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Cost-benefit Analysis of Land Development Projects Based on Fuzzy Comprehensive Evaluation Model

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Abstract Ecological and environmental issues have always been the focus of government work. The economic losses caused by air pollution, water pollution, noise pollution and solid waste pollution caused by land use development projects are estimated, and the total population economic losses are incorporated into project costing. Using the analytic hierarchy process, four benefit indicators and five cost indicators are selected for constructing a fuzzy comprehensive evaluation model to evaluate the cost-benefit of projects of different scales. The projects of different scales are ranked according to the level of comprehensive scores. The results show that large-scale projects are cost-effective and stable over the long term, and there are differences in the main sources of pollution-caused economic losses for projects of different scales. At last, reasonable policy suggestions are made to relevant planning and management personnel.

Key words Pollution-caused economic losses, Cost-benefit, Fuzzy comprehensive evaluation

1 Introduction

Protecting the environment, as one of China's basic national policies, is the basic principle for human survival, and government departments have always attached great importance to ecological issues. Land use and development have brought serious environmental pollution problems while promoting economic development. The economic losses caused by pollution must be taken into account in the cost of projects. The benefits and pollution-caused economic losses brought by projects of different scales are different. Therefore, it is important to analyze the cost-benefit of land use and development projects. Taking the Yangtze River Delta as an example, Zhang Wei *et al.* established a multi-regional CEG model to estimate indirect economic losses caused by water pollution. The study concluded that indirect economic losses far outweigh direct economic losses, and Shanghai's economic losses are more serious[1]. Li Jie estimated the economic losses caused by traffic noise pollution to Beijing using various methods such as market evaluation method and willingness survey and value evaluation[2]. Tian Junfeng conducted empirical study on the comprehensive benefits of land use in the three northeastern provinces, and it is concluded that the economic benefits of urban land use increase first and then decrease, the difference of social benefits is not obvious, and the overall ecological benefits are higher. The characteristics of spatial variation were further analyzed[3]. Taking the Nantong Development Zone as a research sample, Xu Xuemei analyzed the impact of land use planning influencing factors on real estate development and proposed a reasonable and efficient land use planning to maximize project cost-effectiveness[4]. Wu Ying selected indicators from the three aspects of economy, society and ecology to construct a multi-level fuzzy comprehensive evaluation model to evaluate the land consolidation project, analyzed the shortcomings in the project and put forward suggestions[5]. As can be seen from the combing of the literature, fuzzy comprehensive evaluation is widely used in benefit evaluation, performance evaluation, development level assessment, *etc.* After estimating the economic losses caused by environmental pollution caused by the project, based on the hierarchical analysis indexes, the fuzzy comprehensive evaluation model is used to evaluate the cost-benefit of land use and development projects of different scales. Finally, reasonable suggestions are made to relevant personnel based on the research results.

2 Cost-benefit analysis of land development and utilization projects of different scales

2.1 Research ideas The environmental pollution-caused economic losses caused by the land development and utilization project need to be included in the project cost for accounting to ensure the real benefit of the project[6]. Although the cost of the project will increase significantly in the short term, in the long run, after the implementation of improvement measures, the benefits of the project will increase. Fig. 1 shows the relationship between economic losses from pollution and project benefits. Projects of different scales are accompanied by high costs while bringing huge benefits. It is very important to construct a model to evaluate the cost-benefit of land development and utilization projects of different scales.

2.2 Model construction and solution Next, a fuzzy comprehensive evaluation model is constructed based on analytic hierarchy to evaluate the cost-benefit of projects of different scales. First, projects of different scales are divided into small community projects, urban projects, provincial projects, large-scale national projects. Then, four benefit indicators (the increase in per capita disposable

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income, investment yield, increase in land utilization rate and traffic accessibility) and five cost indicators (actual cost of the project itself and environmental costs (air pollution, noise pollution, water pollution and solid waste pollution)) are selected. Thus, nine indicators are used to evaluate the cost-benefit of projects of four different scales. The specific hierarchical analysis is shown in Fig. 2. In order to facilitate the processing of data, the nine indicators of the four projects are quantified. The value of the j-th indicator of the i-th project is expressed as α_{ij}, so the observation matrix is obtained ($A=(\alpha_{ij})_{4\times 9}$). Then, the coefficient of variation method is used to normalize the values of each indicator, so that the weight of each indicator is obtained. Finally, comprehensive analysis and evaluation is carried out based on the weight result.

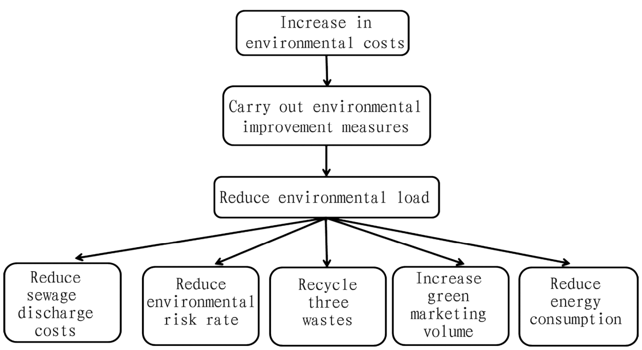

Fig. 1 The relationship between pollution-caused economic losses and project benefits

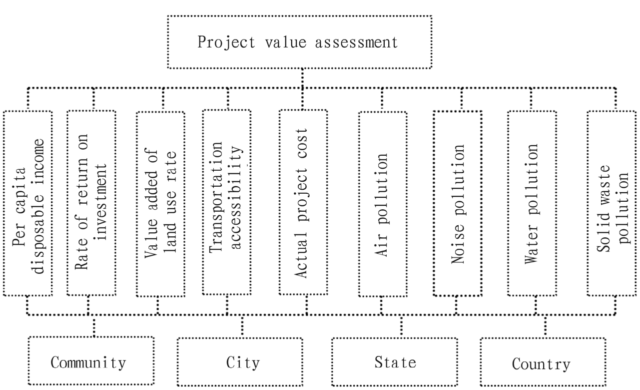

Fig. 2 Composition of analytic hierarchy process

2.2.1 Standardizing the original sample data[7-8]. First, the original sample data is standardized. For the four benefit indicators, the standardization formula is $\overline{a_{ij}}=\frac{a_{ij}-\min\limits_{1\leqslant i\leqslant 4}\{a_{ij}\}}{\max\limits_{1\leqslant i\leqslant 4}\{a_{ij}\}-\min\limits_{1\leqslant i\leqslant 4}\{a_{ij}\}}$; and for the five cost indicators, the standardization formula is $\overline{a_{ij}}=\frac{\max\limits_{1\leqslant i\leqslant 4}\{a_{ij}\}-a_{ij}}{\max\limits_{1\leqslant i\leqslant 4}\{a_{ij}\}-\min\limits_{1\leqslant i\leqslant 4}\{a_{ij}\}}$.

2.2.2 Establishing an ideal solution. In order to facilitate the processing of data, all cost indicators are converted into benefit indicators according to the following formula: $a'_{ij}=\frac{1}{a_{ij}}$. Therefore, the established ideal solution is $\mu=(\mu_1, \mu_2, \mu_3, \mu_4)$. Among them, $\mu_i=\begin{cases}\max\limits_{1\leqslant j\leqslant 9}\{a_{ij}\} & \text{when } a_{ij} \text{ is a benefit indicator}\\ \min\limits_{1\leqslant j\leqslant 9}\{a_{ij}\} & \text{when } a_{ij} \text{ is a cost indicator}\end{cases}$ $(i=1, 2, 3, 4)$, indicating the cost-benefit of the i-th project.

2.2.3 Constructing a relative deviation fuzzy matrix[9-10]. Relative deviation fuzzy matrix is established:

$$R=(r_{ij})_{4\times 9}=\begin{pmatrix} r_{11} & r_{12} & \cdots & r_{19}\\ r_{21} & r_{22} & \cdots & r_{29}\\ r_{31} & r_{32} & \cdots & r_{39}\\ r_{41} & r_{42} & \cdots & r_{49}\end{pmatrix}$$

where $r_{ij}=\frac{|a_{ij}-\mu_i|}{\max\limits_{1\leqslant j\leqslant 9}\{a_{ij}\}-\min\limits_{1\leqslant j\leqslant 9}\{a_{ij}\}}$.

2.2.4 Determining the weight. After completing the above steps, the weight of each evaluation indicator is determined as follows: w_i $(i=1, 2, 3, 4)$. Using the variation coefficient method, the values of each indicator are normalized. The coefficient of variation of each indicator is calculated according to the following formula:

$$v_j=s_j/|\overline{x_j}|$$

where $\overline{x_j}=\frac{1}{4}\sum_{i=1}^{4}a_{ij}$ and $s_j^2=\frac{1}{4-1}\sum_{i=1}^{4}(a_{ij}-\overline{x_j})^2$ are the mean and variance of the j-th indicator, respectively.

2.3 Analysis of results According to the formula for variance coefficient, the coefficient of variation of the nine indicators is obtained. Then, V_j is normalized to obtain the weight of each indicator, and the processing forma is:

$$w_j=v_j/\sum_{j=1}^{9}v_j$$

The coefficient of variance and weight of each indicator are shown in Table 1.

The comprehensive score is calculated based on the weight of each indicator and the fuzzy matrix according to the following formula:

$$F_i=\sum_{j=1}^{9}w_j\cdot r_{ij}$$

The comprehensive score of project of different scale is F_i. The comprehensive scores of small community project, urban project, provincial project and large-scale national project are 82.6, 154.3, 185.5 and 251.8, respectively. It can be seen from the results that as the scale of the project increases, the cost-effectiveness it brings is greater. In land use and development projects, the smaller the scale is, the lower the benefit is, and the lower the cost is. For small community project, urban project, provincial project and large-scale national project, as the scale continues to expand, the benefits and costs continue to increase. But in smaller projects, the benefits are low, so the proportion of costs is often high. The greater the scale is, the lower the proportion of cost is. Therefore, the greater the scale of the project is, the higher the comprehensive evaluation score is, and the higher the cost-benefit is. In addition to the cost of the project, the selected cost indicators also include air pollution, noise pollution, water pollution and solid waste pollution. In small community projects, the atmospheric and noise pollution caused is usually small, and the water pollution and solid waste pollution account for a large proportion. The latter two have a greater impact on the benefit indicators that have been selected, such as the increase in land utilization rate, so the comprehensive score is lower, that is, the cost-benefit is lower. In large-scale projects, such as large-scale national projects, the proportion of atmospheric and noise pollution increases. Both of them have less impact on indicators such as the increase in land utilization rate, so the comprehensive score is higher, that is, the cost-benefit is higher than small projects.

Table 1 Coefficient of variation and weight of each indicator

Indicator	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
Coefficient of variation	1.230	0.965	0.421	0.955	1.840	0.623	0.784	0.412	0.635
Weight	0.156	0.123	0.054	0.121	0.234	0.079	0.100	0.052	0.081

2.4 Sensitivity analysis As project benefits change over time and are affected by multiple factors, in order to study the effect of changes in the indicators of the model on the results, it is necessary perform sensitivity analysis on the indicators in the model to verify the stability of the model and make more comprehensive and accurate conclusions. Taking the project benefit curve in the model as an example, the quadratic parameter in the model is selected as the analysis object. It is assigned as −0.88, −0.89, −0.90, −0.91 and −0.92, respectively to observe the influence of changes in it on the model or on the trend of change. Sensitivity analysis is performed using MATLAB software and the results are shown in Fig. 3. It can be seen that the project benefits increase with time, and the magnitude of the increase gradually decreased and finally stabilizes. Changes in model parameters do not change the trend of project benefits. The change of parameters in the first five years of the sample interval has almost no effect on the model itself; and in the next ten years, the change of project benefits with time has a small change due to the change of parameters, but the error is within the allowable range. The sensitivity analysis verifies the validity of the model from another angle, which is of great significance for the research of this paper.

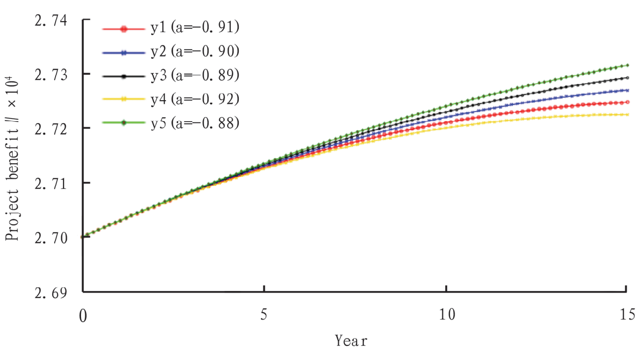

Fig. 3 Sensitivity analysis

3 Policy suggestions

Land use and development pursues the coordination of the three major benefits of ecology, economy and society. Ecological benefits are the premise and foundation of any project. Social benefits are the fundamental purpose of land use and development projects. The pursuit of economic benefits is an inherent requirement in land use and development projects. For land planning and management personnel, in addition to economic and social benefits, ecological benefits must be considered when making decisions. Environmental cost of the project must be reduced reasonably to reduce pollution from the source and protect the ecological environment. Relevant government officials should try to eliminate the adverse effects of project development or minimize its adverse effects through scientific planning and reasonable construction. According to the cost-benefit analysis of projects of different scales, planners can make a reasonable assessment of the land development project first. After fully understanding the cost-benefit of the project and understanding the true value of the project, land resources are utilized rationally, and land utilization rate is improved, which are of great significance to promote urban planning and economic development. Since the project should take into account the economic loss of environmental pollution, this will inevitably increase the difficulty of management. Therefore, managers should adopt new and more effective management programs to supervise the quality and progress of the project.

References

[1] ZHANG W, LIU Y, JIANG L, *et al.* Evaluating the economic loss induced by water pollution based on multi-regional CGE Model: a case study of Yangtze River Delta Basin[J]. China Environmental Science, 2016, 36(9): 2849 –2856. (in Chinese).
[2] LI J, SHEN Y, WANG XM. Economic loss and evaluation of urban road traffic noise pollution [J]. Western China Communications Science & Technology, 2013, 8(9): 33 –37,83. (in Chinese).
[3] TIAN JF, WANG BY, WANG SJ. Urban land use efficiency and its coupling relationship in the three provinces of Northeast China[J]. Scientia Geographica Sinica, 2019, 39(2): 305 –315. (in Chinese).
[4] XU XM, ZHOU LH, WANG L. Real estate development under the background of land use planning: Taking Nantong Economic and Technological Development Zone project as an example [J]. Management Observer, 2014, 34(15): 28 –29. (in Chinese).
[5] WU Y, JIN XB, ZHOU YK. Construction and application of land consolidation project ex post benefit evaluation index system based on multiple levels fuzzy synthetic evaluation[J]. Chinese Agricultural Science Bulletin, 2007, 24(9): 509 –513. (in Chinese).
[6] HU MH. Pollution assessment of industrial wastewater based on pollution lost rate method[J]. Chinese Agricultural Science Bulletin, 2015, 32(7): 185 –188. (in Chinese).
[7] LI WY, ZHONG LH, ZHU L. Cost-benefit analysis of urban sewage treatment projects[J]. Finance and Accounting Monthly, 2015, 36(15): 67 –70. (in Chinese).
[8] LU X, QIN Q. Research on performance evaluation of PPP project based on AHP-FCE watershed management[J]. Journal of Beijing University of Civil Engineering and Architecture, 2019, 35(1): 88 –94. (in Chinese).
[9] YANG J, WANG ZQ, JIN G, *et al.* Post-benefit evaluation of land consolidation project implementation based on AHP and fuzzy comprehensive evaluation[J]. Resources and Environment in the Yangtza Basin, 2013, 22(8): 1036 –1042. (in Chinese).
[10] LIU YC, CHANG CG, LIU N, *et al.* AHP based fuzzy comprehensive evaluation for townifying level[J]. Journal of Shenyang Jianzhu University(Natural Science), 2008, 30(1): 132 –136. (in Chinese).