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Ecosystem Service Evaluation Model based on Land Development and Utilization Project

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Abstract. With the rapid growth of population and dramatical development of economy, the problem of environmental degradation has gradually come into the field of human concern. In order to measure environmental costs more intuitively and accurately, and propose reasonable human intervention measures, we establish a set of Ecosystem Service Evaluation Model based on land development and utilization projects. Our model summarizes the five major environmental cost objects based on the 38 indicators of the invest model, and uses the alternative market evaluation method to quantify the cost objects. According to the advantages and disadvantages of these indicators, we use the gray correlation analysis method to analyze the correlation degree of eight of them. Besides, we analyze 30 actual data, which represents development and utilization projects of different sizes and types. Then determine that the critical value of cost-benefit ratio is 1. 5. We apply our model to the representative development project of thermal powerplant to test the applicability of the model. Finally, we conduct a sensitivity analysis in order to gain some deep understanding our model, and conclude the report via discussing the strengths and weaknesses of our proposed model.

Keywords: environmental degradation; Ecosystem Service Evaluation Model; sensitivity analysis; strengths and weaknesses of our proposed model.

1. Introduction

1.1 Background

Environmental degradation is one of the top 10 threats formally warned by the UN high-level panel on threats, challenges and reforms. Environmental cost refers to the cost of the decline of environmental service quality due to environmental pollution caused by economic activities.

In order to solve this problem, Stanford university, The Nature Conservancy (TNC), and the World Wide Fund for nature (WWF) jointly invest model is developed, realizing the quantitative evaluation of ecosystem service function value space, and based on this model, which in turn produces the concept of Ecosystem Services Evaluation Model, considering the environmental cost of calculation under the condition of real economic cost of the project. Rational development of land use projects to minimize environmental costs has unprecedented significance in today's world.

1.2 Our Work

In order to determine the real economic cost of land development and utilization project, it is necessary to establish an Ecosystem Service Evaluation Model that can determine the environmental cost of the project. By selecting appropriate evaluation indexes and using some existing economic means, such as direct market valuation method and alternative market valuation method, the objects of environmental costs are determined. Then, the model is applied to land development and utilization projects of various sizes to test its applicability and accuracy, and suggestions are put forward for improvement.

To solve these problems as far as possible, we will take the following steps:

•Establish the ecosystem service evaluation model, analysis the project cost and benefit.

•Based on the invest model, we determined the evaluation index through the gray correlation analysis method and MATLAB and other software tools, and then established the general environmental cost measurement model to quantify the environmental cost.

•Apply our model to typical scale characteristics of land development and utilization in the project, and the analysis of the actual impact of their environmental cost factors. We then define a tipping point to determine when a project reaches its maximum environmental cost.

2. Model Establishment and Analysis

2.1 Classification Environmental Costs

Based on the inVEST model and relevant literature, we classify the environmental costs:

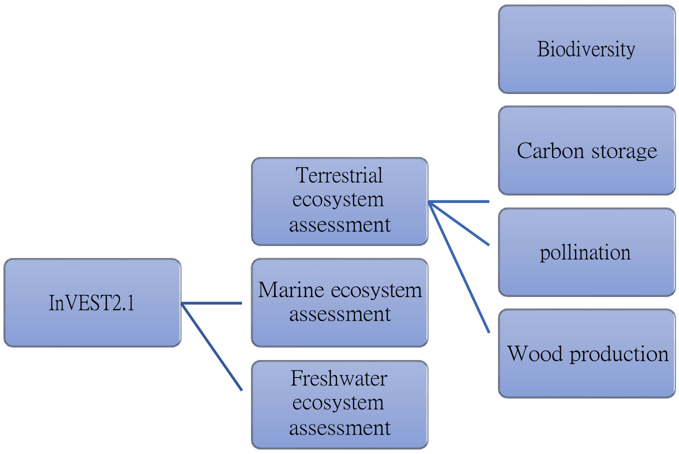

Figure 1. structure diagram

According to the characteristics of the invest model, the indicators of terrestrial ecosystem assessment are classified into biodiversity, carbon storage, pollination and wood yield. For our project, we choose the following practical factors to consider: biodiversity, Carbon storage (carbon density), Water quality, Air quality, Solid waste (waste residue, white garbage, etc.).

2.2 Establishment of Environmental Cost Model

2.2.1 General Environmental Cost Measurement Model

Since the environmental cost does not have the direct market economic value, we use the alternative market evaluation method to transform the environmental cost so as to estimate the environmental cost of the development project.

The application conditions of the alternative market evaluation method are:

(1) although there is no direct market for relevant environmental services, their substitutes or complements can be found;

(2) there are transaction prices and market prices for these alternative or complementary goods.

2.2.2 ESA

Firstly, various indicators related to environmental costs are identified. Then, after identifying relevant data, the environmental cost objects are determined through analysis. Then, alternative market evaluation method is adopted to convert the indicators into economic indicators, so as to calculate environmental costs.

Based on the alternative market evaluation method, we established the environmental cost measurement model:

According to the formula, it can be known that:

Environmental cost (W) = biodiversity (W_B) + noise pollution (Wn) + water pollution (Wp) + solid waste pollution (Ws) + gas pollutant (Wg)

The following will translate the project's impact on five aspects into measurable economic costs:

1) biodiversity (W_B)

Biodiversity is a concept describing the diversity of nature. Different scholars define biodiversity differently. Here, in order to simplify the model, we only consider the value of some organisms that are more affected by the environment in the area of human intervention, and do not consider the biological cost caused by the indirect impact of the project on biodiversity. By referring to the data, we obtained the following formula:

$$C_0 = C_1 + C_2 = \sum \left(\frac{A_I}{Q_I} * N \right) + \gamma * B_P * F \qquad (1)$$

$$L_i = \frac{C_0 * C_1}{k} + C_0 * \left(G - g_i \right) \qquad (2)$$

$$W_B = \sum_{i=1}^{n} \left(\frac{L_i}{\left(1 - \frac{M_i}{Q_i} \right)} * M_i \right) \qquad (3)$$

2) noise pollution (Wn)

Noise pollution refers to the phenomenon that the environmental noise generated exceeds the environmental noise emission standards set by the state and interferes with the normal life, work and study of others. Environmental noise pollution is a kind of energy pollution. Like other industrial pollution, it is a public hazard to human environment. Noise pollution can be divided into low sound shell and high sound shell. By consulting data, we quantify it as economic loss:

$$W_n = L_h + L_1 = RP_d b + C + AP_0 \beta b \left(1 + \lambda_p \right)^t \qquad (4)$$

3) water pollution (Wp)

Water pollution is caused by harmful chemicals that reduce or lose the use value of water and pollute the environment. Through the national sewage discharge standards and charges, we can use the indirect cost method to calculate the environmental cost caused by water pollution:

$$W_p = S_D + L_I \qquad (5)$$

$$S_D = \beta_t \left(Kx + M \right) \qquad (6)$$

$$x = \frac{\sum W_i 10^6}{C_i} \qquad (7)$$

$$L_I = \sum_{i=1}^{n} \varphi_i \left(\frac{Nb}{300} + Pb \right) \qquad (8)$$

4) solid waste pollution (Ws)

$$W_s = \sum_{i=1}^{n} P_i S_i \qquad (9)$$

5) gas pollution (Wg)

$$W_g = \sum_{i=1}^{n} L_i = \sum_{i=1}^{n} \lambda_1 \lambda_e \alpha G_i \qquad (10)$$

Among them: L_i:pollutant discharge fee paid by pollutant I. China's current emission charging standard for thermal power enterprises is based on the pollutant equivalent. The adjustment coefficient of regional charges is taken as 0.8 for underdeveloped regions, 1.0 for normal regions and

1.2 for developed regions. The value of λ_e in charge adjustment coefficient of environmental functional zoning is: class iii 0.9, class ii 1.0 and class I 1.1.

$$G_i = \frac{g_i(1-\eta_i)}{X_i} \tag{11}$$

2.3 Gray Correlation Analysis

A measure of the degree of association between two systems that varies from time to time or from object to object is called the degree of association. By referring to relevant literatures, we established 8 main indicators of the five categories of environmental costs in the model, and standardized the data to obtain the processed data.

Then we use the grey correlation analysis method to explore the correlation degree between these independent factors and environmental costs, and the ranking of each factor was conducted according to the correlation degree. Finally, the results as shown in the following figure were obtained:

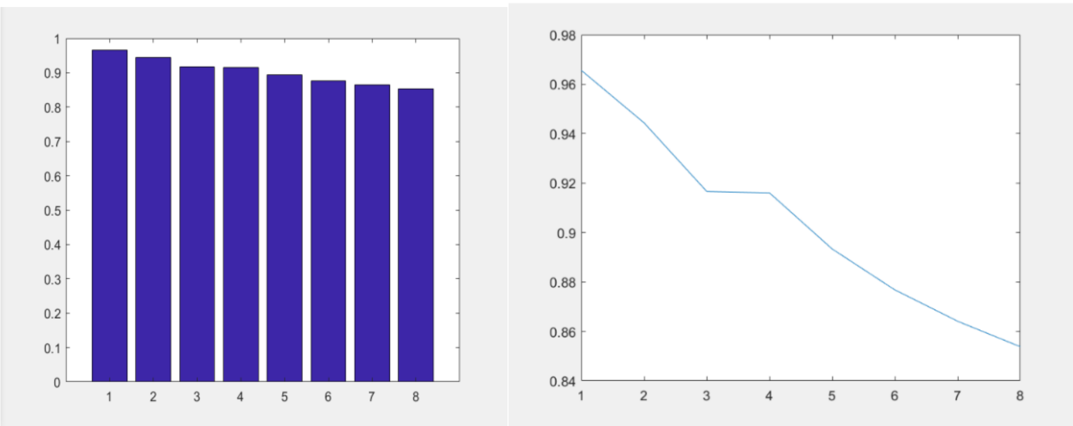

Figure 2. histogram of correlation degree line chart

According to the results shown in the figure, the correlation degree between these eight independent factors and environmental costs is all above 0.8, which is very high. Therefore, we can fully determine that the five indicators we selected are credible and can truly reflect the size of environmental costs.

2.4 Definition of Critical Value

Since the real economic benefits of an enterprise are negative when the economic benefits ratio is less than 1, and since the calculation result of environmental costs is estimated, the value of some secondary environmental factors is neglected, so the critical value of the economic benefits ratio when the enterprise can obtain real economic benefits is defined as 1.5.

3. Case Study of Thermal Power Plant

We verify the correctness of the critical value by analyzing the cost and benefit of a thermal power plant. First of all, we have collected a lot of detailed data about the thermal power plant from the Internet, including the annual investment cost of the thermal power plant, the number of surrounding organisms before the construction of the thermal power plant, the annual water pollution and air pollution treatment cost of the thermal power plant, the annual illness of workers caused by noise pollution and so on.

3.1 Comparative Analysis of Benefits

Based on the data, we can work out the economic benefit ratio of the enterprise without joining the ecological service system, and calculate the economic benefit ratio of the enterprise after joining the environmental cost according to the model.

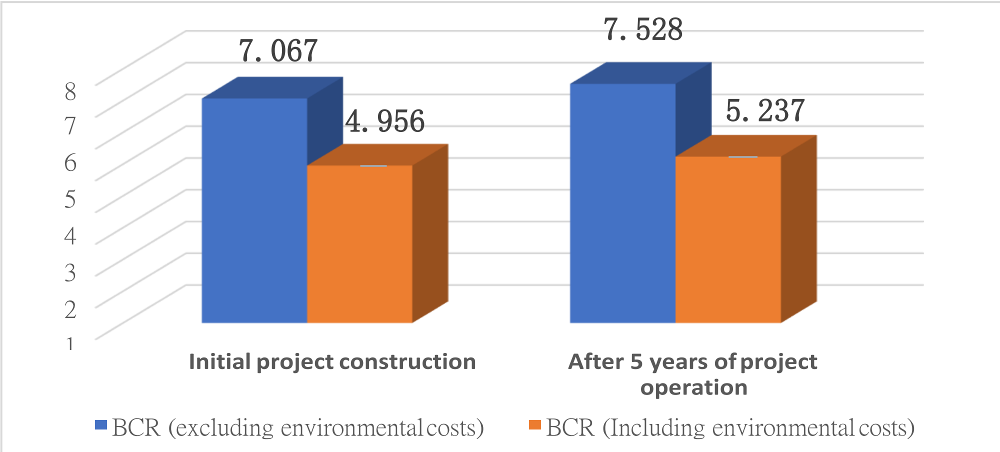

Figure 3. BCR area chart

From the figure we can find that the economic benefit ratio of the enterprise decreases greatly after the environmental cost is added.

3.2 Time Variation Law

With the growth of time and the destruction of ecological environment, the environmental cost will also increase to a certain extent. Therefore, the change of the cost-benefit ratio of the research project with time can be used to analyze the life span of the enterprise.

3.2.1 Curve Fitting of Economic Benefits

In practice, the variables may not all have a linear relationship, such as the relationship between blood concentration and time after taking medicine; Relationship between curative effect and length of treatment; The relationship between toxicant dose and fatality rate is often a curve. Curve fitting is to select the appropriate curve type to fit the observed data and use the fitting curve equation to analyze the relationship between the two variables.

Since it is difficult for us to know the annual earnings of enterprises in the future, we fit the curve according to the economic earnings of enterprises in recent years and predict the economic earnings in the following years. We can use the Curve Fitting tool (cftool) of Matlab for Curve Fitting, and get the following image:

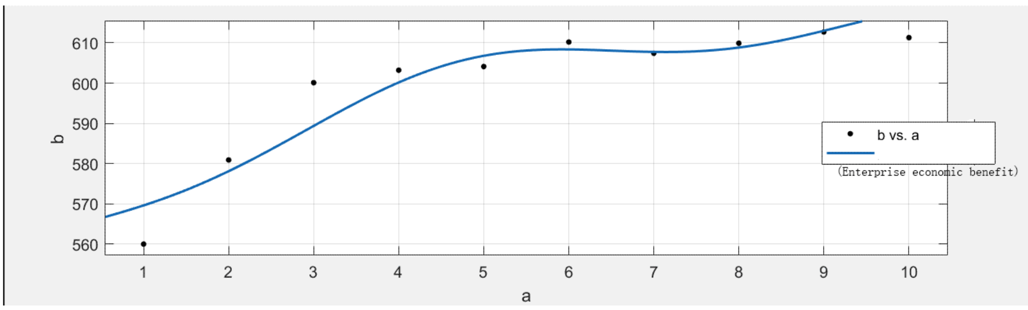

Figure 4. economic benefit fitting curve

From the figure we can know that the economic benefits of enterprises increase first and then tend to be flat in a certain period of time, which is consistent with the economic benefits of most enterprises.

3.2.2 Influence of Time on Economic Benefit Ratio

We ignore the initial project startup capital of the enterprise, only consider the project maintenance and operation cost and environmental cost of the enterprise, calculate its environmental cost through the model, and calculate and draw an image of the change of its environmental benefit ratio over time according to the data:

3.3 Project Evaluation

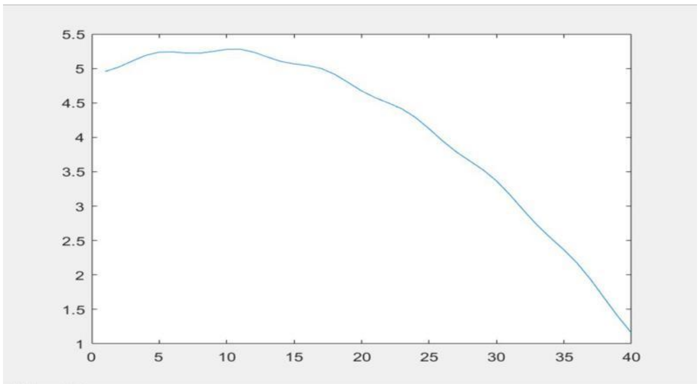

Figure 5. BCR-Time curve

According to the critical value, the ratio of economic benefit has been worked out in the coal-fired power plant in 38 years of real economic benefit is negative, the coal- fired power plant environmental cost and the operation and maintenance cost has been higher than the sum of its economic benefits, so we think, when the operation after 38 years, the economic benefits of his than have greatly reduced the critical value, the enterprise is not appropriate to continue running.

4. Strengths and Weaknesses

4.1 Strengths

Compatibility and flexibility.

We consider that the development project for the land is not single, so we have identified several high-weight indicators through the gray correlation analysis, which are included in almost all land development projects. Moreover, the measurement of these indicators is simple and flexible;

Practicality and universality.

By simply measuring the environmental cost indicators and applying our model, a complex cost-benefit ratio can be obtained. Moreover, for developing countries, the consideration of land project development and its environmental costs is a common problem;

4.2 Weaknesses

There are various external instability factors.

We know that there are many unstable factors (artificial or natural) due to the development of a project. Therefore, the anti-interference of our model has yet to be tested.

5. Conclusion

In our paper, we analyze the impact of environmental costs on land project development. In this specific case, we added the time variable to test the model. Under the normal impact of meeting environmental costs, the reasonable life of the project is predicted (the cost-benefit ratio of the project is less fluctuating within this period), which provides a reference for project planners and managers to accelerate environmental degradation. Thus maximizing benefits without accelerating environmental degradation.

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