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Hierarchical Analysis Model and Application for Risk Assessment of Construction Contractors for High-Altitude Camp Facilities

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Abstract The risk assessment of the camp facilities agency in the highland alpine area is a complex systematic project, and its specificity lies in the superimposed effect of the extreme natural environment and complex management needs. For this reason, this study proposes to combine the fuzzy hierarchical analysis method FAHP with the risk identification technology to construct a risk assessment model applicable to this region. Four core risks and 12 sub-risks, including natural environment, logistics, personnel health and technology management, were systematically identified through brainstorming, and the weights of each index were quantified based on FAHP. The experimental results show that the logistic support risk with a weight of 0.334, and the natural environment risk with a weight of 0.262 are the core challenges, of which the material transportation disruption C4 with a weight of 0.124, the extreme climate impact C1 with a weight of 0.163 and the plateau reaction health problem C7 with a weight of 0.071 are the key sub-risks. The fuzzy comprehensive evaluation further indicated that C7, C8 low-temperature exposure health problems and C11 insufficient equipment adaptability have the highest risk level and need to be prioritized for prevention and control. The point degree centrality analysis reveals the strong conductivity of nodes such as C4 and C7, which validates the dynamic risk network characteristics of the model.

Index Terms fuzzy hierarchical analysis, plateau alpine region, barracks facilities generation, risk assessment

I. Introduction

As an important part of the military logistics support, the infrastructure barracks support in the plateau alpine area has a very special position [1], [2]. Plateau alpine area infrastructure barracks security, not only for the garrison officers and soldiers to provide a good environment, but also to maintain military deterrence and attempt combat operations to create the prerequisites, so the plateau alpine area barracks facilities on behalf of the unit risk assessment for the barracks safety and reliability is of great significance [3]-[6].

Plateau alpine region barracks facilities on behalf of the construction is entrusted to professional construction companies or organizations to complete the enterprise should originally undertake the construction project on their own, although the construction project on behalf of the project to a certain extent can reduce the burden, but there is also a certain quality risk [7]-[10]. Therefore, the risk assessment of barracks facilities on behalf of the construction unit is not only a risk assessment of the barracks where the army is stationed, but also a risk assessment process of the capital, technical level, credit, supervision and management of the construction unit on behalf of the construction unit [11]-[13]. The assessment aims to identify and evaluate potential safety risks and take appropriate measures to reduce or eliminate these risks [14], [15]. The assessment mainly covers building safety, equipment safety, fire safety, and personnel safety [16]. At the end of the assessment, appropriate safety improvement measures and emergency response plans are developed based on the assessment results [17]. This may include strengthening the structural stability of the building, repairing or replacing damaged equipment, providing necessary emergency evacuation training, and enhancing the deployment of security forces [18], [19]. Regular security patrols and maintenance are also required to ensure continuous control and management of security risks [20].

The study proposes to combine the fuzzy hierarchical analysis method FAHP with the risk identification technique to construct a risk assessment model for the barracks facilities construction unit applicable to the highland alpine region. Firstly, the four core risks (natural environment, logistic support, personnel health, and technical management) and 12 sub-risks that may be faced by the agency construction unit in the extreme environment are systematically identified through the brainstorming method. On this basis, the recursive hierarchical structure and two-by-two comparison mechanism of the Analytic Hierarchy Process (AHP) are introduced, and the logical framework of the traditional AHP is systematically elaborated from the construction of the recursive hierarchical model, the construction of the comparison matrix to the computation of the weight vector and the consistency test. Combined with the fuzzy mathematical theory, a fuzzy complementary judgment matrix is constructed. The logical framework of traditional AHP is systematically elaborated from the construction of hierarchical model, the construction of comparison matrix to the calculation of weight vector and consistency test. Effectively solve the contradiction between subjectivity and uncertainty of expert judgment.

II. Construction of a risk assessment model for the construction unit of barracks facilities in highland and alpine regions

II. A. Risk identification

Risk identification is the first content of the risk management research of highland alpine area camp facilities on behalf of the construction unit, the relevant management techniques and tools used mainly include checklists, pre-analysis, flow charts, brainstorming, situational analysis, Delphi method, SWOT analysis, etc. This paper intends to use the brainstorming method to carry out on behalf of the construction unit of the current implementation of the highland alpine area camp facilities on behalf of the implementation of the unit's risks Identification.

(1) Select the participating facility units. Participants in the brainstorming meeting are led by the agency construction unit, mainly selected from the following departments: plateau region camp construction project management, climate and geological research institutions, medical and plateau health protection team, material transportation and logistical support departments, agency construction unit expert pool and representatives of construction contractors and equipment suppliers. The facilitator should have experience in plateau project management, be familiar with coordination in extreme environments, and have strong adaptability and cross-departmental communication skills.

(2) Define the topics for the brainstorming meeting. At least one week in advance to inform the participants of the topic, the topic is: “plateau alpine region barracks facilities on behalf of the construction process, on behalf of the construction unit to face what unique risk factors?”

(3) Clarify the rules of speech. After the start of the meeting, the moderator declared the rules of speech: all participants (regardless of position, unit) equal speech; take turns to put forward the views, prohibited to comment on other people's views; allowed to skip the speech, but need to participate in the whole discussion; the meeting was recorded throughout the whole meeting, and the establishment of a full-time record keeper to organize the risk list.

(4) Summarize. Take turns to speak until everyone has no opinions to put forward, at which time everyone will jointly comment on the recorded opinions, and the moderator will summarize the important conclusions.

(5) Through the meeting, four types of core risks and 12 sub-risks were screened, as follows: the core risk factors of the construction of barracks facilities in the plateau and cold areas were identified, and all the risks faced by the construction agency in each link of the implementation of the construction agency in extreme environments were clarified, and the analysis was made from four aspects: natural environment, logistics support, personnel health, and technical management: natural environment risks include 1. Construction interruption caused by extreme climate (such as snowstorm and low temperature frost damage); 2. The performance of mechanical equipment is attenuated by the lack of oxygen in the plateau environment; 3. Complex geological conditions (permafrost, landslides) increase the difficulty of the project. Logistical support risks include 4. Frequent interruptions of material transportation routes due to climatic influences; 5. Unstable energy supply in plateau areas (e.g. shortage of electricity and fuel); 6. Insufficient emergency medical resources and poor timeliness of rescue response. Personnel health risks include 7. Health problems of construction personnel caused by plateau reaction; 8. Frostbite and chronic diseases caused by long-term low-temperature exposure; 9. High psychological pressure and reduced team stability. Technical management risks include 10. Unclear technical standards for construction in special environments; 11. Inadequate adaptation of equipment to the plateau and increased failure rate; 12. Low efficiency of cross-departmental collaboration and lagging information transfer. Plateau alpine region barracks facilities on behalf of the construction unit risk classification specific as shown in Table 1.

II. B. AHP (hierarchical analysis) basic steps, methods

After clarifying the four types of core risks and sub-risks of barracks facilities construction units in highland alpine areas, how to scientifically quantify the relative importance of each risk indicator becomes a key issue. To this end, this section introduces the hierarchical analysis method (AHP), which decomposes the complex risk system into quantifiable and analyzable hierarchical models by means of a recursive hierarchical structure and a two-by-two comparison mechanism.

Table 1: Risk classification of construction agency units for barracks facilities

Risk level	Class I risk	Class II risk
A:Risks of construction agency units for barracks facilities in plateau and cold regions	B1:Natural environment risk	C1: Impact of extreme climate
		C2: Performance degradation of the equipment at high altitudes
		C3: Construction difficulty of permafrost layer
	B2:Logistics support risk	C4: Disruption of material transportation
		C5: Unstable energy supply
		C6: Insufficient medical rescue capacity
	B3:Personnel health risk	C7: Health risks of altitude sickness
		C8: Health risks of low-temperature exposure
		C9: The psychological stability of the team has declined
	B4:Technical management risk	C10: Construction technical standards are missing
		C11: Insufficient adaptability of the equipment
		C12: Low efficiency in cross-departmental collaboration

Based on the objectives and the nature of the problem, the method is developed with the idea of prioritizing decomposition followed by synthesis, disassembling the complex problem at different levels and with different elements, and then constructing a hierarchical hierarchy based on the relationship of the interacting elements, where the dominant roles are manifested through the progression of the higher and lower levels, and the two-by-two comparison is used to calculate the relative weights of any layer. The relative importance of the lowest level program to the overall goal is ranked through the recursive relationship between the levels. Thus, the strength of practicality, logic, and systematicity is reflected. Figure 1 shows the basic steps of the hierarchical analysis method (AHP).

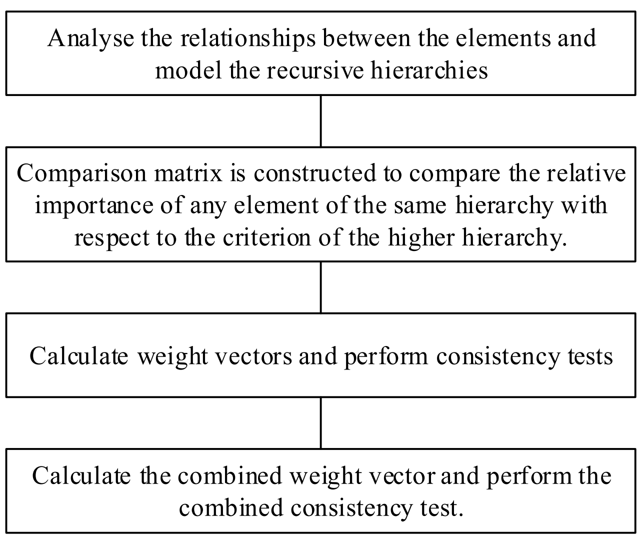

Figure 1: The basic steps of AHP

II. B. 1) Modeling of recursive hierarchies

The creation of a hierarchical model is the first challenge in the use of hierarchical analysis. Top-to-bottom dominance relationships form this structure and hierarchize and systematize the dilemma to form a multilevel analytical model. Multiple elements are disassembled through the problem and then hierarchized according to the differences in attributes. Elements at the same level are both dominant and subject to domination, except that the former is the element underneath it and the latter is the criterion for the level above it. Based on this, the hierarchy can be divided as follows:

(1) Goal level

This is the highest level. This layer has only one element, which is usually positioned as a predetermined goal or the purpose of solving a problem.

(2) Guideline level

i.e., the intermediate level. This layer incorporates all the intermediate links involved in the goal, and may contain guidelines and sub-criteria, constituting a number of levels;

(3) Program level

This is the lowest level. To ensure that the goal can be achieved, and may take measures, programs, decision-making, etc. AHP (hierarchical analysis) of the hierarchical structure from the top to the bottom of the dominant relationship exists, and the entire hierarchical structure of the number of levels is not limited, the number of levels depends on the system analysis itself. Usually, there is and only one highest level element, the bottom, intermediate level elements of the upper limit of 9, if there are too many elements, can be layered again.

The hierarchical analysis method recursive hierarchy model shown in Figure 2 is more typical:

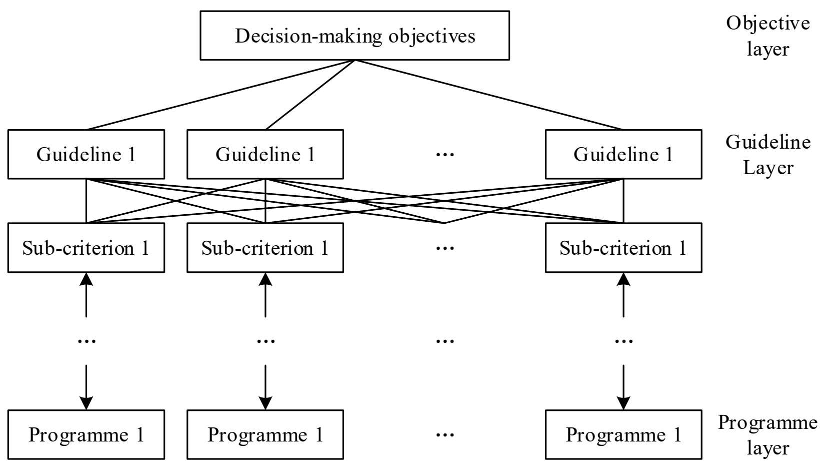

Figure 2: The Analytic Hierarchy Process (AHP) is a hierarchical structure model

The hierarchical model is formed by specifying the contents of each level, and then connecting each level to make it a whole. In order to prevent the method of comparing and analyzing each other from becoming too complicated and difficult, the maximum number of elements that can be managed by each element in each level is set to be 9, otherwise it should be divided into several sub-levels.

II. B. 2) Constructing the comparison matrix

Establishing a recursive hierarchy is tantamount to determining the subordination of elements between the upper and lower levels. An element of the upper level is designated as a criterion, and its subordinate elements are $u_1, u_2, \cdots, u_n$, and then the weights of these elements are assigned according to the relative importance of these elements to a criterion. If the importance of a criterion can be expressed quantitatively, the corresponding weights of the elements can be determined directly.

When the system problem is too complex, it is not possible to obtain the weights of the elements directly, but only with the help of suitable methods to derive their weights. The two-by-two comparison method is the method used.

When obtaining the importance of an element, it is most appropriate to present the quantitative mutual weights of a_{ij} for the j factor and the i factor corresponding to each other in the upper level. Assuming that there are a total of n factors participating in the comparison, $A = (a_{ij})_{n\times n}$ is the so-called judgment matrix.

$$A = \begin{pmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \cdots & \cdots & 1 & \cdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{pmatrix} \quad (1)$$

In this paper, the values of a_{ij} in the judgment matrix are assigned on the following scale, i.e., a_{ij} takes values in the middle of 1-9 and its reciprocal.

$a_{ij}=1$, element i and element j have the same importance to the elements of the previous level;
$a_{ij}=3$, element i is slightly more important than element j;
$a_{ij}=5$, element i is more important than element j;
$a_{ij}=7$, element i is much more important than element j;
$a_{ij}=9$, element i is extremely more important than element j;
$a_{ij}=2n$, $n=1,2,3,4$, elements i and j are between $a_{ij}=2n-1$ and $a_{ij}=2n+1$ in importance;
$a_{ij}=1/n$, $n=1,2,\ldots,9$ if and only if $a_{ji}=n$.
Clearly the judgment matrix has the following properties:
$aij>0$, $aij=1$, $aij=1/aij$, where: $aij=1$ when $i=j$.
This judgment matrix can be made into a positive inverse matrix.
Based on its properties, if n elements exist in this judgment matrix, it is sufficient to give $n(n-1)/2$ a copy of the upper (or lower) triangle.

II. B. 3) Calculate the weight vector and do the consistency test

The judgment matrix A contains n elements $u_1,u_2,\cdots,u_n$, $w_1,w_2,\cdots,w_n$ denote their relative weights for a given criterion and can be represented by a vector formula as $w=\left(w_1,w_2,\cdots w_n\right)^T$.

Whether it is the complexity of objective things or the diversity of personal understandings, it affects the consistency of single-criterion sorting vectors, resulting in the possibility of logical errors such as "A is more important than B, B is more important than C, and C is more important than A", so we need to test them in our calculations. The reasonableness of the analysis is determined by performing a general consistency test on the judgment matrix. The specific steps are as follows:

(1) Calculate the consistency indicator CI.

First calculate the geometric mean $\overline{w_i}$ of all elements in each row of the judgment matrix A (using the geometric mean method to calculate the weights)

$$\overline{w_i}=\sqrt[n]{\prod_{j=1}^{n}x_{ij}} \tag{2}$$

Then calculate w_i

$$w_i=\frac{\overline{w_i}}{\sum_{i=1}^{n}\overline{w_i}} \tag{3}$$

Then compute the largest eigenvalue $\lambda_{\max}$ of A

$$\lambda_{\max}=\sum_{i=1}^{n}\frac{(Xw_i)}{nw_i} \tag{4}$$

Finalization of the calculation of the consistency indicator CI

$$CI=\frac{\lambda_{\max}(A)-n}{n-1} \tag{5}$$

where $\lambda_{\max}$ is the largest eigenvalue of the judgment matrix A and n is the order of the judgment matrix A.
With $CI=0$, there is perfect consistency;
If CI converges to 0 infinitely, the stronger the satisfactory consistency;
If CI is larger, the more severe the satisfactory inconsistency.

(2) Explore the average random consistency index RI of the control: this can be understood by using the average random consistency index RI in Table 2.

Table 2: Mean random Consistency Index RI

Order	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.12	1.26	2.36	1.41	1.46

(3) Accurately calculate the stochastic consistency ratio CR of judgment matrix A

$$CR = \frac{CI}{RI} \tag{6}$$

If $CR < 0.1$, the degree of inconsistency of this judgment matrix is included within the tolerance, indicating that the consistency testing process this matrix meets the requirements; if $CR > 0.1$, the judgment matrix needs to be reconstructed to adjust a_{ij}.

II. B. 4) Calculate portfolio weight vector and do portfolio consistency test

The so-called hierarchical total ranking is the process of ranking the weights of any factor at a given level against the relative criticality of the overall factors at the previous level. This process is done layer by layer from the topmost to the bottom. Since the top level is the overall goal, the calculation of the relative importance of all elements at a given level relative to the overall goal also relies on the hierarchical general ordering. The methodology is as follows:

Suppose that $a_1, a_2, \cdots, a_m$ totaling m elements are in level A and $w_{a1}, w_{a2}, \cdots, w_{am}$ are the weights of their hierarchical total rankings, while $b_1, b_2, \cdots, b_n$ and other n factors in the next level B, their hierarchical single ordering weights for $a_j \left(j = 1, 2, \cdots, m \right)$ are $w_{b1j}, w_{b2j}, \cdots, w_{bnj}$, and the B hierarchical total ordering weights can be computed in accordance with Table.

Similarly the consistency of the final result of the test has to be judged on the acceptability of its overall consistency.

II. C. Fuzzy Hierarchy Analysis (FAHP)

Although the traditional AHP provides a systematic framework for weight assignment, its dependence on precise scaling is difficult to adapt to the ambiguity of risk factors and the uncertainty of expert judgment in highland alpine regions. Therefore, this section further proposes the fuzzy hierarchical analysis method (FAHP) to optimize the weight calculation process and enhance the fault tolerance and applicability of the model through the fuzzy complementary judgment matrix and consistency transformation.

The process of fuzzy hierarchical analysis is as follows

(1) Construct a hierarchical model. Decompose the top-level objectives into layers, combine the evaluation indicators with the actual situation of the research object and decompose each level of indicators into a number of sub-indicators, and ultimately form a progressive evaluation indicator system from the lowest level of research indicators to the research objective layer by layer.

(2) Construction of fuzzy judgment matrix. The core of fuzzy judgment matrix construction is to compare the indicators of each level two by two in accordance with the expert opinion, and to reflect the relationship between the indicators of each level two by two through the fuzzy matrix. If the fuzzy judgment matrix A satisfies two basic conditions: $a_{ij} = 0.5$, $a_{ij} + a_{ji} = 1$, then A is called fuzzy complementary judgment matrix. In making comparisons of indicators, a scale of 0.1-0.9 adapted to the construction of additive consistent complementary judgment matrices is used, and the scaling method is shown in Table 3.

The weight coefficient $a_{ij} = 0.5$ indicates that in the fuzzy complementary matrix, factor i is of the same importance as itself in comparison; $a_{ij} > 0.5$ indicates that element i is more important than element j, and $a_{ij} < 0.5$ indicates that element j is more important than element i.

Table 3: Fuzzy Analytic Hierarchy Process (FAHP) 0.1-0.9 scale method

Scale	Definition	Explanation
0.5	Factor i is as important as j	The two elements are equally important
0.6	Factor i is slightly more important than j	The row factor i is slightly more important than the column factor j
0.7	Factor i is significantly more important than j	The row factor i is significantly more important than the column factor j
0.8	Factor i is more strongly important than j	The row factor i is strongly more important than the column factor j
0.9	Factor i is extremely important than j	The row factor i is extremely important than the column factor j
0.1	Inverse comparison of factors	If factor i and j are compared to obtain aij, then the judgment obtained by comparing factor j and i is (1-aij)
0.2		
0.3		
0.4		

A fuzzy judgment matrix A can be obtained by comparing the elements of the matrix two by two:

$$A=\begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} \tag{7}$$

(3) Testing the consistency of fuzzy judgment matrix.

Due to the complexity in solving practical problems, it leads to the fact that experts cannot avoid the subjectivity of their own judgments even when they carry out the analysis. Therefore, in order to avoid contradictions in the calculation, it is necessary to test the consistency of the fuzzy judgment matrix A. When there is a deviation that cannot pass the consistency test, it is necessary to make necessary adjustments to the results. The difference of the fuzzy complementary matrix is utilized as a test in the adjustment: if the difference of any two rows in the matrix A is constant, it indicates that the matrix satisfies the consistency condition, if it is not constant then it must be further adjusted until the fuzzy judgment matrix A is transformed into a fuzzy consistency matrix R.

(4) Fuzzy complementary matrix A is converted to fuzzy consistency matrix R.

The elements in the consistency matrix R satisfy $r_{ij}=r_{ik}-r_{jk}+0.5$, noting that $r_i=\sum r_{ik}$, and the fuzzy judgment matrix can be converted to fuzzy consistency matrix by using formula (8).

$$r_{ij}=\frac{r_i-r_j}{2n}+0.5 \tag{8}$$

(5) Fuzzy consistency matrix weight confirmation. Fuzzy hierarchical analysis method relative to the hierarchical analysis method of its weight formula is simple to calculate, and the practical significance is easy to understand.

The weight of element R_i under the superior index is:

$$s_i^k=\frac{1}{n}-\frac{1}{2a}+\frac{\sum_{j=1}^{n} r_{ij}}{na} \tag{9}$$

where $i=1,2,3,\cdots,n$

The value of parameter a ranges from $a\geq\frac{n-1}{2}$, with smaller values indicating that the decision maker attaches more importance to the difference in importance between different elements. The s_i^k denotes the importance of the factor R_i in this layer of objectives, in descending order. From the fuzzy agreement matrix R, the relative weight size of each level can be judged.

(6) Hierarchical total sorting. Layer-by-layer transformation of each indicator layer under the total goal can obtain the comprehensive weight, and finally layer-by-layer multiplication to get the comprehensive ranking of elemental weights, i.e., the size of the weights of each indicator.

III. Comprehensive evaluation of the risk of building units on behalf of barracks facilities in highland and alpine areas

After constructing the risk assessment model through the fuzzy hierarchical analysis method (FAHP), it is necessary to further combine the fuzzy mathematical theory with the actual expert evaluation data to quantitatively analyze and comprehensively evaluate the risk of the barracks facilities construction unit in the highland and alpine areas, so as to clarify the specific weaknesses and put forward targeted improvement measures.

III. A. Research based on fuzzy hierarchical analysis

III. A. 1) Judgment matrix consistency test

In the process of establishing the fuzzy judgment matrix, it is necessary to ensure as much as possible that the consistency of the evaluation information before and after the same expert is within an acceptable range, so that the difference is not too large to affect the final evaluation results, and also to ensure that the consistency of the preferences of different experts is within a certain range. A common method is to participate in the evaluation and scoring experts, compare the judgment matrix constructed by each other, and then constantly discuss the optimization results, under normal circumstances, the judgment matrix constructed by this method is able to maintain good consistency, if necessary, in accordance with this principle can be determined based on the fuzzy number of triangles of the complementary judgment matrix to meet the consistency requirements.

Before the consistency verification of the judgment matrix, it is necessary to summarize the fuzzy judgment information of each evaluator according to the weighting rules of the complementary judgment matrix constructed according to the evaluation results of the five experts, and construct a comprehensive judgment matrix based on triangular fuzzy numbers, and according to the calculation formula of the judgment matrix and the weight proportion, the comprehensive fuzzy judgment matrix MB of the middle layer B1~B4 and the comprehensive fuzzy judgment matrix MB of the middle layer B1~B4 are shown in Table 4.

Table 4: The comprehensive fuzzy judgment matrix of the middle layer B1 to B4

aij	B1	B2	B3	B4
B1	0.5	0.519	0.524	0.611
	0.5	0.530	0.422	0.504
	0.5	0.490	0.522	0.471
B2	0.510	0.5	0.484	0.496
	0.470	0.5	0.548	0.428
	0.481	0.5	0.559	0.667
B3	0.478	0.441	0.5	0.443
	0.578	0.452	0.5	0.566
	0.476	0.516	0.5	0.564
B4	0.529	0.333	0.436	0.5
	0.496	0.572	0.434	0.5
	0.389	0.504	0.557	0.5

Table 4 reflects the experts' fuzzy evaluation of the relative importance of each level of risk category. Each element of the matrix has a value between 0.1 and 0.9, which is in accordance with the scaling rules of the fuzzy hierarchical analysis method FAHP. For example, the comparative value of B1 to itself is 0.5 (equally important), while the value of B1 to B4 is 0.611, which indicates that B1 (natural environment risk) has a certain level of importance in comparison to B4 (technology management risk). It is worth noting that the value of B4 to B2 (logistical security risk) is only 0.333, indicating that technology management risk is considered significantly less important than logistical security risk in the expert assessment. Overall, B2 has higher values in most comparisons (e.g., B2 vs. B3 has a value of 0.667), suggesting that logistical security risk may be perceived as a more central challenge by experts.

The consistency test of the matrix of fuzzy judgment is to calculate the consistency index CI. when CI=0, it indicates that the judgment matrix has complete consistency; when CI is close to 0, it indicates that the judgment matrix has satisfactory consistency; the larger CI is, it indicates that the consistency of the judgment matrix is poorer, and according to Equation (5), it is concluded that the CI about the risk assessment index of the barracks and facilities substitute unit in the high plateau and high alpine area is 0.0823.

Query the corresponding stochastic average synchronization coefficient RI in Table 2: at n=4, RI=0.89.

Substitute RI=0.89 into the formula and account for the consistency ratio CR=0.0925, the value of CR is less than 0.1, which proves that the fuzzy judgment matrix has a satisfactory consistency, i.e., the integrated fuzzy judgment matrix MAB of the middle layer B1~B4 completes the consistency test. By the same token, the consistency test results of the integrated fuzzy judgment matrix of each sublayer of the middle layer are shown in Table 5.

Table 5: Consistency test of comprehensive fuzzy judgment matrices of each sub-layer

M(mij)n×n	λ_{max}	CI	RI	CR	Consistency comparison results	Conclusion
MAB1	2.872	0.0023	1.12	0.0021	<0.1	Satisfactory consistency
MAB2	3.786	0.0435	0.52	0.0837	<0.1	Satisfactory consistency
MAB3	4.057	0.0967	1.26	0.0767	<0.1	Satisfactory consistency
MAB4	3.980	0.0146	0.89	0.0164	<0.1	Satisfactory consistency
MAB	3.284	0.0823	0.89	0.0925	<0.1	Satisfactory consistency

The consistency ratio CR of all judgment matrices is less than 0.1, indicating that they all pass the consistency test and the expert assessment has high logical consistency. Among them, the sublayer matrix MAB3 corresponding to B3 personnel health risk has the highest CI value of 0.0967, which is close to the critical value of 0.1, probably reflecting that there is some disagreement in the experts' judgment of personnel health risk. In addition, the CR =

0.0837 for the B2 sublayer of logistical security risk is within a reasonable range, but its CI value of 0.0435 is higher than that of the other sublayers, suggesting that the judgments at this level need to be further optimized. Overall, the results of the consistency test for each level support the reliability of the model and lay the foundation for subsequent weight calculations.

III. A. 2) Judgment matrix weights

According to the calculation steps of judgment matrix and weights, MB1, MB2, MB3 and MB4 parameters are calculated. The weights of the risk assessment indicators of the camp facilities construction unit in highland and alpine areas are shown in Table 6.

Table 6: The weight of risk assessment indicators for the project management unit

Evaluation index: Class I risk	Weight	Evaluation index: Class II risk	Sub Weight	Total Weight
B1	0.262	C1	0.622	0.163
		C2	0.213	0.056
		C3	0.165	0.043
B2	0.334	C4	0.372	0.124
		C5	0.356	0.119
		C6	0.272	0.091
B3	0.233	C7	0.303	0.071
		C8	0.352	0.082
		C9	0.345	0.080
B4	0.171	C10	0.352	0.060
		C11	0.471	0.081
		C12	0.177	0.030

Among the first-level risks, B2 logistics risk has the highest weight of 0.334, highlighting its criticality in extreme environments, especially C4 material transportation disruption, with a weight of 0.124, and C5 unstable energy supply, with a weight of 0.119, contributing significantly.B1 natural environment risk has a weight of 0.262, with C1 extreme climate impacts, with a weight of 0.163, dominating, indicating that climate is the main trigger of construction disruption.B3 Personnel health risk weight 0.233, with sub-risks C8 Low temperature exposure health problems, weight 0.082 and C7 Plateau reaction, weight 0.071 being more prominent, reflecting the direct impact of prolonged low temperature and oxygen deprivation on the personnel.B4 Technical management risk weight is the lowest, 0.171, but C11 Inadequate equipment adaptation, weight 0.081 is significantly higher than the The weight of 0.081 is significantly higher than that of other sub-items, suggesting that equipment adaptability at plateau is the core shortcoming of technical management. The overall weight distribution is in line with the characteristics of the plateau and alpine environment, and provides a quantitative basis for risk management prioritization.

III. B. Identification of risk weaknesses of the agency based on the fuzzy comprehensive evaluation method

After completing the scientific allocation of risk indicator weights, it is necessary to combine the weights with expert ratings through the fuzzy comprehensive evaluation method to identify the core risk level faced by the agency in extreme environments from both qualitative and quantitative dimensions.

III. B. 1) Setting the rubric

Each evaluation model has a corresponding set of comments to measure the results of the system, and the evaluation index set V={High, Medium, Low} is set as the evaluation set of the model. "High" means that the risk is high and will affect the construction of barracks facilities in the plateau and cold areas, "medium" means that the risk is moderate and the probability of causing serious consequences is low, and "low" means that the risk is small and the probability of loss is low.

III. B. 2) Constructing indicator weight sets

By applying fuzzy hierarchical analysis to determine the weight matrix, the weight values of the indicators at each level are derived as follows

Criteria layer W1=(0.262,0.334,0.233,0.171)

Indicator layer W2=(0.622,0.213,0.165)

W3=(0.372,0.356,0.272)

W4=(0.303,0.352,0.345)
W5=(0.352,0.471,0.177)

III. B. 3) Evaluation weights for each indicator of risk

Designing relevant questionnaires, a total of 30 relevant experts were invited to visit and investigate the selection of the degree of risk assessment indicators of the barracks facility substitute unit in the highland alpine region, which resulted in the matrix of the proportion of the number of people with the degree of risk at the guideline and indicator levels to the total number of people investigated, as shown in Table 7.

Table 7: Evaluation of risk factors for the construction agency of barracks facilities

Index	High-risk	Medium-risk	Low-risk
C1	0.57	0.27	0.17
C2	0.73	0.23	0.03
C3	0.53	0.33	0.13
C4	0.53	0.33	0.13
C5	0.57	0.17	0.27
C6	0.53	0.20	0.27
C7	0.57	0.30	0.13
C8	0.73	0.20	0.07
C9	0.67	0.33	0.00
C10	0.53	0.23	0.23
C11	0.57	0.37	0.07
C12	0.60	0.27	0.13

According to the table, the main factor fuzzy matrix of the secondary indicators on the risk of the natural environment under the risk assessment of the barracks facility substitute unit in the highland alpine region can be derived:

$$R1=\begin{bmatrix} 0.57 & 0.27 & 0.17 \\ 0.73 & 0.23 & 0.03 \\ 0.53 & 0.33 & 0.13 \end{bmatrix} \tag{10}$$

Principal factor fuzzy matrix for secondary indicators of logistical security risk:

$$R2=\begin{bmatrix} 0.53 & 0.33 & 0.13 \\ 0.57 & 0.17 & 0.27 \\ 0.53 & 0.20 & 0.27 \end{bmatrix} \tag{11}$$

Principal factor fuzzy matrix for secondary indicators of personnel health risk:

$$R3=\begin{bmatrix} 0.57 & 0.30 & 0.13 \\ 0.73 & 0.20 & 0.07 \\ 0.67 & 0.33 & 0 \end{bmatrix} \tag{12}$$

Principal factor fuzzy matrix for secondary indicators of technology management risk:

$$R4=\begin{bmatrix} 0.53 & 0.23 & 0.23 \\ 0.57 & 0.37 & 0.07 \\ 0.60 & 0.27 & 0.13 \end{bmatrix} \tag{13}$$

III. B. 4) Results of the evaluation of normative level indicators

The fuzzy comprehensive judgment model Bi=W*Ri(i=1,2,3,4) was used to calculate the evaluation result Bi(i=1,2,3,4) of the first-level indicators, and the comprehensive evaluation result of the risk of the barracks facilities' substitute unit in the highland alpine region was projected by taking the small - taking the large operator:

$$B1=\begin{bmatrix}0.622 & 0.213 & 0.165\end{bmatrix}*\begin{bmatrix}0.57 & 0.27 & 0.17\\ 0.73 & 0.23 & 0.03\\ 0.53 & 0.33 & 0.13\end{bmatrix}=\begin{bmatrix}0.62 & 0.28 & 0.10\end{bmatrix} \tag{14}$$

Similarly, B2 = [0.57 0.25 0.18]
B3 = [0.65 0.26 0.09]
B4 = [0.60 0.25 0.15]
The evaluation matrix for the criterion layer can be obtained as

$$R=\begin{bmatrix}0.62\ 0.28\ 0.10\\ 0.57\ 0.25\ 0.18\\ 0.65\ 0.26\ 0.09\\ 0.60\ 0.25\ 0.15\end{bmatrix} \tag{15}$$

Adding the corresponding risk types and importance levels to get the risk importance distribution of the barracks facilities construction units in highland and alpine areas is shown in Figure 3.

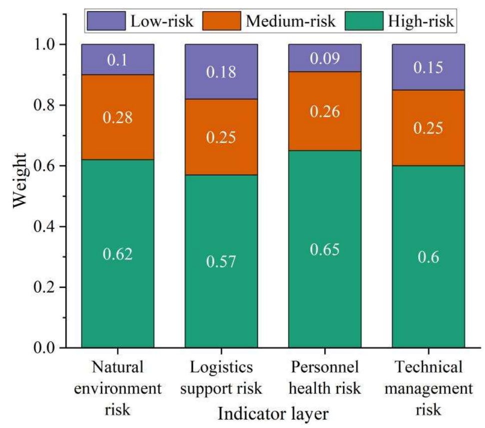

Figure 3: Distribution of importance of risk in agency construction of barrack facilities

This leads to the evaluation of the quasi-stratigraphic indicators:

$$R=\begin{bmatrix}0.262 & 0.334 & 0.233 & 0.171\end{bmatrix}*\begin{bmatrix}0.62 & 0.28 & 0.10\\ 0.57 & 0.25 & 0.18\\ 0.65 & 0.26 & 0.09\\ 0.60 & 0.25 & 0.15\end{bmatrix}=\begin{bmatrix}0.62 & 0.27 & 0.11\end{bmatrix} \tag{16}$$

III. C. Point centrality analysis

Individual network analysis is mainly to quantitatively analyze the interrelationship between individuals. By analyzing the interrelationships and the degree of influence between the various nodes of the risky project of the barracks facility generation unit in the highland alpine region, the status and influence of each risk factor in the whole network is determined. Point degree centrality is commonly used in individual network analysis to express the individual network situation.

Point degree centrality indicates the number of other nodes directly adjacent to a node, if the greater the number of other adjacent nodes indicates that its position in the network is more important, and vice versa, the less important. Given that the risk factor network constructed in this paper is a binary directed network, it is necessary to analyze the point degree centrality from 2 indicators such as the point out degree and the point in degree. Where point-in degree indicates the sum of the number of other nodes pointing to a node, and point-out degree indicates the sum of the number of nodes pointing to other nodes from a node.

The point out degree and point in degree about each node of the risk of the barracks facility proxy unit in the highland alpine region are shown in Table 8.

Table 8: The out-point degree and in-point degree of each node

Index	Point out degree	Point in degree
C1	1	7
C2	5	3
C3	0	7
C4	10	2
C5	1	6
C6	9	2
C7	10	9
C8	6	10
C9	7	7
C10	5	5
C11	6	9
C12	7	0

Table 8 shows the distribution of point-out and point-in degrees of each node in the risk network of the barracks facility substitute unit in the highland alpine region. As seen from the data, the point out degree of C4 material transportation interruption and C7 plateau reaction health problem both reach 10, indicating that these two risks have the strongest direct impact on other nodes and may be the core hub of risk transmission.The point in degree of C8 low temperature exposure health problem is as high as 10, indicating that it is significantly affected by other risk nodes, and we need to be vigilant of the multifactorial superposition effect. In addition, C12 cross-departmental collaboration inefficiency has a point-in of 0, indicating its strong independence, but a point-out of 7, suggesting that it may indirectly trigger other risks through management problems. Overall, nodes C7, C8, and C11 Inadequate equipment adaptability have high point-in and point-out scores, reflecting the critical position of personnel health and equipment management in the risk network, which should be prioritized for prevention and control.

IV. Conclusion

This study constructed a risk assessment model of the barracks facilities substitute unit in highland alpine area based on the fuzzy hierarchical analysis method FAHP, and verified the reliability and applicability of the model through experimental data. The main conclusions are as follows:

Logistical security risk B2 (weight 0.334) is the highest priority, and its sub-risks of material transportation interruption C4 and energy supply instability C5 account for 0.124 and 0.119, respectively; the natural environment risk B1 (weight 0.262) has the highest weight of extreme climatic impact C1, which is 0.163, highlighting the constraints of the climate and material security on construction.

Although the weights of personnel health risk B3 and technology management risk B4 are low, the expert scores of C7 plateau reaction, C8 low-temperature exposure and C11 inadequate equipment adaptability show that the proportion of high risk reaches 57%-73%, indicating that it is necessary to strengthen the management of health monitoring and equipment adaptability.

The analysis of point-degree centrality shows that C4 (point-out degree 10), C7 (point-out degree 10) and C8 (point-in degree 10) are the core nodes with strong risk transmission effect, and a multi-sectoral collaborative prevention and control mechanism needs to be established.

FAHP effectively integrates the ambiguity of expert judgment and the systematicity of hierarchical analysis, and the consistency test (CR all < 0.1) confirms the logical rationality of the model.

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