Civil Engineering and Technology
December 2015, Volume 4, Issue 4, PP.48-52

Application of Sustainable Post-assessment System Model in the Water Conservancy Construction Project

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Abstract

Sustainable post-assessment of great water conservancy construction projects is lack of systemic and quantitative research at present. To solve this problem, based on the theory of sustainable development, construction principles of post-assessment index of water conservancy construction project are put forward. Combined with cases, a sustainable post-assessment model and method are developed using the hierarchic analysis method.

Keywords: Water Conservancy Construction; Infrastructure Project; Sustainability; Post-Assessment; Model

1 INTRODUCTION

Post-assessment of the water project began in the late 1990s'.However, in the post-assessment of the water project, the internal and external conditions are usually analyzed in an easy way, and sustainability assessment is often limited to qualitative description and summary, lack of systemic and quantitative research[1,2].

The evaluation of sustainable development is a decision problem of multi-level and multi-field. In order to enhance the guiding role of sustainable development in water conservancy construction, firstly, the target of the sustainable development can be expressed by some quantitative and concrete indicators, instead of qualitative and abstract indexes. Secondly, an index system is set up to explicitly describe the water conservation project with some quantitative indexes. Thirdly, a rule is put forward to provide theoretical support for scientific decision-making of water conservancy construction project

2 CONSTRUCTION PRINCIPLE OF POST-ASSESSMENT INDEX OF SUSTAINABLE DEVELOPMENT OF WATER CONSERVANCY CONSTRUCTION PROJECT

A scientific and reasonable index system is the basis of accurate and reliable assessment. Some indexes are used to make quality assessment on evaluation objects in one, many or comprehensive ways, according to some regulations and methods. The principles of an assessment index system are as follows[3]:

(1)Principle of science

Indicators of an assessment system should be built following the principle of science, and can objectively reflect the connotation of the sustainable system of water conservancy projects, and reflect the basic characteristics of the sustainable development of water conservancy construction project.

(2) Principle of comprehensive and systematic

Water conservancy construction project is a complicated system with multiple attributes, which involves many aspects of economic, social and natural environment and so on, all of which influence the water project's sustainability. Evaluation index should reflect the overall situation of water conservancy construction project in the evaluation period from the point of comprehensiveness and system at city. Evaluation indexes constitute an indicator system including multiple groups and levels.

(3)Principle of coordination

The definition of indicator should be specific, and data is easy to collect and obtain, and index statistics are consistent with the planned and accounting standards and the evaluation index and corresponding computational method should be standardized and normalized.

(4)Principle of dynamic and open

Water conservancy construction project sustainability is not only a goal, but also a development process, which determines the index system is not static. The establishment of the index system should follow the principle dynamic openness in maintaining the overall stability and can show the trend of the time.

3 POST-EVALUATION METHOD FOR SUSTAINABLE DEVELOPMENT OF WATER CONSERVANCY CONSTRUCTION PROJECT

The analytic hierarchy process (AHP) [4]divides the decision problem into a control relationship of multiple hierarchical levels. The top layer is the target layer, the middle is the principle level, there are multiple sub-principle levels according to the problem, and the last is program level. In the hierarchical relationship, the lower level elements are controlled by the upper elements, and the importance of the lower elements is determined by the comparison between any two means, which is also called weight. Based on the analyses of a series of factors influencing the target, to compare their relative importance, the program whose final score is highest is the optimal solution.

The hierarchical structure of AHP simplified the relationship between the elements of the system, and it can solve all kinds of complex systems. The post evaluation of water conservancy construction project involves many aspects, such as engineering technology, economy, society, environment, management, etc. There is not only qualitative index, but also quantitative index,

The water conservancy construction project involves engineering technology, economic, society, environment, arrangement and so on; gradation is strong, and the evaluation has a certain ambiguity. The application of fuzzy analytic hierarchy process is more ideal. The procedures are shown as follows:

(1) An evaluation factor set is set up: $U = \{u_1, u_2, \cdots u_m, \}$, comment set is $V = \{v_1,\ v_2,\ \cdots v_n\}$.

(2) The weight vector $W$of$m$valuation factors is determined. The water project sustainable assessment is of the characteristics of multi-objective decision,and it presents obvious layers between various factors. AHP is used to determine the weight vector of the assessment indicator.

(3) Establish membership matrix R

$$R = \begin{bmatrix} R_1 \\ R_2 \\ \cdots \\ R_m \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \quad (1)$$

Where, $R_i = \{r_{i1},\ \ r_{i2}\ \ r_{i3}\ \ \cdots\ \ r_{in}\}$ is the single factor evaluation set ofu_i, r_{ij} is frequency distribution, which will meet its normalization$\sum_{j=1}^{n} r_{ij} = 1$.

(4) Calculate the comprehensive score of evaluation object

$$P = WR \quad (2)$$

4 PRACTICAL APPLICATION IN ENGINEERING

In a water conservancy expansion project, the city flood control standard is to withstand the worst flood in 50 years, designed flood discharge capacity is 4000 m^3/s. The main construction contains hydro project excavation, river beach width, embankment reinforcement, culvert and bridge engineering. Budge estimate of project investment is 215 million RMB.

4.1 Establishment of Sustainable Development Post-Assessment System and Comment Set of Water Conservancy Construction Project

The sustainable development post-assessment system of water conservancy construction project aims at the characteristics of the water project, which is composed of various kinds of indexes, such as engineering technology, economic, society, environment, and management mechanism, reflecting the interrelation and interaction index set of the water project. In the construction of indicators, we should pay attention to the dynamic performance, long-term and universal, but also to the comprehensive and representative indicators, aiming at different water construction projects, and realizing various types of the water construction sustainable in different directions, different scopes and different levels.

In order to make a scientific and whole assessment on sustainable capacity of water conservancy construction project, the sustainable of the water construction project is combined under the guidance of the sustainable assessment indicators system of the water project, aiming at the characteristics of the field of water construction[2,3].The sustainable assessment indicator system of the water construction project is established as shown in Fig.1.

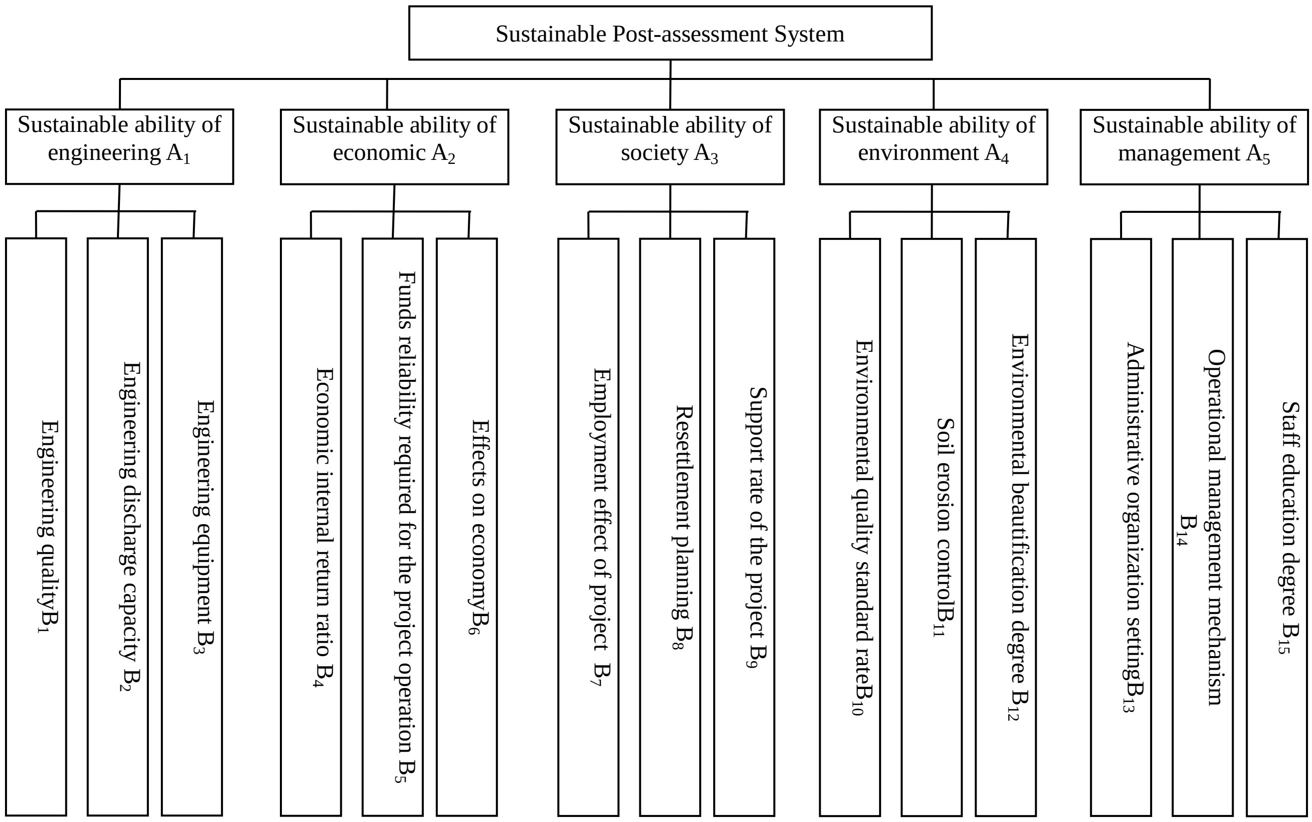

FIG.1 THE POST-ASSESSMENT OF SUSTAINABLE HIERARCHICAL STRUCTURE OF THE PROJECT

On the basis of some relative research results of the society sustainable development, the comment set of this project is divided into five kinds of classes: unsustainable, insufficient sustainable, sustainable, and sufficient sustainable and strong sustainable.

4.2determining the Evaluation Criterion Weight

The evaluation criterion weight is an important factor in multi-index comprehensive evaluation systems. As shown in table 1, a 2×2 judgment matrix by using expert scoring method is built and maximum matrix characteristic root and eigenvector of the judgment matrix are calculated by numerical simulation, hierarchy single ranking and its uniformity inspection, hierarchy general ranking, uniformity inspection, then the evaluation criterion weights at various levels are obtained.

TABLE 1 EVALUATION CRITERION WEIGHT

comprehensive evaluation index	first grade indexes	weight	second grade indexes	type	weight	qualitative/quantitative basis
Sustainable Post-assessment System (P)	Sustainable ability of engineering (A_1)	0.3015	Engineering quality (B_1)	quantitative	0.1437	Engineering quantity of excellent grade/Total engineering quantity
			Engineering discharge capacity (B_2)	qualitative	0.1055	Indicators of flood control standards before and after construction
			Engineering equipment (B_3)	quantitative	0.0503	Actual/theoretical number of devices
	Sustainable ability of economic (A_2)	0.1983	Economic internal return ratio (B_4)	quantitative	0.0843	Contribution to the national economy
			Funds reliability required for the project operation (B_5)	qualitative	0.0744	Project fund input and output
			Effects on economy (B_6)	qualitative	0.0387	Impact on the life and industrial structure
	Sustainable ability of society (A_3)	0.1387	Employment effect of project (B_7)	quantitative	0.0267	Number of jobs available/total investment
			Resettlement planning (B_8)	qualitative	0.0475	Living environment and economic level of immigrants
			Support rate of the project (B_9)	quantitative	0.0614	the population number supporting project/total population quantity of project area
	Sustainable ability of environment (A_4)	0.1037	Environmental quality standard rate (B_{10})	quantitative	0.0404	(standard-reaching rate of air quality+water environment+noise environment)/3
			Soil erosion control (B_{11})	quantitative	0.0363	Soil erosion amount before and after take measures
			Environmental beautification degree (B_{12})	qualitative	0.0249	Greening environment in the project area with environmental harmony
	Sustainable ability of management (A_5)	0.2587	Administrative organization setting (B_{13})	qualitative	0.0918	If management organization is conducive to project operation
			Operational management mechanism (B_{14})	qualitative	0.0981	Perfection and operability of rules and regulations
			Staff education degree (B_{15})	qualitative	0.0670	Educational background, professional title of staff

4.3 Membership Matrix of the Comment Index

1)Membership Matrix of The Qualitative Index

For the qualitative index, the comment set of the qualitative indicators is obtained by adopting fuzzy statistical method to calculate experts' opinion. For example, five experts known of this project are invited to make a comprehensive evaluation on B2 "engineering flood discharge capacity", which involves construction management, planning and design, operation management and so on, instead of experts in participation department which are exclusive. There is one expert that believes "basic sustainable", three experts consider "sufficient sustainable", one expert thinks that "strong sustainable", then according to experts' opinion, the fuzzy statistical matrix of B_2 is$(\mathbf{0}, \mathbf{0}, \mathbf{0.2}, \mathbf{0.6}, \mathbf{0.2})$.In the same way, we can obtain other indicators.

2)Membership Matrix of the Quantitative Index

For the quantitative index, membership's values are determined by forming membership function. The paper fixes on low half echelon school function and trapezoidal distribution function as membership function.

The evaluation index factor set is:$X_T = (x_1, x_2, \ldots, x_m)$, evaluation grade standard is: $V = (v_1, v_2, \ldots, v_n)$, at the assumption of v_j and v_{j+1} being two adjacent level standard, we get v_j

$$R_j = \begin{cases} \begin{cases} 1 & x_i \le v_1 \\ \frac{v_2 - x_i}{v_2 - v_1} & v_1 < x_i < v_2 \quad j = 1 \\ 0 & x_i \ge v_2 \end{cases} \\ \begin{cases} 1 - r_{j-1} & v_{j-1} \le x_i \le v_j \\ \frac{v_{j+1} - x_i}{v_{j+1} - v_j} & v_j < x_i < v_{j+1} \quad j = 2, 3 \ldots \ldots, n \\ 0 & x_i \le v_{j-1} \text{或} x_i \ge v_{j+1} \end{cases} \end{cases} \quad (3)$$

According to Eq.(3), normalization processing was made to the membership value r_{ij}, we get the membership matrix of $\boldsymbol{R}$.

3) Appraisal Conclusion

Evaluation results must be calculated in conjunction withweight vector W and membership matrix, we can get

$$P = (W_{ij})_{1\times15} \cdot (R_{ij})_{15\times5} = (0,0.007117,0.162361,0.506418,0.324104) \quad (4)$$

The results show that this project has a 50.6% chance that belongs to “sufficient sustainable”, and the maximum degree of membership belongs to this grade, so that the project's sustainable capacity is “sufficient sustainable". Although the possibility of this project's sustainable capacity being strong and sufficient sustainable is 83.1%, but there are still some weak sustainable. Relevant departments should take measures to enhance the project's sustainable capacity.

ACKNOWLEDGEMENT

This research was supported by the Scientific Research Project of Hebei Province Water Resources Bureau (No.2012115).

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