i4}	C_{i5}	C_{i6}		
Professional technology C_{31}	1	1/5	1/9	1/7			0.06	0.66
Organizational motivation C_{32}	5	1	1/5	1/3				0.20
Command and coordination C_{33}	9	5	1	3				0.05
Comprehensive guarantee C_{34}	7	3	1/3	1				0.09
Restore order C_{41}	1	7					0.00	0.13
Summary and improvement C_{42}	1/7	1						0.87

Table A10. Judgment matrices and weights of third-level assessment indicators.

Third-Level Indicators C_{ijl}	Third-Level Indicators							CR	Weights
	C_{ij1}	C_{ij2}	C_{ij3}	C_{ij4}	C_{ij5}	C_{ij6}	C_{ij7}		
Completeness C_{111}	1	5	7					0.06	0.07
Operability C_{112}	1/5	1	3						0.28
Scientificalness C_{113}	1/7	1/3	1						0.65
Job qualifications C_{121}	1	1/3	3	1/5	3			0.08	0.14
Staff number C_{122}	3	1	9	1/3	5				0.06
Emergency rescue experience C_{123}	1/3	1/9	1	1/9	1/5				0.54
Cooperation ability C_{124}	5	3	9	1	7				0.03
Professional level C_{125}	1/3	1/5	5	1/7	1				0.23
Daily funds C_{131}	1	6	1	1/3				0.07	0.14
Reserve funds C_{132}	1/6	1	1/7	1/6					0.67
Training funds C_{133}	1	7	1	1/3					0.13
Scientific research funds C_{134}	3	6	3	1					0.06
Specification scale C_{141}	1	1/4	1/3	3	1/3			0.09	0.24
Purchasing management C_{142}	4	1	1/3	5	3				0.08
Design and production C_{143}	3	3	1	5	3				0.06
Maintenance C_{144}	1/3	1/5	1/5	1	1/5				0.48
Patrol inspection C_{145}	3	1/3	1/3	5	1				0.14
Individual training C_{151}	1	1/3	3					0.04	0.26
Team training C_{152}	3	1	5						0.11
Development system C_{153}	1/3	1/5	1						0.63
Scientific research consciousness C_{161}	1	1/3	1/5	1				0.01	0.41
Innovation ability C_{162}	3	1	1	3					0.12
Research ability C_{163}	5	1	1	3					0.11
Implementation of rectification C_{164}	1	1/3	1/3	1					0.36
Channel construction C_{211}	1	1/3	1					0.00	0.43
Daily monitoring C_{212}	3	1	3						0.14
Special patrol C_{213}	1	1/3	1						0.43
Grading system C_{221}	1	3	1					0.00	0.20
Management responsibilities C_{222}	1/3	1	1/3						0.60
Management mechanism C_{223}	1	3	1						0.20
Task identification C_{231}	1	1/3	1	1/5				0.02	0.39
Team formation C_{232}	3	1	3	1/3					0.15
Material allocation C_{233}	1	1/3	1	1/5					0.39
Loading efficiency C_{234}	5	3	5	1					0.07
Route planning C_{241}	1	3	1/3					0.04	0.26
Quick configuration C_{242}	1/3	1	1/5						0.64
Aid acquisition C_{243}	3	5	1						0.10

Table A10. *Cont.*

Third-Level Indicators C_{ijl}	Third-Level Indicators							CR	Weights
	C_{ij1}	C_{ij2}	C_{ij3}	C_{ij4}	C_{ij5}	C_{ij6}	C_{ij7}		
Route strain C_{251}	1	7	5					0.06	0.07
Scheme deduction C_{252}	1/7	1	1/3						0.65
Remote consultation C_{253}	1/5	3	1						0.28
Plan implementation C_{311}	1	1/5	3	5	1/7	1/3	1/3	0.06	0.16
Quick coaching C_{312}	5	1	5	7	1/3	1	3		0.05
Safe operation C_{313}	1/3	1/5	1	1	1/5	1/3	1/3		0.25
Man-machine Coordination C_{314}	1/5	1/7	1	1	1/9	1/5	1/5		0.36
On-site warning C_{315}	7	3	5	9	1	3	5		0.03
Operation guarantee C_{316}	3	1	3	5	1/3	1	1		0.07
Danger prediction C_{317}	3	1/3	3	5	1/5	1	1		0.08
Emotion management C_{321}	1	1/3						0.00	0.75
Team motivation C_{322}	3	1							0.25
Resource allocation C_{331}	1	1	1/5					0.00	0.46
Decision-making advice C_{332}	1	1	1/5						0.46
Organization and Implementation C_{333}	5	5	1						0.08
Logistic service C_{341}	1	1/3	1/5					0.04	0.64
On-site emergency C_{342}	3	1	1/3						0.26
Publicity ability C_{343}	5	3	1						0.10
Safe evacuation C_{411}	1	1/5						0.00	0.83
Functional recovery C_{412}	5	1							0.17
Post assessment C_{421}	1	1/5	1/3					0.04	0.64
Feedback ability C_{422}	5	1	3						0.11
Improvement scheme C_{423}	3	1/3	1						0.25

Table A11. Weights of competency assessment indicators of the full-time emergency rescue team.

Weights of Second-Level Indicators W_{ij}	Weights of Third-Level Indicators W_{ijl}
$W_{1j} = [0.19 \quad 0.22 \quad 0.11 \quad 0.21 \quad 0.15 \quad 0.12]$	$W_{11l} = [0.34 \quad 0.23 \quad 0.43]$ $W_{12l} = [0.19 \quad 0.16 \quad 0.30 \quad 0.12 \quad 0.23]$ $W_{13l} = [0.31 \quad 0.22 \quad 0.20 \quad 0.27]$ $W_{14l} = [0.22 \quad 0.12 \quad 0.24 \quad 0.23 \quad 0.19]$ $W_{15l} = [0.33 \quad 0.21 \quad 0.46]$ $W_{16l} = [0.39 \quad 0.17 \quad 0.18 \quad 0.26]$
$W_{2j} = [0.09 \quad 0.36 \quad 0.19 \quad 0.14 \quad 0.22]$	$W_{21l} = [0.39 \quad 0.24 \quad 0.37]$ $W_{22l} = [0.35 \quad 0.32 \quad 0.33]$ $W_{23l} = [0.18 \quad 0.18 \quad 0.43 \quad 0.21]$ $W_{24l} = [0.41 \quad 0.33 \quad 0.26]$ $W_{25l} = [0.29 \quad 0.39 \quad 0.32]$
$W_{3j} = [0.38 \quad 0.27 \quad 0.17 \quad 0.18]$	$W_{31l} = [0.19 \quad 0.14 \quad 0.20 \quad 0.12 \quad 0.09 \quad 0.14 \quad 0.12]$ $W_{32l} = [0.65 \quad 0.35]$ $W_{33l} = [0.47 \quad 0.25 \quad 0.28]$ $W_{34l} = [0.33 \quad 0.32 \quad 0.35]$
$W_{4j} = [0.39 \quad 0.61]$	$W_{41l} = [0.69 \quad 0.31]$ $W_{42l} = [0.47 \quad 0.18 \quad 0.35]$

Table A12. Assessment information matrixes of third-level indicators.

Third-Level Indicators C_{ijl}	Assessment Information					Membership Degrees					Assessment Grades
	I	II	III	IV	V	I	II	III	IV	V	
Completeness C_{111}	0	0	0	2	5	0.00	0.00	0.00	0.29	0.71	Level V
Operability C_{112}	0	0	0	6	1	0.00	0.00	0.00	0.86	0.14	Level IV
Scientificalness C_{113}	0	0	1	5	1	0.00	0.00	0.14	0.72	0.14	Level IV
Job qualifications C_{121}	0	2	4	1	0	0.00	0.29	0.57	0.14	0.00	Level III
Staff number C_{122}	0	0	1	6	0	0.00	0.00	0.14	0.86	0.00	Level IV
Emergency rescue experience C_{123}	0	0	0	3	4	0.00	0.00	0.00	0.43	0.57	Level V
Cooperation ability C_{124}	0	0	1	5	1	0.00	0.00	0.14	0.72	0.14	Level IV
Professional level C_{125}	0	0	0	2	5	0.00	0.00	0.00	0.29	0.71	Level V
Daily funds C_{131}	0	0	1	1	5	0.00	0.00	0.14	0.14	0.72	Level V
Reserve funds C_{132}	0	0	1	5	1	0.00	0.00	0.14	0.72	0.14	Level IV
Training funds C_{133}	0	0	2	5	0	0.00	0.00	0.29	0.71	0.00	Level IV
Scientific research funds C_{134}	1	1	5	0	0	0.14	0.14	0.72	0.00	0.00	Level III
Specification scale C_{141}	0	0	0	1	6	0.00	0.00	0.00	0.14	0.86	Level V
Purchasing management C_{142}	0	0	0	6	1	0.00	0.00	0.00	0.86	0.14	Level IV
Design and production C_{143}	0	0	2	2	3	0.00	0.00	0.29	0.29	0.42	Level V
Maintenance C_{144}	0	0	0	2	5	0.00	0.00	0.00	0.29	0.71	Level V
Patrol inspection C_{145}	0	0	1	1	5	0.00	0.00	0.14	0.14	0.72	Level V
Individual training C_{151}	0	0	1	5	1	0.00	0.00	0.14	0.72	0.14	Level IV
Team training C_{152}	0	0	1	6	0	0.00	0.00	0.14	0.86	0.00	Level IV
Development system C_{153}	0	0	2	5	0	0.00	0.00	0.29	0.71	0.00	Level IV
Scientific research consciousness C_{161}	0	1	2	4	0	0.00	0.14	0.29	0.57	0.00	Level IV
Innovation ability C_{162}	0	0	1	6	0	0.00	0.00	0.14	0.86	0.00	Level IV
Research ability C_{163}	0	0	2	5	0	0.00	0.00	0.29	0.71	0.00	Level IV
Implementation of rectification C_{164}	0	0	1	6	0	0.00	0.00	0.14	0.86	0.00	Level IV
Channel construction C_{211}	0	2	4	1	0	0.00	0.29	0.57	0.14	0.00	Level III
Daily monitoring C_{212}	0	0	1	6	0	0.00	0.00	0.14	0.86	0.00	Level IV
Special patrol C_{213}	1	5	1	0	0	0.14	0.72	0.14	0.00	0.00	Level II
Grading system C_{221}	0	0	1	6	0	0.00	0.00	0.14	0.86	0.00	Level IV
Management responsibilities C_{222}	0	0	2	5	0	0.00	0.00	0.29	0.71	0.00	Level IV
Management mechanism C_{223}	0	0	2	1	4	0.00	0.00	0.29	0.14	0.57	Level V
Task identification C_{231}	0	0	1	1	5	0.00	0.00	0.14	0.14	0.72	Level V
Team formation C_{232}	0	0	2	1	4	0.00	0.00	0.29	0.14	0.57	Level V
Material allocation C_{233}	0	0	2	2	3	0.00	0.00	0.29	0.29	0.42	level IV
Loading efficiency C_{234}	0	0	1	1	5	0.00	0.00	0.14	0.14	0.72	Level V
Route planning C_{241}	0	0	1	1	5	0.00	0.00	0.14	0.14	0.72	Level V
Quick configuration C_{242}	0	0	1	0	6	0.00	0.00	0.14	0.00	0.86	Level V
Aid acquisition C_{243}	0	1	4	2	0	0.00	0.14	0.57	0.29	0.00	Level III
Route strain C_{251}	0	1	1	5	0	0.00	0.14	0.14	0.72	0.00	Level IV
Scheme deduction C_{252}	0	1	2	4	0	0.00	0.14	0.29	0.57	0.00	Level IV
Remote consultation C_{253}	0	1	1	5	0	0.00	0.14	0.14	0.72	0.00	Level IV
Plan implementation C_{311}	0	0	0	2	5	0.00	0.00	0.00	0.29	0.71	Level V
Quick coaching C_{312}	0	1	2	4	0	0.00	0.14	0.29	0.57	0.00	Level IV
Safe operation C_{313}	0	1	5	1	0	0.00	0.14	0.72	0.14	0.00	Level III
Man-machine Coordination C_{314}	0	0	1	1	5	0.00	0.00	0.14	0.14	0.72	Level V
On-site warning C_{315}	0	2	4	1	0	0.00	0.29	0.57	0.14	0.00	Level III
Operation guarantee C_{316}	0	0	0	5	2	0.00	0.00	0.00	0.71	0.29	Level IV
Danger prediction C_{317}	0	1	1	5	0	0.00	0.14	0.14	0.72	0.00	Level IV

Table A12. *Cont.*

Third-Level Indicators C_{ijl}	Assessment Information					Membership Degrees					Assessment Grades
	I	II	III	IV	V	I	II	III	IV	V	
Emotion management C_{321}	0	1	2	4	0	0.00	0.14	0.29	0.57	0.00	Level IV
Team motivation C_{322}	0	1	2	3	1	0.00	0.14	0.29	0.43	0.14	Level IV
Resource allocation C_{331}	0	0	2	5	0	0.00	0.00	0.29	0.71	0.00	Level IV
Decision-making advice C_{332}	0	0	0	2	5	0.00	0.00	0.00	0.29	0.71	Level V
Organization and Implementation C_{333}	0	0	1	6	0	0.00	0.00	0.14	0.86	0.00	Level IV
Logistic service C_{341}	0	0	2	4	1	0.00	0.00	0.29	0.57	0.14	Level IV
On-site emergency C_{342}	0	0	2	5	0	0.00	0.00	0.29	0.71	0.00	Level IV
Publicity ability C_{343}	0	1	6	0	0	0.00	0.14	0.86	0.00	0.00	Level III
Safe evacuation C_{411}	0	0	0	1	6	0.00	0.00	0.00	0.14	0.86	Level V
Functional recovery C_{412}	0	0	0	1	6	0.00	0.00	0.00	0.14	0.86	Level V
Post assessment C_{421}	0	0	0	2	5	0.00	0.00	0.00	0.29	0.71	Level V
Feedback ability C_{422}	0	2	5	0	0	0.00	0.29	0.71	0.00	0.00	Level III
Improvement scheme C_{423}	0	1	1	5	0	0.00	0.14	0.14	0.72	0.00	Level IV

Table A13. Assessment information matrixes of second-level indicators.

Second-Level Indicators C_{ij}	Membership Degrees					Assessment Grades
	Level I	Level II	Level III	Level IV	Level V	
Plan early warning C_{11}	0.00	0.00	0.06	0.60	0.34	Level IV
Team building C_{12}	0.00	0.06	0.15	0.44	0.35	Level IV
Financial security C_{13}	0.04	0.04	0.33	0.34	0.25	Level IV
Material reserves C_{14}	0.00	0.00	0.10	0.30	0.60	Level V
Training and development C_{15}	0.00	0.00	0.21	0.74	0.05	Level IV
Technological innovation C_{16}	0.00	0.05	0.23	0.72	0.00	Level IV
Information acquisition C_{21}	0.05	0.38	0.31	0.26	0.00	Level II
Early warning preparation C_{22}	0.00	0.00	0.24	0.57	0.19	Level IV
Task conversion C_{23}	0.00	0.00	0.23	0.21	0.56	Level V
Fast delivery C_{24}	0.00	0.04	0.26	0.13	0.57	Level V
Parallel processing C_{25}	0.00	0.14	0.20	0.66	0.00	Level IV
Professional technology C_{31}	0.00	0.09	0.27	0.38	0.26	Level IV
Organizational motivation C_{32}	0.00	0.14	0.29	0.52	0.05	Level IV
Command and coordination C_{33}	0.00	0.00	0.17	0.65	0.18	Level IV
Comprehensive guarantee C_{34}	0.00	0.05	0.48	0.42	0.05	Level III
Restore order C_{41}	0.00	0.00	0.00	0.14	0.86	Level V
Summary and improvement C_{42}	0.00	0.10	0.18	0.38	0.34	Level IV

Table A14. Assessment information matrixes of first-level indicators.

First-Level Indicators C_i	Membership Degrees					Assessment Grades
	Level I	Level II	Level III	Level IV	Level V	
Organizational readiness competency C_1	0.00	0.03	0.16	0.51	0.30	Level IV
Organizational response competency C_2	0.00	0.07	0.24	0.43	0.26	Level IV
Organizational execution competency C_3	0.00	0.08	0.30	0.47	0.15	Level IV
Organizational recovery competency C_4	0.00	0.06	0.11	0.29	0.54	Level V

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