Fuzzy Evaluation Method of Highway Green Construction in Ecological Protection Area Based on PSR Model

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Abstract. In view of the special conditions of cold and drought ecological protection areas in northwest China, the existing evaluation indexes of green construction are not comprehensive. Therefore, on the basis of 'four saving and one environmental protection', the evaluation system adds the first-level indicators of green construction management and the second-level indicators such as natural ecological protection areas, animal and plant resources protection, and water source protection, and proposes a highway green construction evaluation system that conforms to the natural environment and construction characteristics of ecological protection areas. The evaluation system can be converted into PSR model, which verifies the rationality of the evaluation system. The fuzzy comprehensive evaluation method is used to evaluate the green construction grade, and the results are compared with those of the extension matter-element method. By changing the weight of different indicators, it is found that the change of the weight of the first-level indicators has little effect on the results, and the change of the weight of the second-level indicators has a greater impact on the results. Finally, compared with the ' four saving and one environmental protection ' evaluation system, it is found that the new system has great advantages in the green construction evaluation of ecological protection areas.

Keywords: green construction; PSR model; comprehensive fuzzy evaluation; Extension matter-element method; highway construction; ecological reserve

1 Introduction

The northwest ecological protection area is dry and rainless, the soil erosion is serious, the ecological environment is fragile, and the Jiading town to Xihai town Highway passes through more water source protection areas. Under this condition, a large number of tunnels and bridges are inevitably designed, and the surrounding ecological environment will be greatly affected. Therefore, it is significant to propose a green construction evaluation system suitable for ecological protection areas.

Many domestic and foreign scholars have studied the green construction evaluation system in recent years. The establishment of evaluation system can use a variety of methods, such as uncertain analytic hierarchy process[1-4], fuzzy neural network[5-6], grey clustering method[7-9], the entropy weight and cloud model[10], BIM prediction[11] etc.

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The resource environment and construction characteristics of the ecological protection zone are fully considered in this paper. The evaluation system of highway green construction is constructed from the aspects of effectively maintaining the ecological environment, comprehensively controlling the allocation of resources and strictly controlling the construction pollution. Finally, the K42 + 050.942 ~ K64 + 571.5 section of Jiading town to Xihai town highway is selected to evaluate its green construction level according to the evaluation system established in this paper. And the corresponding improvement measures are proposed according to the evaluation results.

2 Green construction evaluation system

2.1 Perfect Scheme of green index

The evaluation standard evaluation system is shown in Figure 1. [1] These 25 indicators can also be divided by the PSR model (pressure-state-response model) evaluation system, which reflects the impact of human activities on the environment and proves that the evaluation system is reasonable and scientific. The green construction evaluation index system based on the PSR model is shown in Figure 2. [2]:

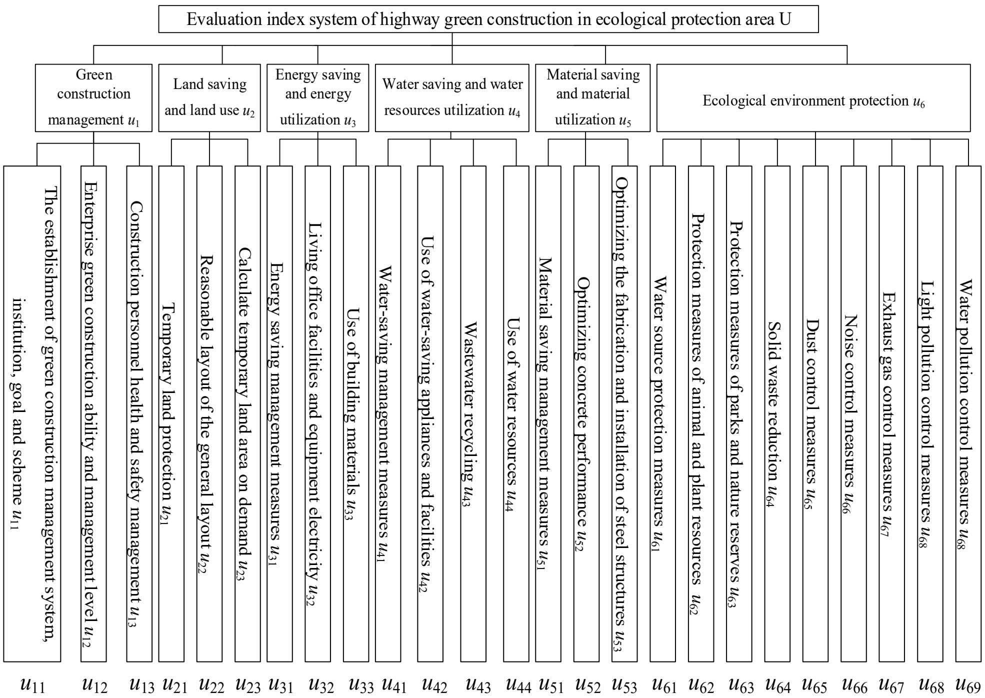

Fig. 1 Evaluation index system diagram

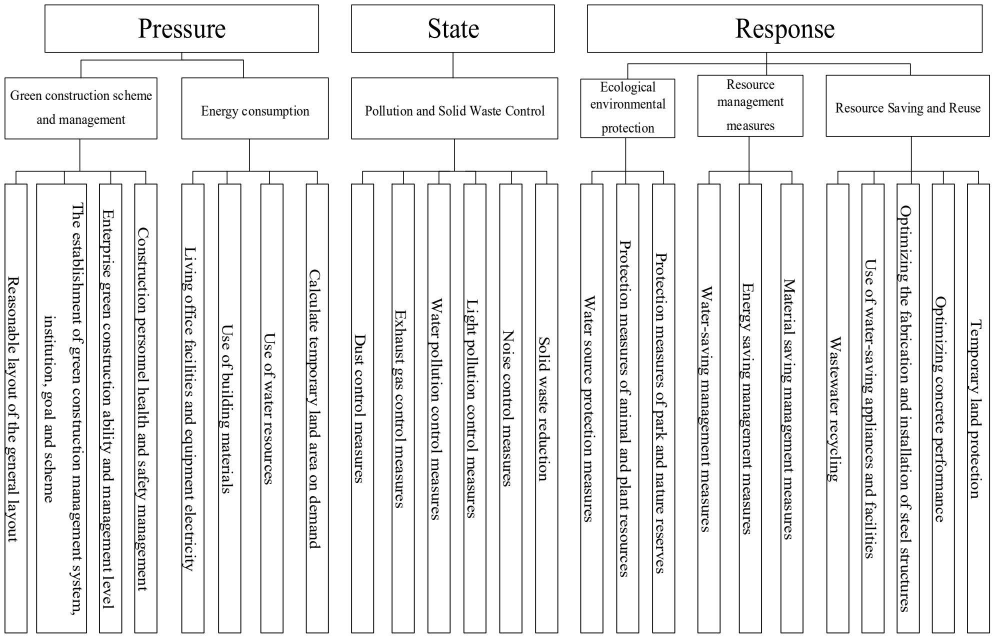

Fig. 2. PSR Evaluation index system diagram

2.2 Evaluation and Analysis of Green Construction of Jiading Town to Xihai Town Highway

Aiming at this Highway, 11 experts were invited from the construction unit, the Ministry of Transportation and the scientific research unit to score it. The green construction grade was evaluated based on the fuzzy comprehensive evaluation method.

2.2.1 Determination of evaluation scheme

In order to study the influence of different indicators on the evaluation system, the importance of different indicators is changed by the author. The nine-scale method is used to construct different judgment matrices, and the weights of each indicator under different judgment matrices are obtained based on the analytic hierarchy process. Finally, three schemes are proposed for comparative study . The weight values of different indicators in the case of three different schemes are shown in Table 1 :

Table 1. Weight calculation of three schemes

First index	Scheme1	Scheme2	Scheme3	Second index	Scheme1	Scheme2	Scheme3
u_1	0.165	0.172	0.171	u_{11}	0.1634	0.1634	0.5396
				u_{12}	0.297	0.5396	0.297
				u_{13}	0.5396	0.297	0.1634
u_2	0.153	0.153	0.153	u_{21}	0.5584	0.3196	0.3196
				u_{22}	0.3196	0.5584	0.122
				u_{23}	0.122	0.122	0.5584

				u_{31}	0.3761	0.3453	0.2786
u_3	0.171	0.169	0.165	u_{32}	0.3453	0.3761	0.3453
				u_{33}	0.2786	0.2786	0.3761
				u_{41}	0.3885	0.2893	0.1687
u_4	0.169	0.171	0.172	u_{42}	0.1535	0.1535	0.3885
				u_{43}	0.1687	0.3885	0.2893
				u_{44}	0.2893	0.1687	0.1535
				u_{51}	0.4333	0.3105	0.2562
u_5	0.170	0.170	0.169	u_{52}	0.3105	0.4333	0.3105
				u_{53}	0.2562	0.2562	0.4333
				u_{61}	0.1728	0.0913	0.1568
				u_{62}	0.1568	0.0115	0.1417
				u_{63}	0.1417	0.0099	0.1056
				u_{64}	0.1040	0.1941	0.1040
u_6	0.172	0.165	0.170	u_{65}	0.0576	0.1151	0.0576
				u_{66}	0.0499	0.0159	0.0499
				u_{67}	0.1056	0.1311	0.0913
				u_{68}	0.0913	0.1203	0.0679
				u_{69}	0.1203	0.3108	0.2252

2.2.2 Fuzzy comprehensive evaluation of different schemes

Through the evaluation of each member of the statistical expert group on the secondary indicators, the following single-factor evaluation matrix is obtained:

$$R_1 = \begin{bmatrix} 0.43 & 0.29 & 0.14 & 0.14 \\ 0.14 & 0.29 & 0.29 & 0.28 \\ 0.43 & 0.14 & 0.29 & 0.14 \end{bmatrix} R_2 = \begin{bmatrix} 0.43 & 0.14 & 0.29 & 0.14 \\ 0.29 & 0.29 & 0.29 & 0.13 \\ 0.14 & 0.29 & 0.43 & 0.14 \end{bmatrix} R_3 = \begin{bmatrix} 0.29 & 0.29 & 0.29 & 0.13 \\ 0.14 & 0.43 & 0.29 & 0.14 \\ 0.00 & 0.29 & 0.43 & 0.28 \end{bmatrix}$$

$$R_4 = \begin{bmatrix} 0.43 & 0.43 & 0.14 & 0.00 \\ 0.14 & 0.14 & 0.43 & 0.29 \\ 0.29 & 0.29 & 0.29 & 0.13 \\ 0.00 & 0.29 & 0.43 & 0.28 \end{bmatrix} R_5 = \begin{bmatrix} 0.14 & 0.43 & 0.14 & 0.29 \\ 0.14 & 0.29 & 0.29 & 0.28 \\ 0.43 & 0.14 & 0.29 & 0.14 \end{bmatrix} R_6 = \begin{bmatrix} 0.14 & 0.29 & 0.43 & 0.14 \\ 0.43 & 0.29 & 0.14 & 0.14 \\ 0.14 & 0.43 & 0.14 & 0.29 \\ 0.43 & 0.43 & 0.14 & 0.00 \\ 0.29 & 0.29 & 0.29 & 0.13 \\ 0.43 & 0.14 & 0.29 & 0.14 \\ 0.14 & 0.29 & 0.29 & 0.28 \\ 0.14 & 0.29 & 0.43 & 0.14 \\ 0.00 & 0.29 & 0.43 & 0.28 \end{bmatrix}$$

The calculation formula of fuzzy comprehensive evaluation is shown in equation (1):

$$B = A * R \tag{1}$$

Fuzzy comprehensive evaluation of first-level indicators:

$$B = \begin{bmatrix} 0.2524 & 0.2853 & 0.2839 & 0.1784 \end{bmatrix}$$

Similarly, Scheme 2 and Scheme 3 can be obtained:

Scheme 2: $$B = \begin{bmatrix} 0.2468 & 0.3024 & 0.2965 & 0.1889 \end{bmatrix}$$

Scheme 3: $B=\begin{bmatrix}0.2429 & 0.2901 & 0.3114 & 0.1913\end{bmatrix}$

According to the principle of maximum membership degree, The result of scheme 1 is $[0.2524\ 0.2853\ 0.2839\ 0.1784]_{max} = 0.2853$; The result of scheme 2 is $[0.2468\ 0.3024\ 0.2965\ 0.1889]_{max} = 0.3024$; The result of scheme 3 is $[0.2429\ 0.2901\ 0.3114\ 0.1913]_{max} = 0.3114$. It can be seen that scheme 1 and scheme 2 have the highest membership degree for *good* evaluation and scheme 3 has the highest membership degree for *qualified* evaluation. Therefore, the overall evaluation of green construction in Schemes 1 and 2 is *good*, and the overall evaluation in Scheme 3 is *qualified*.

2.3 Analysis and comparison of extension matter-element method

Using the weight of each index obtained by the analytic hierarchy process, the evaluation index can be calculated by the extension matter-element method. After obtaining the results calculated by the extension matter-element method, it is compared with the calculation results of the fuzzy comprehensive evaluation method. See Equation (2) to equation (3) for the calculation formula of the extension matter-element method.

$$K_j(x_i)=\begin{cases}\dfrac{\rho(x_{0i},X_{ji})}{\rho(x_{0i},X_{pi})-\rho(x_{0i},X_{ji})}, x_{0i}\notin X_{ji}\\ \dfrac{-\rho(x_{0i},X_{ji})}{\left|X_{ji}\right|}, x_{0i}\in X_{ji}\end{cases} \tag{2}$$

$$\rho(x_{0i},X_{ji})=\left|x_i-\frac{1}{2}(a_{ji}+b_{ji})\right|-\frac{1}{2}(b_{ji}-a_{ji}) \tag{3}$$

$$K_1(N_0)=\sum_{i=1} a_i K_1(x_i)=-0.1615 \qquad K_2(N_0)=\sum_{i=1} a_i K_2(x_i)=0.0306$$

$$K_3(N_0)=\sum_{i=1} a_i K_3(x_i)=-0.2806 \qquad K_4(N_0)=\sum_{i=1} a_i K_4(x_i)=-0.5607$$

It can be seen that after the weight is determined according to the analytic hierarchy process, the green construction evaluation of the highway is good through the extension matter-element analysis. This is consistent with the results calculated by the fuzzy comprehensive evaluation method. It shows that the results are reasonable.

3 Analysis of evaluation results

The evaluation results of three schemes show that the evaluation results of green construction will be affected by the change of index importance. In order to further study the role of each index in the evaluation, the first-level indicators and second-level indicators of the three schemes were sorted and combined by the author, and the changes of the indicators were analyzed according to the evaluation results. First: On the basis of scheme 1, the weight of the second-level index is kept unchanged, and the first-level index weights of the three schemes are adopted respectively. Second: On the basis of scheme 1, the weight of the first-level index is kept unchanged, and the weight of the second-level index of the three schemes is adopted respectively. The evaluation results are shown in Figure 3. [3] and Figure 4. [4].

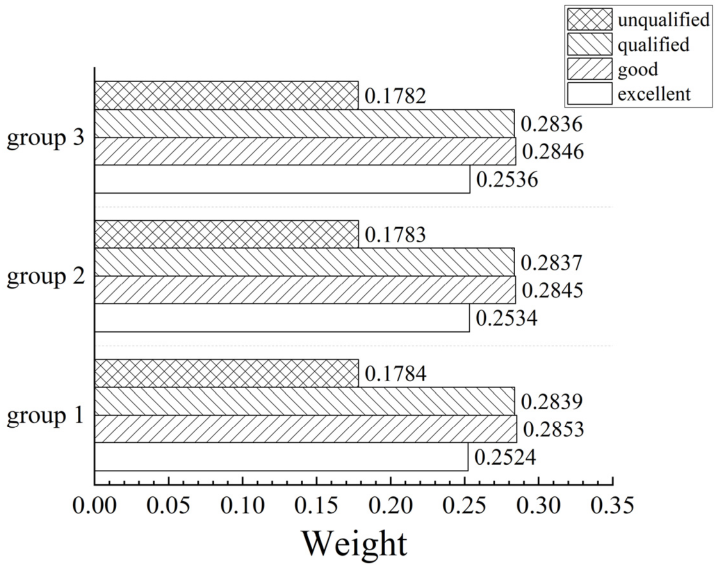

Fig. 3. The evaluation result chart with the constant weight of the secondary index

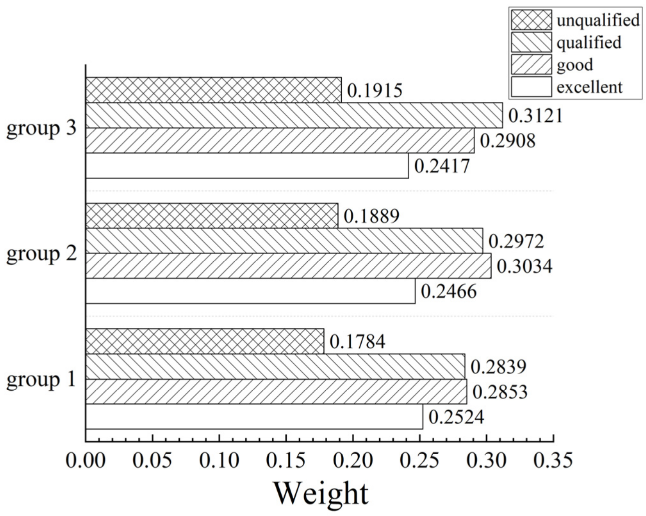

Fig. 4. The evaluation result chart with a constant weight of first-level indicators

According to the principle of maximum membership degree, when the first change scheme is adopted, the three combination evaluation results are *good*. When the second change scheme is adopted, the evaluation results of the first group and the second group are *good*, and the evaluation results of the third group are *qualified*. It can be found that under the condition of constant expert scoring, the change of the weight of the first-level index has little effect on the evaluation results, and the change of the weight of the second-level index will affect the evaluation results.

4 Comparative analysis with the original system

On the basis of the first scheme, remove the first-level index green construction management and the second-level index water source protection measures, animal and plant resource protection measures and park and nature reserve protection measures, and put the original evaluation system into the new evaluation system to consider, which can fully show the difference between considering the new index and not considering the new index. In the new system, the new index score is set to the lowest, and the following calculation results are obtained :

Modify R_1 to R_1^* and R_6 to R_6^*:

$$R_1^* = \begin{bmatrix} 0.00 & 0.00 & 0.00 & 1.00 \\ 0.00 & 0.00 & 0.00 & 1.00 \\ 0.00 & 0.00 & 0.00 & 1.00 \end{bmatrix} \quad R_6^* = \begin{bmatrix} 0.00 & 0.00 & 0.00 & 1.00 \\ 0.00 & 0.00 & 0.00 & 1.00 \\ 0.00 & 0.00 & 0.00 & 1.00 \\ 0.43 & 0.43 & 0.14 & 0.00 \\ 0.29 & 0.29 & 0.29 & 0.13 \\ 0.43 & 0.14 & 0.29 & 0.14 \\ 0.14 & 0.29 & 0.29 & 0.28 \\ 0.14 & 0.29 & 0.43 & 0.14 \\ 0.00 & 0.29 & 0.43 & 0.28 \end{bmatrix}$$

$$B^* = A * R^* = \begin{bmatrix} 0.1760 & 0.2229 & 0.2199 & 0.3797 \end{bmatrix}$$

According to the principle of maximum membership degree, [0.1760 0.2229 0.2199 0.3797]$_{max}$=0.3797, so the evaluation result is *unqualified*.

5 Conclusions

(1) The established green construction evaluation system is divided according to the PSR model. It is found that the results after division are in line with the theory of pressure-state-response model, indicating that the established evaluation system is reasonable. The results of the extension matter-element method and the fuzzy comprehensive evaluation method are compared, and the evaluation results are good.

(2) When the first-level index of green construction management is not considered and considered respectively, the results calculated by the fuzzy comprehensive evaluation method are [0.1957 0.2493 0.2401 0.3134]$_{max}$ = 0.3134 and [0.2524 0.2853 0.2839 0.1784]$_{max}$ = 0.2853. The results prove that it is reasonable to set ' green construction management ' as the first-level index, which can provide reference for the future green construction evaluation system.

(3) After setting the expert scoring of the new added indicators in the new evaluation indicators as the worst, the evaluation result is [0.1760 0.2229 0.2199 0.3797]$_{max}$ = 0.3797 (*unqualified*), and after considering the new first-level indicators and second-level indicators, the evaluation result is [0.2524 0.2853 0.2839 0.1784]$_{max}$ = 0.2853 (*good*).

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