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Evaluation of management level of water conservancy construction supervision unit based on variable weight fuzzy theory

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ABSTRACT

This paper establishes an evaluation index system for the management level of water conservancy construction supervision units. For the problem that the analytic hierarchy process (AHP) cannot provide more reasonable weights, the idea of variable weight processing is introduced. Variable weight processing is based on the AHP to determine the constant weight vector of evaluation indexes. This paper studies the evaluation of the management level of water conservancy construction supervision units based on the variable weight fuzzy theory, and finally proves the rationality and effectiveness of the method with examples.

Keywords: Evaluation index; Variable weight; Fuzzy theory; Management level

1. Introduction

In 1965, Professor LA Zadeh, a cybernetician at University of California in the United States, published a seminal paper titled Fuzzy Collection in journal Information and Control, marking the birth of fuzzy mathematics. Today, a complete branch of mathematics has been formed. In the 1970s, China began to study fuzzy mathematics, now which has been widely used in various fields. Yin et al. [1], Zhongming et al. [2], and Huaji and Zhou [3] applied fuzzy mathematics to assess the material quality loss in critical assembly processes of complex electro-mechanical products applied fuzzy mathematics to the classification of water environment in the karst area applied fuzzy mathematics to the determination of the subjective evaluation index weights for vehicle handling stability. Zhang Haliya Daliliehan and Lin [4] applied fuzzy mathematics to risk assessment of reservoir induced earthquakes; Lu et al. [5] applied fuzzy mathematics to water quality assessment; Li et al. [6] applied fuzzy mathematics to transformer state evaluation.

The evaluation of the management level of water conservancy construction supervision units needs to comprehensively consider the impact of various factors. In order to improve the accuracy and rationality of the evaluation results, the weights of the primary and secondary index need to be determined [7]. There are many ways to determine weights, which are generally divided into two categories: subjective weighting and objective weighting. Subjective weighting methods include subjective weighting, expert survey, analytic hierarchy process (AHP), comparative weighting, multivariate analysis, and fuzzy statistics. Objective weighting methods include entropy method, principal component analysis, mean square error, gray correlation, and rough set-based method [8]. This paper builds an evaluation index system based on the “double-random,

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one-public" supervision and inspection of water conservancy construction supervision units. Due to the hierarchical nature of the evaluation indexes of management units, this paper chooses AHP to determine the weight vector of each index. In order to make the distribution of weights more accurate, the weight vector determined by AHP is subjected to a variable weighting process, and the fuzzy comprehensive evaluation method is used to evaluate the management level of the supervision unit [9,10].

2. Building the evaluation index system for the management level of water conservancy construction supervision unit

There are many influencing factors in the management level of water conservancy construction supervision units, which mainly include the unit management status and supervision project management status. According to the "double-random, one-public" requirements of the Ministry of Water Resources on "water conservancy construction supervision units" and the content of inspections, the Delphi Expert Method was used to determine the factors affecting the management level of water conservancy construction supervision unit [11]. The evaluation index system for the management level of water conservancy construction supervision unit is shown in Fig. 1.

3. Determination of variable weight vectors for evaluation index of the management level of water conservancy construction supervision unit

3.1. Determination of constant weight vector

The AHP is used to determine the constant weight vectors of primary and secondary indexes.

$$D_i = \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1j} \\ d_{21} & d_{22} & \cdots & d_{2j} \\ \vdots & \vdots & \vdots & \vdots \\ d_{j1} & d_{j2} & \cdots & d_{jj} \end{bmatrix} \tag{1}$$

3.1.1. Determination of constant weight vector of secondary indexes

The AHP is used to determine the constant weight vectors of primary and secondary indexes.

The two sub-indexes are compared on the basis of the importance of the sub-indexes they belong to, and the judgment matrix D_i is constructed.

D_i is a positive reciprocal matrix, $i = 1, 2, 3, 4, 5, 6, 7$, $j \in N_i$, N_i is the number of secondary indexes corresponding to the ith primary index. $d_{jj} = 1$ indicates that the jth secondary index is equally important to itself, $d_{ij} = 1/d_{ji}$, $d_{ij} > 1$ indicates that the ith index is more important than the jth index, and $d_{ij} < 1$ indicates that the jth index is more important than the ith index. The scale and meanings are shown in Table 1.

To perform hierarchical ordering, find the maximum (absolute value) eigenvalue λ_{max} of the judgment matrix D_i, and then use its corresponding characteristic equation $D_iA_i = \lambda_{max}A_i$ to solve the corresponding eigenvector A_i, normalize the eigenvector, that is, the constant weight vector of the secondary index relative to the primary index.

3.1.2. Determination of constant weight vector of primary indexes

The importance of each level of the primary indexes on the management level of water conservancy construction supervision unit is compared in twos and the judgment matrix E is constructed.

$$E = \begin{bmatrix} e_{11} & e_{12} & \cdots & e_{17} \\ e_{21} & e_{22} & \cdots & e_{27} \\ \vdots & \vdots & \vdots & \vdots \\ e_{71} & e_{72} & \cdots & e_{77} \end{bmatrix} \tag{2}$$

As with the method for determining the weights of secondary indexes, the E-characteristic vectors are first obtained and normalized to obtain the constant weight vector for each primary index.

However, when constructing a judgment matrix to perform pairwise comparisons, due to the subjectivity and one-sidedness of the knowledge, the judgment matrix may have serious deviations. Finally, the weight vector error is too large, and the evaluation of the management level is unreasonable and inaccurate. Therefore, consistency check of the judgment matrix is needed. The quantitative index used to measure the degree of inconsistency in the judgment matrix is called the consistency index, denoted by:

$$C = \frac{\lambda_{max} - n}{n - 1} \tag{3}$$

when $C = 0$, the judgment matrix is the same. The larger the C value is, the more inconsistent the judgment matrix is. Use R to indicate random consistency indexes. Let

$$R = \frac{\bar{\lambda}_{max} - n}{n - 1} \tag{4}$$

$\bar{\lambda}_{max}$ is the average of the maximal eigenvalues of multiple n-order reciprocal matrices. When the random consistency ratio $C_R = C/R < 0.1$, the inconsistency of the judgment matrix is acceptable. The random consistency index values corresponding to different orders of the judgment matrix are shown in Table 2.

3.2. Determination of variable weight vectors

The secondary index weight vector $A = (a_{11}, a_{12}, \ldots, a_{ij}, \ldots, a_{76})$ and the primary index weight vector $A' = (a_1, a_2, a_3, a_4, a_5, a_6, a_7)$ determined by the AHP are used. The weight vector represents the degree of relative importance between evaluation indexes in a more ideal situation. That is, in the

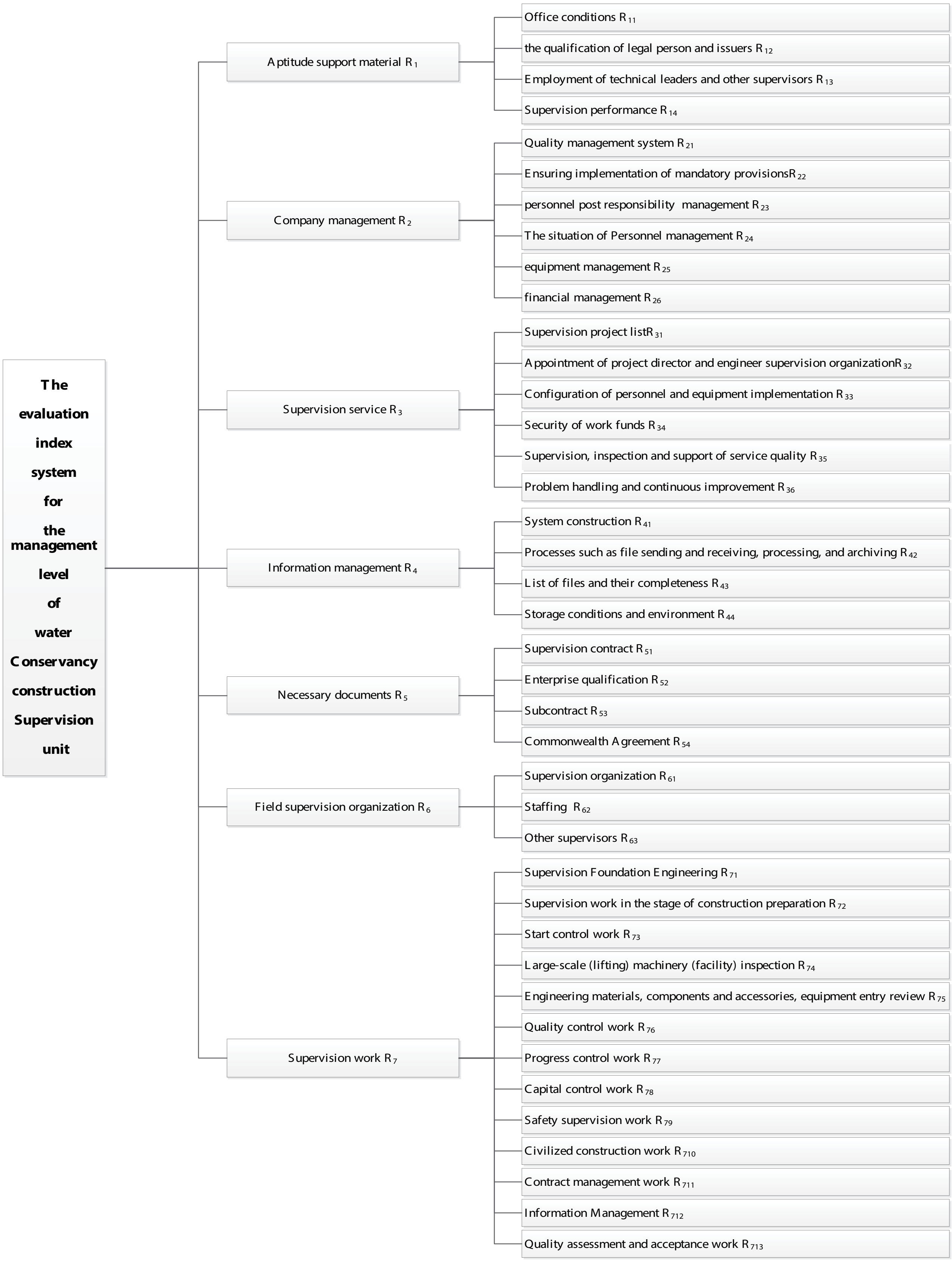

Fig. 1. Evaluation index system for the management level of water conservancy construction supervision unit.

Table 1
Scale and meanings

d_{ij}	ith index compared with the jth
1	Equally important
3	Slightly important
5	Important
7	Very important
9	Absolutely important
1/3	Slightly unimportant
1/5	Not important
1/7	Not important at all
1/9	Absolutely not important

Note: The scales 2, 4, 6, 8, 1/2, 1/4, 1/6, 1/8 and their representative meanings are among them.

Table 2
Random consistency index values corresponding to different orders of judgment matrix

N	R
1	0
2	0
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

equally important case, the weight vectors are determined by comparing evaluation index with each other. This shows that the weight vector determined by AHP is not very reasonable in the application of management evaluation. In order to solve such problems, He et al. [12] and Luo et al. [13] proposed the idea of variable weight in combination with practical problems on the basis of determining the weights of the AHP and proved through practical applications that the evaluation results after the variable weighting process were more reasonable. Based on the research results of He et al. [12] and the characteristics of the evaluation index system for the management level of water conservancy construction supervision unit, this paper applies variable weights to the weight values of the evaluation indexes of management units. That is, on the basis of the constant weight vector, the weight values of primary or secondary evaluation index in the worst impact degree are appropriately increased, so that the fuzzy comprehensive evaluation result of the management unit's management level becomes more reasonable [14]. Taking the constant weight vector (a_1, a_2, a_3, a_4) of the secondary index (r_{11}, r_{12}, r_{13}, r_{14}) contained in the primary index R_i as an example, the variable weighting process is described as follows:

Set the constant weight vector (a_{11}, a_{12}, a_{13}, a_{14}) of the secondary index (r_{11}, r_{12}, r_{13}, r_{14}) undergo a variable weighting process as (b_{11}, b_{12}, b_{13}, b_{14}), then

$$b_{1k} = \frac{\alpha_k\left(\beta_k\right)}{\sum_{j=1}^{4}\alpha_j\left(\beta_j\right)} \quad j,k = 1,2,3,4 \tag{5}$$

where β_j is the evaluation index r_{1j}, the fuzzy comprehensive evaluation value of the comment set M, then $\beta_j = \sum_{k=1}^{4} W_{1jk} \times \lambda_k$;

$\alpha_k(\beta_k)$ is a function, $\alpha_k\left(\beta_k\right) = \alpha''_k \alpha_{0k} \left\{ \frac{\alpha' \exp\left[\beta_k / \lambda_1\right]^{1-p_k}}{1-p_k} \right\}$,

where: $\alpha_{0k} = \frac{\alpha_{0k}\sum_{j\neq k} a_{1j}}{1-a_{0k}}$, $p_k = 1 - \frac{1}{\ln\left\{\frac{\alpha_{0k}\left(\alpha''_k + a_{1k}\right)}{\alpha' a_{1k}}\right\}}$,

$a_{0k} = \frac{a_{1k}}{\left(\min_{1\le j\le n} a_{1j} + \max_{1\le j\le n} a_{1j}\right)}$, $\alpha''_k = \sum_{j\neq k}\alpha_{0j}$, $\alpha' = \sum_{j=1}^{4}\alpha_{0j}$

4. Evaluation of management level of water conservancy construction supervision unit based on variable weight fuzzy comprehensive evaluation method

4.1. Building the evaluation matrix

To apply the above-mentioned evaluation index system to evaluate the management level of water conservancy construction supervision unit, we must first determine the management level comment set [15]. This comment set is a fuzzy set described by the management level and is defined as M = {m_1-excellent, m_2-good, m_3-medium, m_4-bad}. In order to achieve a transition from a qualitative description to a quantitative description of the evaluation of the management level of water conservancy construction supervision unit, a corresponding specific value is assigned to the comment set, $\lambda = \{\lambda_1, \lambda_2, \lambda_3, \lambda_4\} = (7, 5, 3, 1)$.

According to the evaluation index system for the management level of water conservancy construction supervision unit and management level comment sets, the evaluation matrix for each level of the evaluation index is as follows:

$$W_i = \begin{bmatrix} W_{i11} & W_{i12} & \cdots & W_{i14} \\ W_{i21} & W_{i22} & \cdots & W_{i24} \\ \vdots & \vdots & \vdots & \vdots \\ W_{ij1} & W_{ij2} & \cdots & W_{ij4} \end{bmatrix} \tag{6}$$

The evaluation matrix W_i is composed of secondary index r_{ij} and membership degree vectors of comments in the comment set. The Delphi Expert method can be used to determine the degree of membership vector [16].

4.2. Fuzzy comprehensive evaluation of each primary index

For the fuzzy comprehensive evaluation of primary evaluation index of the management level of water conservancy construction supervision unit, the membership degree of each primary evaluation index to the comment in the review set M is calculated, and the calculation formula is as follows [17]:

$$N_i = B_i \times W_i \tag{7}$$

where B_i (i = 1, 2, 3, 4, 5, 6, 7) is the weight vector of secondary index r_{ij} with respect to primary index R_i, where b_{ij} ($j \in N_i$) is a_{ij} with variable weights via formula (5) after variable weighting.

4.3. Fuzzy comprehensive evaluation of the management level of water conservancy construction supervision unit

Use the primary index evaluation result $W = [N_1, N_2, N_3, N_4, N_5, N_6, N_7]^T$ as the evaluation matrix, the membership level vector of each comment in the management level of water conservancy construction supervision unit M is calculated by formula (8), namely the fuzzy comprehensive evaluation [18–24].

$$P = \tilde{B} \times W \tag{8}$$

where $\tilde{B} = \left[b_1, b_2, b_3, b_4, b_5, b_6, b_7\right]$ is the weighted vector of the constant weight vector A of the primary evaluation index after variable weighting performed by formula (5), and β_j in formula (5) is the fuzzy comprehensive evaluation value of the evaluation set M for the primary evaluation index, namely $\beta_j = N_j \times \lambda^T$ (j = 1, 2, …, 7).

5. Application

5.1. Introduction

A water conservancy construction supervision unit in Henan Province has Grade A qualification for water conservancy project construction supervision, Grade A qualification for water and soil conservation engineering construction supervision, Grade B qualification for supervising mechanical and electrical equipment and metal structure equipment manufacturing, and environmental protection supervision qualification for water conservancy project construction [25–27]. The results of this study are applied to evaluate the management level of the supervision unit.

5.2. Determination of the evaluation index weight

5.2.1. Determination of constant vector

After pairwise comparisons of the 40 indexes in the seven dimensions, the following judgment matrix is obtained:

$$D_1 = \begin{bmatrix} 1 & 1/2 & 1/5 & 1/7 \\ 2 & 1 & 1/3 & 1/5 \\ 5 & 3 & 1 & 1/2 \\ 7 & 5 & 2 & 1 \end{bmatrix} \tag{9}$$

$$D_2 = \begin{bmatrix} 1 & 1/3 & 3 & 1/5 & 4 & 1/7 \\ 3 & 1 & 1/4 & 1/6 & 3 & 1/8 \\ 1/3 & 4 & 1 & 1/4 & 5 & 1/6 \\ 5 & 6 & 4 & 1 & 7 & 1/4 \\ 1/4 & 1/3 & 1/5 & 1/7 & 1 & 1/9 \\ 7 & 8 & 6 & 4 & 9 & 1 \end{bmatrix} \tag{10}$$

$$D_3 = \begin{bmatrix} 1 & 1/3 & 1/5 & 1/5 & 1/9 & 1/9 \\ 3 & 1 & 1/2 & 1/2 & 1/5 & 1/5 \\ 5 & 2 & 1 & 1 & 1/3 & 1/3 \\ 5 & 2 & 1 & 1 & 1/3 & 1/3 \\ 9 & 5 & 3 & 3 & 1 & 1 \\ 9 & 5 & 3 & 3 & 1 & 1 \end{bmatrix} \tag{11}$$

$$D_4 = \begin{bmatrix} 1 & 1/5 & 1/3 & 2 \\ 5 & 1 & 2 & 7 \\ 3 & 2 & 1 & 5 \\ 2 & 7 & 5 & 1 \end{bmatrix} \tag{12}$$

$$D_5 = \begin{bmatrix} 1 & 7 & 5 & 9 \\ 1/7 & 1 & 1/3 & 3 \\ 1/5 & 3 & 1 & 5 \\ 1/9 & 1/3 & 1/5 & 1 \end{bmatrix} \tag{13}$$

$$D_6 = \begin{bmatrix} 1 & 3 & 9 \\ 1/3 & 1 & 7 \\ 1/9 & 1/7 & 1 \end{bmatrix} \tag{14}$$

$$D_7 = \begin{bmatrix} 1 & 1/2 & 1/2 & 1/3 & 1/4 & 1/9 & 1/7 & 1/6 & 1/8 & 1/4 & 1/5 & 1/4 & 1/2 \\ 2 & 1 & 1 & 1/2 & 1/3 & 1/8 & 1/6 & 1/5 & 1/7 & 1/3 & 1/4 & 1/3 & 1 \\ 2 & 1 & 1 & 1/2 & 1/3 & 1/8 & 1/6 & 1/5 & 1/7 & 1/3 & 1/4 & 1/3 & 1 \\ 3 & 2 & 2 & 1 & 1/2 & 1/7 & 1/5 & 1/4 & 1/6 & 1/2 & 1/3 & 1/2 & 2 \\ 4 & 3 & 3 & 2 & 1 & 1/6 & 1/4 & 1/3 & 1/5 & 1 & 1/2 & 1 & 3 \\ 9 & 8 & 8 & 7 & 6 & 1 & 3 & 4 & 2 & 6 & 5 & 6 & 8 \\ 7 & 6 & 6 & 5 & 4 & 1/3 & 1 & 2 & 1/2 & 4 & 3 & 4 & 6 \\ 6 & 5 & 5 & 4 & 3 & 1/4 & 1/2 & 1 & 1/3 & 3 & 2 & 3 & 5 \\ 8 & 7 & 7 & 6 & 5 & 1/2 & 2 & 3 & 1 & 5 & 4 & 5 & 7 \\ 4 & 3 & 3 & 2 & 1 & 1/6 & 1/4 & 1/3 & 1/5 & 1 & 1/2 & 1 & 3 \\ 5 & 4 & 4 & 3 & 2 & 1/5 & 1/3 & 1/2 & 1/4 & 2 & 1 & 2 & 4 \\ 4 & 3 & 3 & 2 & 1 & 1/6 & 1/5 & 1/3 & 1/5 & 1 & 1/2 & 1 & 3 \\ 2 & 1 & 1 & 1/2 & 1/3 & 1/8 & 1/6 & 1/5 & 1/7 & 1/3 & 1/4 & 1/3 & 1 \end{bmatrix} \quad (15)$$

$$E = \begin{bmatrix} 1 & 1/3 & 3 & 1 & 1/2 & 1 & 1/3 \\ 3 & 1 & 7 & 3 & 5 & 3 & 1 \\ 1/3 & 1/7 & 1 & 1/3 & 1/2 & 1/3 & 1/7 \\ 1 & 1/3 & 3 & 1 & 2 & 1 & 1/3 \\ 2 & 1/5 & 2 & 1/2 & 1 & 1/2 & 1/3 \\ 1 & 1/3 & 3 & 1 & 2 & 1 & 1/5 \\ 3 & 1 & 7 & 3 & 3 & 5 & 1 \end{bmatrix} \quad (16)$$

The calculated ratio of random agreement C_{R1} = 0.045 < 0.1, C_{R2} = 0.056 < 0.1, C_{R3} = 0.068 < 0.1, C_{R4} = 0.043 < 0.1, C_{R5} = 0.051 < 0.1, C_{R6} = 0.041 < 0.1, C_{R7} = 0.077 < 0.1, C_{Re} = 0.063 < 0.1, all meet the consistency requirements. Use the sum method to normalize each column of the judgment matrix to obtain a normalized matrix, and then obtain each line to get the corresponding feature vector of the judgment matrix. Normalized A_i and A' are each the constant weight vector of the index. A_1 = [0.603 0.110 0.301 0.526], A_2 = [0.090 0.074 0.100 0.240 0.028 0.468], A_3 = [0.034 0.076 0.124 0.162 0.330 0.274], A_4 = [0.108 0.176 0.180 0.536], A_5 = [0.643 0.101 0.208 0.048], A_6 = [0.649 0.294 0.057], A_7 = [0.014 0.021 0.021 0.032 0.048 0.247 0.137 0.100 0.185 0.048 0.071 0.048 0.028], A' = [0.123 0.403 0.050 0.145 0.142 0.137 0.410].

5.2.2. Determination of constant vector

Use formula (5) to perform a variable weighting process on the index constant weight vector to obtain the secondary index A weight: B_1 = [0.091 0.143 0.028 0.485], B_2 = [0.103 0.082 0.111 0.221 0.057 0.426], B_3 = [0.056 0.089 0.133 0.152 0.305 0.265], B_4 = [0.139 0.164 0.195 0.502], B_5 = [0.522 0.144 0.207 0.117], B_6 = [0.538 0.301 0.161], B_7 = [0.013 0.026 0.022 0.039 0.051 0.216 0.132 0.101 0.176 0.052 0.076 0.057 0.039], B' = [0.119 0.349 0.064 0.133 0.158 0.157 0.430].

5.3. Determination of evaluation index membership vector

The membership vector of the secondary index to the comment set determined by three rounds of scoring by experts in 10 related fields is as follows:

$$W_1 = \begin{bmatrix} 0.54 & 0.32 & 0.13 & 0.01 \\ 0.63 & 0.30 & 0.05 & 0.02 \\ 0.48 & 0.41 & 0.10 & 0.01 \\ 0.59 & 0.28 & 0.11 & 0.02 \end{bmatrix} \quad (17)$$

$$W_2 = \begin{bmatrix} 0.15 & 0.47 & 0.32 & 0.06 \\ 0.13 & 0.38 & 0.43 & 0.06 \\ 0.10 & 0.41 & 0.31 & 0.18 \\ 0.21 & 0.37 & 0.33 & 0.09 \\ 0.29 & 0.51 & 0.13 & 0.07 \\ 0.33 & 0.42 & 0.20 & 0.05 \end{bmatrix} \quad (18)$$

$$W_3 = \begin{bmatrix} 0.32 & 0.43 & 0.18 & 0.07 \\ 0.40 & 0.39 & 0.11 & 0.10 \\ 0.26 & 0.36 & 0.31 & 0.07 \\ 0.22 & 0.39 & 0.23 & 0.16 \\ 0.41 & 0.31 & 0.11 & 0.17 \\ 0.24 & 0.35 & 0.29 & 0.12 \end{bmatrix} \quad (19)$$

$$W_4 = \begin{bmatrix} 0.18 & 0.39 & 0.33 & 0.10 \\ 0.20 & 0.35 & 0.28 & 0.17 \\ 0.31 & 0.42 & 0.23 & 0.04 \\ 0.53 & 0.34 & 0.09 & 0.04 \end{bmatrix} \quad (20)$$

$$W_5 = \begin{bmatrix} 0.44 & 0.41 & 0.11 & 0.04 \\ 0.53 & 0.38 & 0.07 & 0.02 \\ 0.38 & 0.32 & 0.22 & 0.08 \\ 0.21 & 0.39 & 0.33 & 0.07 \end{bmatrix} \quad (21)$$

$$W_6 = \begin{bmatrix} 0.37 & 0.25 & 0.32 & 0.06 \\ 0.19 & 0.34 & 0.38 & 0.09 \\ 0.23 & 0.39 & 0.23 & 0.15 \end{bmatrix} \quad (22)$$

$$W_7 = \begin{bmatrix} 0.53 & 0.32 & 0.12 & 0.03 \\ 0.44 & 0.33 & 0.21 & 0.02 \\ 0.39 & 0.42 & 0.11 & 0.08 \\ 0.23 & 0.47 & 0.21 & 0.09 \\ 0.18 & 0.52 & 0.19 & 0.11 \\ 0.11 & 0.39 & 0.43 & 0.07 \\ 0.12 & 0.38 & 0.39 & 0.11 \\ 0.21 & 0.37 & 0.41 & 0.01 \\ 0.35 & 0.42 & 0.14 & 0.09 \\ 0.39 & 0.41 & 0.19 & 0.01 \\ 0.43 & 0.35 & 0.11 & 0.11 \\ 0.25 & 0.44 & 0.30 & 0.01 \\ 0.31 & 0.34 & 0.33 & 0.02 \end{bmatrix} \quad (23)$$

5.4. Fuzzy comprehensive evaluation

5.4.1. Fuzzy comprehensive evaluation of primary evaluation index

By substituting the values of B_i and W_i into formula (7), the membership vector of each comment in the comment set by each primary evaluation index can be obtained and normalized as follows:

$$N_1 = \begin{bmatrix} 0.560 & 0.323 & 0.047 & 0.016 \end{bmatrix} \overset{\text{Normalization}}{=} \begin{bmatrix} 0.592 & 0.341 & 0.050 & 0.017 \end{bmatrix}$$

$$N_2 = \begin{bmatrix} 0.241 & 0.415 & 0.268 & 0.076 \end{bmatrix} \overset{\text{Normalization}}{=} \begin{bmatrix} 0.241 & 0.415 & 0.268 & 0.076 \end{bmatrix}$$

$$N_3 = \begin{bmatrix} 0.310 & 0.353 & 0.206 & 0.130 \end{bmatrix} \overset{\text{Normalization}}{=} \begin{bmatrix} 0.310 & 0.354 & 0.206 & 0.130 \end{bmatrix}$$

$$N_4 = \begin{bmatrix} 0.384 & 0.364 & 0.182 & 0.069 \end{bmatrix} \overset{\text{Normalization}}{=} \begin{bmatrix} 0.384 & 0.365 & 0.182 & 0.069 \end{bmatrix}$$

$$N_5 = \begin{bmatrix} 0.409 & 0.381 & 0.152 & 0.049 \end{bmatrix} \overset{\text{Normalization}}{=} \begin{bmatrix} 0.413 & 0.384 & 0.154 & 0.049 \end{bmatrix}$$

$$N_6 = \begin{bmatrix} 0.309 & 0.311 & 0.338 & 0.086 \end{bmatrix} \overset{\text{Normalization}}{=} \begin{bmatrix} 0.296 & 0.298 & 0.324 & 0.082 \end{bmatrix}$$

$$N_7 = \begin{bmatrix} 0.247 & 0.399 & 0.286 & 0.069 \end{bmatrix} \overset{\text{Normalization}}{=} \begin{bmatrix} 0.247 & 0.398 & 0.286 & 0.069 \end{bmatrix}$$

5.4.2. Fuzzy comprehensive evaluation of the management level of water conservancy construction supervision unit

Use the primary index evaluation result $W = [N_1, N_2, N_3, N_4, N_5, N_6, N_7]^T$ as an evaluation matrix and substitute it into formula (8):

$$P = \tilde{B} \times W = \begin{bmatrix} 0.443 & 0.535 & 0.335 & 0.096 \end{bmatrix}$$

After the normalization process, P = [0.314 0.380 0.238 0.068] is obtained, it is the membership vector of the management level of water conservancy construction supervision units to the comment set M [28]. This shows that the management level of the unit is good, and the quantification value of the management level is $\beta = P^{*}\lambda^{T} = 4.88$.

The evaluation results are consistent with the actual management level of the unit, which shows that the variable weight-based fuzzy comprehensive evaluation method studied in this paper is feasible and practical for the evaluation of the management level of water conservancy construction supervision units [29,30].

6. Conclusion

This paper analyzes the "double-random, one-public" requirements of the Ministry of Water Resources on "water conservancy construction supervision units" and the content of inspections, uses the Delphi expert method to establish seven primary indexes, forty secondary indexes, determines the membership vector of the evaluation system for the comment set, and uses the AHP to determine the constant weight vector of the index system, and a variable weighting process was performed. On the basis of variable weights, a fuzzy comprehensive evaluation was conducted on the management level of the supervision units. Finally, a water conservancy construction supervision unit in Henan Province was taken as an example. The evaluation results were consistent with the actual management level of the unit, indicating the effectiveness and practicability of fuzzy comprehensive evaluation of management level under variable weights. This paper has important guiding significance for the evaluation of management level of water conservancy construction supervision units, which is conducive to the better implementation of the "double-random, one-public" supervision and inspection.

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