Research on Highway Project Sustainable Development Evaluation under the Perspective of Engineering Philosophy

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Abstract. According to the status of the highway project, and combining with the significance of engineering philosophy, the paper determines the sustainable development evaluation index, using the entropy weight -fuzzy theory to establish the comprehensive sustainable development evaluation model. The actual highway project was made sustainable development evaluation by applying the comprehensive evaluation model, from a practical angle, to verify the feasibility and practicability of the highway project sustainable development comprehensive evaluation model.

Keywords: Engineering philosophy, Sustainable development, Highway project, Entropy theory; Fuzzy evaluation method, Evaluation index

1. Introduction

Engineering philosophy is used to study the engineering practice and analyze the coordinated development of engineering and the natural environment, engineering and the humanities environment, engineering and the social environment. Engineering philosophy is the tie connecting engineering, natural and human and a thinking of human transform natural activities.

Sustainable development is a comprehensive concept of rich connotation, mainly including three aspects: First, ecological economy system is regarded as the basic research object of sustainable development to seek the limit range economic and ecological system, and realize the coordinated development of ecological and social; Second, the scarcity of energy resources together to form a constraint conditions of the economic and social development; Third, when we are pursuing today's economic and social development and its own interests, but also cannot ignore the interests of people in the future. Therefore, sustainable development is a comprehensive concept, including economic, ecological and social fields, involving the relationship of inter and intra generation and that between man and nature. The connotation of sustainable development of project combines the influence of the ecological environment and the use of natural resources and the tolerance of environment etc. From three aspects of economy, environment and society, the sustainable development of construction projects including economic sustainable development, ecological sustainable development and social sustainable development.

The Chinese are promoting the development of the world economy at an unprecedented rate , and has made great achievements, but it is at the expense of consume a large amount of natural resources, energy and cause the negative effects of environment, a lot of highway engineering has been in not friendly to the environment, low level, low efficiency, high consumption and high pollution state, such as ecological destruction, environmental pollution, nonrenewable resources and various social problems, the development is not sustainable. The engineering practice is full of dialectics, the relationship between the engineering activities not only involves the human and nature, but also relates to the people and people, people and society, area and area, different levels of relationship between individual and collective, relates to the whole, overall, fundamental and abstract philosophical questions. In order to achieve the sustainable development of highway engineering, we should follow the philosophy of dialectical engineering of "practice, cognition, practice again,

re-understand", embody the dialectical unity of interdependence, interaction, mutual influence between human and nature.

At present, China is still not a complete evaluation system of sustainable development of highway engineering, the existing evaluation system of project is not completely built on idea and theory of sustainable development, the need of sustainable development is not reflected fully in content. To solve the above problems, this paper will establish the complete evaluation system of sustainable development of highway engineering under the perspective of philosophy, and carries on the objective and accurate evaluation to sustainable development of actual project by fuzzy comprehensive evaluation method.

2. Establishment of fuzzy entropy comprehensive sustainable development evaluation model

2.1. Establishment of evaluation index system

According to the evaluation factor set to establish evaluation index system, the steps are as follows:

(1).Let $U=\{u_1,u_2,...,u_n\}$ being n kinds of sustainable development factors (or indexes), $V=\{v_1,v_2,...,v_m\}$ being m kinds of evaluations. Various factor's position is different, its effect is different also, certainly, weight is different also, so evaluation is different also.

The sustainable development evaluation factor set $U=\{u_1,u_2,...,u_n\}$ is divided into several groups $U=(U_1,U_2,...,U_k)$, $U=\bigcup_{i=1}^{k}U_i$, $U_i\bigcap U_j=\phi(i=j)$, $U=(U_1,U_2,...,U_k)$ is called the first factor set.

Let $U_i=\left\{u_1^{(i)},u_2^{(i)},...,u_{n_i}^{(i)}\right\}(i=1,2,...,k)$, which $n_1+n_2+...+n_k=\sum_{i=1}^{k}n_i=n$ is called the second factor set.

(2).Let have n sustainable development evaluation indexes and select m reviewers, m reviewers evaluate n sustainable development evaluation indexes for formation of the original data matrix $U=(u_{ij})_{n\times m}$.

$$U=\begin{pmatrix} u_{11} & \cdots & u_{1m} \\ u_{21} & \cdots & u_{2m} \\ \vdots & & \vdots \\ u_{n1} & \cdots & u_{nm} \end{pmatrix}$$

2.2Determination of evaluation set

Various evaluation results of evaluation object are form evaluation set, in this model, $V=\{v_1,v_2,...,v_m\}$ being m kinds of evaluations

2.3. Establishment of sustainable development evaluation matrix

Through the expert investigation method and the practical statistical method, using a review account for all the expert-reviewed percentage to determine the membership degree of sustainable development factors, and get the membership degree matrix of second index of sustainable development evaluation.

Making standardized treatment for the original data of membership matrix, the standardized treatment formula as follows: $a'_{ij}=\dfrac{a_{ij}-\min\{a_{ij}\}}{\max\{a_{ij}\}-\min\{a_{ij}\}}$

2.4 Determination of the second index weight tables

When sustainable development evaluation matrix is determined, in order to make a value judgment, through consulting with industry experts to get initial weight of each factor in general,

namely obtain the subjective weight of each factor of the second index and make standardized treatment for the original experts evaluation weight tables.

2.5 Calculation of entropy and weight

Using entropy formula to calculate the weight of the second index, which, the calculation formula of entropy as follows: $e_i = -k\sum_{j=1}^{n} r_{ij} \ln r_{ij}$, which $k = 1/\ln m$, $r_{ij} = \frac{R_{ij}}{\sum_{j=1}^{n} R_{ij}}$; m represents the number of evaluation expert.

The calculation formula of weight as follows: $A_i = \frac{1-e_i}{n-\sum_{i=1}^{n} e_i}, (i = 1,2,...,n)$, which, $0 \le A_t \le 1, \sum_{i=1}^{n} A_t = 1$, n represents the number of evaluation index.

2.6 Determination of the first grade index membership degree

To determine the first grade index membership degree using fuzzy comprehensive evaluation method, steps as follows:

(1)Let evaluation set $V = \{v_1, v_2, ..., v_m\}$, the single factor evaluate n_i factors of the second factor set $U_i = \{u_1^{(i)}, u_2^{(i)}, ..., u_{n_i}^{(i)}\}$, the single factor evaluation matrix is $R_i = \begin{pmatrix} r_{11}^{(i)} & \cdots & r_{1m}^{(i)} \\ r_{21}^{(i)} & \cdots & r_{2m}^{(i)} \\ \vdots & & \vdots \\ r_{n_i 1}^{(i)} & \cdots & r_{n_i m}^{(i)} \end{pmatrix}$.

(2)Let weight of $U_i = \{u_1^{(i)}, u_2^{(i)}, ..., u_{n_i}^{(i)}\}$ is $A_i = (a_1^{(i)}, a_2^{(i)}, ..., a_{n_i}^{(i)})$, which get comprehensive evaluation is $A_i \circ R_i = B_i (i = 1,2,...,k)$.

(3) Comprehensive evaluation the first factors set $U = (U_1, U_2, ..., U_k)$ .Let weight of $U = (U_1, U_2, ..., U_k)$ is $A = (a_1, a_2, ..., a_k)$, the first grade index membership degree matrix is $R = \begin{pmatrix} B_1 \\ B_2 \\ \vdots \\ B_k \end{pmatrix}$.

Note: weight determination method of the first grade index and second index are same.

2.7 Fuzzy comprehensive sustainable development evaluation

To evaluate comprehensively the highway project sustainable development evaluation under the perspective of engineering philosophy by the first grade index weight vector and the first grade index membership degree matrix, the formula is $B = A \times R$, which, B represents the comprehensive membership degree, A represents the first grade index weight vector; R represents the first grade index membership degree matrix.

3. Practical engineering application and analysis

Evaluating sustainable development of an actual highway project under the perspective of engineering philosophy.

3.1 Establishment of evaluation index system

Through detailed analysis and study and combined with the significance of engineering philosophy, sustainable development of the project was evaluated from three aspects of economy, environment

and society: social influence index U_1, environmental influence index U_2, economic benefit index U_3, which is confirmed three the first grade evaluation indexes. The evaluation factor set including the first factor set and the second factor set two parts. The hierarchical structure of sustainable development evaluation index as follows: The first grade factor set is $U=\{U_1,U_2,U_3\}$; the second factor set is $U_1=\{U_{11},U_{12},U_{13}\}$, $U_2=\{U_{21},U_{22},U_{23},U_{24},U_{25}\}$, $U_3=\{U_{31},U_{32},U_{33}\}$, establishment of the evaluation index system structure as shown in table 1.

Table 1 Sustainable development evaluation index system structure

total index	first grade index	second index
Highway project sustainable development evaluation under the perspective of engineering philosophy U	social influence index U_1	promoting social stability degree U_{11}
		promoting political stability degree U_{12}
		promoting social development degree U_{13}
	environmental influence index U_2	highway arterial air pollution degree U_{21}
		highway arterial noise pollution degree U_{22}
		highway arterial garbage pollution degree U_{23}
		highway arterial ecological destruction degree U_{24}
		highway greening degree U_{25}
	economic benefit index U_3	economic promotion of project U_{31}
		highway engineering resources and environment support capability U_{32}
		the project own economic situation U_{33}

3.2Determination of evaluation set

Each index value is divided into five grades, which through fuzzy evaluation to determine. To evaluate set V selected five risk evaluation levels: $V=\{V_1,V_2,V_3,V_4,V_5\}$, V_1 represents poor, V_2 represents less poor, V_3 represents general, V_4 represents less good, and V_5 represents good.

3.3. Establishment of sustainable development evaluation matrix

Using a review account for all the expert-reviewed percentage to determine the membership degree of sustainable development evaluation factors and establish evaluation matrix. See Table 2.

3.4 Establishment of second index weight tables

When sustainable development evaluation matrix is determined, through consulting with industry experts to obtain the subjective weight of each factor of the second index (shown in table 3) and make standardized treatment for the original expert evaluation weight tables, the processing results are shown in table 4.

Table 2 Membership degree matrix of second index of sustainable development evaluation

first grade index U_i	second index U_{ij}	Level				
		poor	less poor	general	less good	good
U_1	U_{11}	2	4	2	1	1
	U_{12}	2	2	3	3	0
	U_{13}	2	3	2	2	1
U_2	U_{21}	2	3	2	1	2
	U_{22}	1	4	1	2	2
	U_{23}	0	2	3	3	2
	U_{24}	2	3	2	2	1
	U_{25}	3	4	1	2	0
U_3	U_{31}	4	3	1	2	0
	U_{32}	2	3	2	2	1
	U_{33}	2	2	3	2	1

Table 3 Sustainable development factors second index weight table

first grade index U_i	second index U_{ij}	evaluation experts 1	2	3	4	5	6	7	8	9	10
U_1	U_{11}	0.025	0.075	0.05	0.05	0.075	0.025	0.025	0.1	0.075	0.05
	U_{12}	0.025	0．05	0.075	0.025	0.05	0.025	0.025	0.025	0.05	0.025
	U_{13}	0.05	0.025	0.025	0.075	0.025	0.1	0.05	0.025	0.025	0.075
U_2	U_{21}	0.2	0.1	0.15	0.175	0.125	0.2	0.15	0.15	0.2	0.1
	U_{22}	0.125	0.2	0.1	0.1	0.1	0.1	0.15	0.1	0.15	0.1
	U_{23}	0.1	0.1	0.15	0.15	0.1	0.1	0.1	0.15	0.1	0.15
	U_{24}	0.175	0.15	0.1	0.1	0.175	0.15	0.1	0.1	0.1	0.2
	U_{25}	0.1	0.15	0.2	0.125	0.15	0.15	0.2	0.2	0.15	0.15
U_3	U_{31}	0.1	0.05	0.075	0.1	0.075	0.05	0.1	0.05	0.05	0.075
	U_{32}	0.05	0.05	0.025	0.075	0.1	0.075	0.05	0.025	0.025	0.05
	U_{33}	0.05	0.05	0.05	0.025	0.025	0.025	0.05	0.075	0.075	0.025

Table 4 Sustainable development factors second index weight table

First grade index U_i	second index U_{ij}	evaluation experts 1	2	3	4	5	6	7	8	9	10
U_1	U_{11}	0	0.667	0.333	0.333	0.667	0	0	1	0.667	0.333
	U_{12}	0	0.5	1	0	0.5	0	0	0	0.5	0
	U_{13}	0.333	0	0	0.667	0	1	0.333	0	0	0.667
U_2	U_{21}	1	0	0.5	0.75	0.25	1	0.5	0.5	1	0
	U_{22}	0.25	1	0	0	0	0	0.5	0	0.5	0
	U_{23}	0	0	1	1	0	0	0	1	0	1
	U_{24}	0.75	0.5	0	0	0.75	0.5	0	0	0	1
	U_{25}	0	0.5	1	0.25	0.5	0.5	1	1	0.5	0.5
U_3	U_{31}	1	0	0.5	1	0.5	0	1	0	0	0.5
	U_{32}	0.333	0.333	0	0.667	1	0.667	0.333	0	0	0.333
	U_{33}	0.5	0.5	0.5	0	0	0	0.5	1	1	0

3.5 Calculation of entropy and weight

Using entropy formula $e_i = -k\sum_{j=1}^{n} r_{ij} \ln r_{ij}$, $A_i = \frac{1-e_i}{n-\sum_{i=1}^{n} e_i}, (i = 1, 2, ..., n)$ to obtain the weight of second index A, the calculation process as shown in Table 5.

Table 5 the second indexes weight table

First grade index	second index	$\sum R_{ij}$	$\sum r_{ij} \ln r_{ij}$	E_i	A_i
U_1	U_{11}	4	-1.8635	0.8093	0.1813
	U_{12}	2.5	-1.4661	0.6367	0.3454
	U_{13}	3	-1.1566	0.5023	0.4732
U_2	U_{21}	5.5	-1.9960	0.8669	0.0966
	U_{22}	2.25	-1.2730	0.5529	0.3245
	U_{23}	4	-1.3863	0.6021	0.2888
	U_{24}	3.5	-1.5741	0.6836	0.2296
	U_{25}	5.75	-2.1108	0.9167	0.0605
U_3	U_{31}	4.5	-1.7351	0.7535	0.2913
	U_{32}	3.666	-1.4916	0.6478	0.4163
	U_{33}	4	-1.7329	0.7526	0.2924

3.6 Determination of the first grade index membership degree

To determine the first grade index membership degree using fuzzy comprehensive evaluation method, the first grade index sustainable development level membership degree as shown in table 6, weight determination method of the first grade index and second index are same,the first grade indexes weight table as shown in table 7.

Table 6 the first grade index sustainable development level membership degree matrix table

R_i	poor	Less poor	general	Less good	good
U_1	2	2.8356	2.3452	2.1639	0.6545
U_2	1.1584	3.0962	1.9038	2.1922	1.6494
U_3	2.5826	2.7076	2.0011	2	0.7087

Table 7 the first grade index weight table

first grade index	$\sum R_{ij}$	$\sum r_{ij} \ln r_{ij}$	E_i	A_i
U_1	2	-2.2836	0.9918	0.0787
U_2	1.85	-2.2878	0.9936	0.0614
U_3	1.25	-2.2824	0.9912	0.0845
U_4	1.35	-2.2747	0.9879	0.1161
U_5	1.45	-2.2732	0.9872	0.1228
U_6	1.2	-2.2604	0.9817	0.1756
U_7	0.9	-2.2161	0.9624	0.3608

3.7 Comprehensive evaluation of sustainable development

The calculation formula of sustainable development comprehensive evaluation is as follows: $B = AR = (A_1, A_2, A_3)(R_1, R_2, R_3)$

This A represents the first grade index weight vector; R represents the first grade index membership degree matrix. The results are as follows:

$B = (1.3042, 3.0556, 1.9327, 2.1769, 1.5319)$

3.8 Analysis of evaluation results

(1) According to the maximum membership degree principle, highway project sustainable development evaluation under the perspective of engineering philosophy is" less poor".

(2)From the first grade index weights to see, the biggest sustainable development factor is the environmental impact factor in the project, so the highway project should pay more attention to highway arterial air pollution degree and highway arterial noise pollution degree and highway arterial garbage pollution degree and highway arterial ecological destruction degree and highway greening degree.

(3) The highway project should pay more attention to promote social stability degree and promote social development degree and highway engineering resources and environment support capability in order to improve sustainable development according to the second indexes weight and membership degree.

4. Conclusion

The fuzzy comprehensive evaluation method based on entropy was applied to evaluate on highway project sustainable development evaluation under the perspective of engineering philosophy, the first grade index membership degree matrix and the second index weight and membership degree were obtained by using the traditional fuzzy evaluation method. The subjective weight of experts was standardized processing to obtain comprehensive weight, which can make determination of the weight more scientific, reasonable, and ensure the reliability of the evaluation results. The fuzzy comprehensive evaluation method based on entropy can overcome the shortcomings of single

sustainable development evaluation method, and make the sustainable development assessment process more practical and safe and the evaluation results more objective.

References

[1] D.Qiu, L.H.Wang: Reflection on the Practical of Philosophy of Engineering, Studies in Philosophy of Science and Technology, Vol. 31 (2014) No.1, p.72-75.

[2] G.Zhao,H,Liu: Practical risk assessment based on multiple fuzzy comprehensive evaluations and entropy weighting, J Tsinghua Univ(Sci & Tech), Vol. 52 (2012) No.10, p.1382-1387.

[3] Y.Y.Jiao,Y.M.Ye: Sustainable development evaluation research based on the philosophical thinking, Southeast Academic Research,Vol. 2 (2013) p.87-94.

[4] N.Rosales: Towards the modeling of sustainability into urban planning: Using indicators to build sustainable cities, Procedia Engineering, Vol. 21 (2011), p.641-647.

[5] D.W.Liu,L.Lei,B.Li: Fuzzy-Entropy Theory Comprehensive Evaluation Method and Its Application in Building Construction Safety, Procedia Engineering, Vol. 43 (2012), p.137-142.

[6] W.L.Dong,J.Mackeea,M.Mak: Exploratory analysis of the traditional philosophy underpinned urban sustainability model for Chinese cities, Procedia Engineering,Vol. 21(2011), p.838-845.

[7] H.L.Sun,X.W.Li: Construction of large infrastructure sustainable development ability evaluation system, Statistical and Decision,Vol. 16 (2013), p.29-31.

[8] C.S.Sun,L.Y.Shen: Study on the construction project sustainability based on information flow analysis, China Civil Engineering Journal, Vol. 45 (2012) No.2, p.316-320.

[9] J.X.Zhang,L.G.Wang: Study on construction project sustainable construction system under eco-economic perspective, Construction Economy,Vol. 10 (2012) , p.5-10.

[10] S.X.Duan: Hydraulic engineering management under the philosophy perspective, Enterprise Economy, Vol. 8 (2012) , p.55-59.

[11] F.G.Pan,X.K.Wu: Sustainable development of high-rise building, Procedia Engineering,Vol. 21 (2011) , p.943-947.

[12] X.Zhao,Z.L.Li: Study on construction project dynamic evaluation system under the sustainable development idea, Construction Economy, Vol. 5 (2010) , p.107-110.

[13] X.W.Li,H.Chen,H.P.Shao,etc: Evaluation model of urban traffic sustainable development based on matter element with AHP and entropy, J.Xi'an Univ. of Arch. & Tech(Natural Science Edition),Vol. 43 (2010) No.6 , p.831-837,858.

[14] C.D.Chen,H.J.Fu: Appraisal method on sustainable development for highway project, Journal of Ha Erbing of Technology,Vol.41 (2009) No.4 , p.253-256.

[15] R.Zeng,H.K.Chen,J.Y.Li: Fuzzy Comprehensive Evaluation Method Based on Entropy in Road Flood Risk Assessment, Journal of Chongqing Jiaotong University(Natural Science Edition),Vol.29 (2010) No.4 , p.587-591.