

Ecological Perspective of Cost-benefit Analysis

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Abstract: In this paper, in order to establish an environmental cost assessment model for land use projects, we first select three indicators, namely, the natural resource depletion cost during the project implementation process, environmental pollution actual governance and virtual governance costs, and the sum of the latter two to quantitatively describe environmental degradation. Virtual cost. Using the sum of the three, we can calculate the environmental costs of a land-use project.

In order to carry out a more comprehensive and comprehensive evaluation of land use projects, we put the service value change of the construction land ecosystem into consideration, and based on the costanza model, we established an ecosystem service value evaluation model by using the value equivalent factor method. The economic value of the annual grain yield of the farmland with an average yield of 1hm² is taken as the equivalent factor "1", which is multiplied by the matrix of the equivalent factor coefficients, that is, the value of the unit area of each type of ecosystem, and then multiplied by the corresponding area. The value of the services of the ecosystem can be obtained.

In the calculation model of the ecosystem service value, since the equivalence factor coefficient matrix is a constant matrix, it is static. The ecosystem is changing from time to time. Therefore, although the above model is easy to calculate, it cannot reflect the dynamic relationship between land use projects and ecosystem service values. Therefore, we optimized the limitation of this the model and proposed a space-time algorithm calculation method based on the dynamic factor-based ecosystem service value.

Using the above model, we can conduct a comprehensive evaluation of the land use project. In the case study, we applied the model to the land project in Nanjing. The land project's contribution to GDP minus its environmental cost, plus the ecological benefits measured by the ecosystem service value, can get the actual income of the project. By calculating our goal of minimizing the ratio between cost to benefit, we make reasonable suggestions for planners and managers of land use projects.

1. Introduction

Ecosystem is the foundation of human survival and development. It not only provides space for human survival, but also provides various resources needed for human development and absorbs the waste generated by human production and life. Eco-environmental resources are globally allocated, and the benefits are shared globally. The use of eco-environmental resources by a country or region often affects the well-being of people in all countries.

According to this problem, we should evaluate the environmental cost of land use and development projects, and take environmental degradation into consideration in the evaluation process. At the same time, considering the change of time, optimize the model. Through the model established by us, we will carry out cost-benefit analysis on specific land use and development projects, and make suggestions to relevant personnel based on the results obtained by us.

2. Problem Analysis

In order to solve the problem given by the problem, we must first analyze the problem. The

questions given in the title are all comprehensive evaluation questions. For the environmental cost assessment of land-use development projects that consider environmental degradation, we analyze the cost of the environment to include environmental degradation costs and natural resource loss costs. Environmental degradation can have some adverse effects. In order to compensate for the impact of environmental degradation, we need some cost to repair the environment, so we need to include environmental degradation costs in environmental costs. In the cost-benefit analysis of land-use development projects, we considered green GDP and established a corresponding model to solve the problem. Through the analysis of a real project, we validated our model and gave relevant advice to the project's planning managers. When considering the time variation factor, we optimized the model in time and space. The corresponding process is as Figure 1.

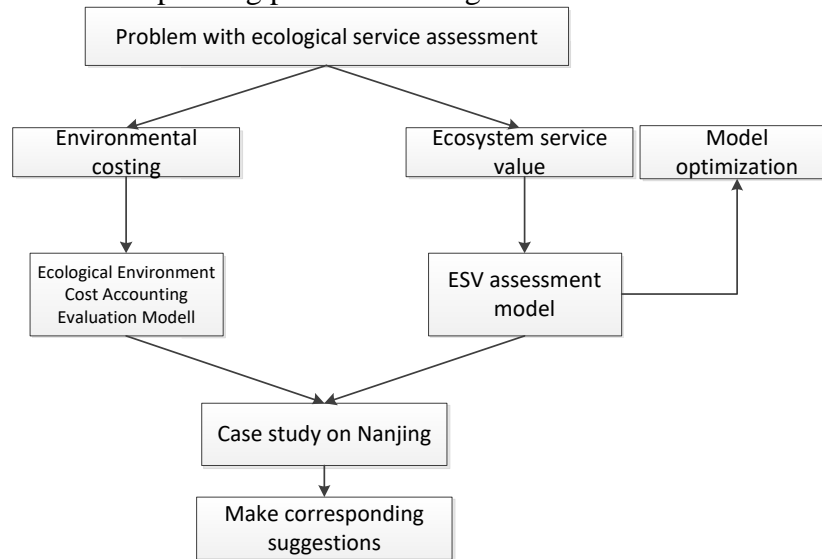


Figure 1: Problem analysis flow chart

3. Symbol Description

Table 1. Symbol Description

<i>Symbols</i>	<i>Definition</i>	<i>Units</i>
Ea	Equivalent ecological service value	yuan
V_M	Mineral and energy resource values	yuan
V_W	Total value of water resources	yuan
V	Total natural resource value	yuan
\bar{C}_i	Unit governance cost	yuan/hm ²
C	The treatment cost of each pollutant	yuan
E_{ij}	Unit price of ecological service function	yuan/hm ²

4. Ecological Environment Cost Accounting Evaluation Model

4.1 Establishment of Ecological Environment Cost Accounting Evaluation Model

When developing the eco-environment costing evaluation model, we selected three indicators as part of the environmental cost, namely resource consumption cost, environmental pollution damage cost, and environmental pollution virtual governance cost, which is based on the SEEA system and on the basis of the SEEA system. Developed a model for the establishment of a green GDP accounting system. The formula for measuring environmental costs is as follows:

Environmental cost = $\sum(\text{resource consumption cost}) + \sum(\text{actual pollution control cost}) + \sum(\text{virtual pollution control cost})$

4.2 Accounting method for resource consumption cost

In the establishment of this model, the method we use is the net present value method, which is to convert the net cash flow of the project throughout the life period into the sum of the present value of the equivalent target yield. The sum of the net present values is also equal to the algebraic sum of the present value of all cash inflows and the present value of all cash outflows. Its modified general expression is:

$$RV = \sum_{t=1}^n \frac{R_t}{(1+r)^t} = \sum_{t=1}^n \frac{R(1+i)^t}{(1+r)^t} = \sum_{t=1}^n R \left(\frac{1+i}{1+r} \right)^t$$

In the formula: i —the price growth rate of resources

r —discount rate

R —resource rent

N —resource life

According to the above formula, specific value assessment methods for different natural resources can be obtained. We mainly choose minerals and energy resources, water resources, and land resources for evaluation. The specific evaluation formula is as follows:

Valuation of mineral and energy resource:

$$V_M = RR \cdot E \cdot \frac{(1+i)}{(r-i)} \cdot \left(1 - \left(\frac{1+i}{1+r} \right)^{S/E} \right)$$

S —Constant stock level

E —Constant resource annual mining rate

RR —Constant unit resource rent

Calculation of the value of surface water resources

$$V_s = \sum_{t=1}^{n_1} \frac{R_s}{(1+r)^t} = \sum_{t=1}^{n_1} \frac{P_s \cdot Q_s}{(1+r)^t}$$

R_s —Rent of surface water resources

P_s —Water resource fee for surface water, representing unit resource rent

Q_s —Total surface water

n_1 —The current surface water available life

Calculation of the value of groundwater resources

$$V_g = \sum_{t=1}^{n_2} \frac{R_g}{(1+r)^t} = \sum_{t=1}^{n_2} \frac{P_g \cdot Q_g}{(1+r)^t}$$

Total value of water resources:

$$V_W = V_s + V_g$$

Valuation of land resource:

This paper believes that the life of- the land is permanent.

$$V_L = \sum_{t=1}^{\infty} \frac{J}{(1+r)^t} = \frac{J}{r}$$

In the formula: J —annual net income of land

In summary, the total natural resource value is estimated to be

$$\sum V = V_M + V_W + V_L$$

4.3 Environmental pollution control cost accounting method

The accounting for environmental pollution virtual governance costs is calculated based on the governance cost coefficient method. The method calculates the treatment cost coefficient of each pollutant according to the benefit of the treatment facility,' and distributes the treatment cost among the pollutants, thereby obtaining the unit treatment cost of each pollutant, and finally obtaining the total environmental pollution virtual treatment cost. Calculated as follows:

$$C = \sum_{i=1}^n \bar{C}_i Q_i$$

i ——Contaminant types, \bar{C}_i ——unit cost of treatment for each pollutant, Q_i ——emissions of each pollutant.

The following is an estimate of the unit cost of pollutant treatment:

Firstly, the treatment efficiency of a certain treatment facility for pollutant i is calculated. This paper considers that the treatment cost is not only related to the treatment efficiency of the facility, but also related to the difficulty of controlling pollutants. In this paper, the ratio of the export concentration of various pollutants to the imported concentration is used to measure the difficulty of the treatment of pollutants. The following, equation can be used to express:

$$a_i = \frac{E_i}{I_i}$$

In the formula, the expressions of inlet concentration and outlet concentration of pollutants are respectively:

Import concentration = (contaminant emissions + pollutant removal) /waste discharge

Export concentration = pollutant emissions/waste emissions

The processing benefits of a treatment facility that takes into account the difficulty of governance can be expressed as:

$$\eta_i = \frac{I_i - E_i}{S_i} \cdot \frac{E_i}{I_i}$$

In the formula: S_i ——Emission standards for pollutant i , η_i ——Treatment efficiency of type i pollutant at the treatment facility

Then, according to the ratio of the treatment benefit of each pollutant to the total treatment benefit, the coefficient of governance cost is obtained. The governance cost coefficient can be expressed as the following equation:

$$\gamma_i = \frac{\eta_i}{\sum_{i=1}^n \eta_i}$$

According to the treatment cost coefficient of each pollutant, the cost of each pollutant treatment is apportioned, and the treatment cost of each pollutant is obtained. The equation is expressed as follows:

$$C_i = C \cdot \gamma_i$$

Finally, the unit treatment cost of each pollutant is the ratio of the treatment cost of each pollutant to the removal amount of the corresponding pollutant. The equation is expressed as follows :

$$\bar{C}_i = \frac{C_i}{(I_i - E_i) \times M}$$

In the formula: M —— total amount of residue

After finishing, the final unit governance cost can be expressed as:

$$\bar{C}_i = \frac{C \cdot \eta_i / \sum \eta_i}{(I_i - E_i) \times M} = \frac{C \cdot \frac{I_i - E_i}{S_i} \cdot \frac{E_i}{I_i} / \sum (\frac{I_i - E_i}{S_i} \cdot \frac{E_i}{I_i})}{(I_i - E_i) \times M} = C \cdot \frac{E_i}{I_i} / S \cdot M \cdot \sum (\frac{I_i - E_i}{S_i} \cdot \frac{E_i}{I_i})$$

5. Ecosystem Service Value Assessment Model

The evaluation of ecosystem service value is based on the value equivalent factor method of the costanza model. This method was proposed by costanza et al. It has been applied to the evaluation of wetland ecological service value in Suzhou Province and has strong practicability.

5.1 Establishment of Equivalent Ecological Service Value Model

The core of the method is to construct an equivalent factor table. This paper combines Costanza's approach with the Millennium Ecosystem Assessment (MA) to divide ecosystem services into four categories: supply services, regulatory services, support services and cultural services, as well as nine sub-categories of gas regulation, climate regulation, water conservation, soil formation and protection, waste management, biodiversity conservation, food production, raw materials and recreational culture. Based on these indicators, an extensive questionnaire survey was conducted in selected countries or regions, and the final analysis of the country or region's equivalent factor table was obtained. The equivalent factor is set to the equivalent "1" of the annual economic output of one hectare of farmland in the national average yield, and the equivalent factor of other types of ecosystem = the ratio of the ecological service value / equivalent economic value. For a defined area, the value of equivalent ecological services is denoted by Ea said that among them:

$$Ea = \frac{1}{6} \sum_{i=1}^n \frac{m_i p_i q_i}{M} (i=1, 2, 3 \dots n)$$

In the formula: i —— Crop types (rice, wheat, corn, soybeans, rapeseed, cotton)

p_i —— The national average price of crop i (yuan/t)

q_i —— The unit annual output of crop i (t/hm^2)

m_i —— Crop sown area of crop i (hm^2)

M —— Total area planted with food crops (hm^2)

5.2 Establishment of An Unit Ecological Service Value Model

According to the model of the equivalent ecological service value and the equivalent factor table, the unit price of each service function of each ecosystem can be obtained as:

$$E_{kj} = e_{kj} Ea (j=1, 2, 3, \dots, 6; k=1, 2, 3, \dots, 9)$$

In the formula: j ——the type of ecosystem

k ——the function of the ecosystem

E_{kj} ——The unit price of k-type ecological service function in j-type ecosystem (yuan/ hm^2)

e_{kj} ——The equivalent factor of service unit price provided by k-type ecosystem in j-type ecosystem relative to farmland ecosystem

5.3 Establishment of an Ecosystem Service Value Model

The service value of various ecosystems calculated according to the costanza model:

$$V_j = \sum_{k=1}^9 A_j E_{kj} (k=1, 2, \dots, 9; j=1, 2, \dots, 6)$$

The value of each service a function is:

$$V_k = \sum_{j=1}^6 A_j E_{kj} (k = 1, 2, \dots, 9; j = 1, 2, \dots, 6)$$

The total value of ecosystem services is:

$$V = \sum_{k=1}^9 \sum_{j=1}^6 A_j E_{kj} (k = 1, 2, \dots, 9; j = 1, 2, \dots, 6)$$

In the formula: A_j — The area of j-type ecosystem

V_j — Value of j-type ecosystem services

V_k — The value of k-type service functionality

V — The total value of ecosystem services

6. Model Optimization Considering Time-space Variation Factors

Our initial ecosystem service value models were built on the basis of the costanza model, which can be used to measure the service value of each ecosystem in a monetized way, but this method has certain limitations, as follows:

1) There may be differences in the functional value of inter-regional ecosystems, and regional differences are not considered in the model based on Costanza;

2) In the same ecosystem, the value of ecosystem function varies with the quality of the ecosystem, and the model does not consider the spatial heterogeneity of the ecosystem;

3) In the Costanza model, the WTP of the ecosystem function is considered to be constant, but in fact, with the development of society, the WTP of the service function may be different from the WTP of the commodity function.

These neglected factors are the spatial, qualitative, and temporal characteristics that affect the value of ecosystem services. Through the above analysis, we establish regional differences, spatial heterogeneity and WTP effect factors to characterize the spatial, quality and temporal characteristics of ecosystems in each region. Combined with the Costanza model, a new comprehensive evaluation method for ecosystem functions is proposed as follows:

$$V = \sum_{i=1}^m \sum_{j=1}^n A_j \cdot E_{ij} \cdot S_j \cdot Q_j \cdot T_j (m=9, n=6)$$

In the formula: A_j — the area of the j-type ecosystem

E_{ij} — the unit price of the k-type ecological service function of the j-type ecosystem (yuan/ hm^2)

S_j — j-type ecosystem regional difference factor

Q_j — j-type ecosystem spatial difference factor

T_j — j type ecosystem WTP factor, ie time factor

7. Calculation Method of Difference Factor

7.1 Calculation Method of Regional Difference Factor

Ecosystem services between different regions vary with net primary productivity (npp). Therefore, regional differences coefficients are established to reflect regional differences in the existence of regional ecosystems.

S_j = average NPP value of ecosystems in the study area j / average NPP value of the ecosystem of China j species

7.2 Calculation Method of Spatial Difference Factor

Spatial heterogeneity is one of the most obvious characteristics of ecosystem quality, which affects the function of ecosystems. The quality of an ecosystem is usually determined by the growth of the vegetation. Usually, the normalized vegetation index (NDVI) is used to indicate the growth state of vegetation. Therefore, the spatial difference factor established based on NDVI can reflect the internal difference of ecosystem function. The formula is as follows:

$$Q_j = \frac{NDVI_j - NDVI_{\min}}{NDVI_{\max} - NDVI_{\min}} (0 < Q_j < 1)$$

7.3 The Calculation Method of WTP Factor (time factor)

The function of the ecosystem is a dynamic concept with the change of the WTP factor. The change of time is reflected in the development of society. It can be measured by the coefficient of social development. The equation for this coefficient is expressed as follows:

$$l = \frac{L}{1 + e^{-(1/E_n - 3)}}$$

Where: L ——the WTP of the most affluent stage of social development, is defined as 1.

e ——natural logarithm

E_n —— Engel coefficient

Here we think that people's preference for the commodity function and service function of the ecosystem is equal, then the WTP factor is:

$$T_i = \begin{cases} l & \text{goods fuction} \\ l_{\text{study area}} / l_{\text{country}} & \text{services fuction} \end{cases}$$

8. Case study on Nanjing

8.1 Cost-benefit analysis of land use projects in Nanjing

Through three years of remote sensing image maps and data, we can visually see that the area of forest land and the area of construction land are increasing year by year, and the area of cultivated land is decreasing year by year. Based on the obtained three-year land type area statistics of Nanjing City, we can use the accounting model of ecosystem service value to obtain the value of ecosystem services in Nanjing for three years, as shown in the following table1:

Table2: Value and sum of various services (ten thousand yuan)

	woodland	arable land	Grassland	Waters	Unutilized land	sum
1998	94527.20	381146.09	9166.89	343094.44	88.91	828023.52
2008	261261.73	496161.54	5714.74	389862.88	164.96	1153165.84
2016	798681.96	540260.08	14301.86	675036.32	758.35	2029038.57

As can be seen from Table 2, the total value of ecosystem services in Nanjing in 1998, 2008 and 2016 was 828023.52 million yuan, 1153165.84 million yuan and 2029038.57 million yuan respectively. In order to better reflect the changes in the value of various types of ecosystem services in different periods, the data in the above table is represented by a histogram, as follows:

It can be seen from Figure 2 that the value of ecosystem services in forest land is the most significant and is increasing year by year. Through our investigation, we have learned that since the reform and opening up, the level of urban green space construction in Nanjing has been continuously improved, and between 1998 and 2016, cultivated land and unused land have been converted to forest land, and the economic value of the service functions provided by forest land is higher than that of cultivated land. The value of ecosystem services has increased. The variability of cultivated land and unused land with small ecological value coefficient is relatively large, and it is

transformed into a garden with high ecological value coefficient, which leads to an increase in the overall ecosystem service value of Nanjing. Therefore, the impact of land use change on the environment in Nanjing is generally positive, and this result is consistent with reality.

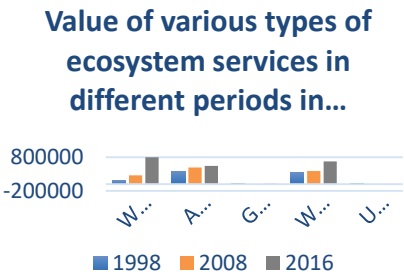


Figure 2: Value of various types of ecosystem services in different periods in Nanjing

Then we obtained the data of various pollutant discharges in Nanjing by analyzing the statistical yearbook of Jiangsu Province. The virtual treatment cost of wastewater, waste gas and solid waste in Nanjing was obtained by using the model of environmental pollution treatment cost accounting, as shown below:

Table3: Virtual Management Costs in Nanjing

	Air Pollution	Water pollution	Solid waste pollution	Total cost
1998	14716.67	510.2696	7225.68	22452.61
2008	6549.425	1222.038	10046.4	17817.86
2016	9664.554	866.7138	10005	20536.27

The calculated virtual governance cost and the actual governance cost are summed up, and the environmental cost obtained is shown in the following table4:

Table4: Final environmental degradation costs in Nanjing

	Air Pollution	Water pollution	Solid waste pollution	Total cost
1998	133829.7	82665.27	7225.68	223720.6
2008	172302.4	199333	10046.4	381681.9
2016	478909.6	159384.7	10005	648299.3

In order to more intuitively see the changes in the cost of environmental degradation, the data in the above table 3 is represented by a histogram, as follows:

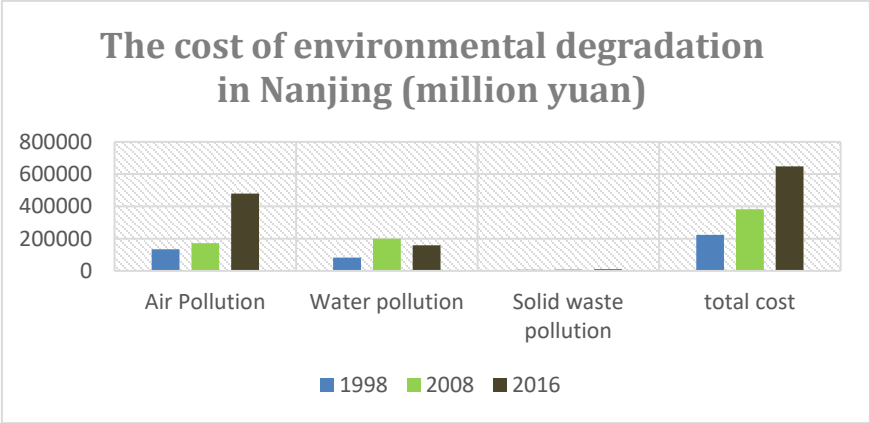


Figure 3: Cost of environmental degradation in Nanjing

As can be seen from the figure 3, the cost of environmental degradation in Nanjing is increasing year by year, among which the growth trend of air pollution is the most obvious and has occupied a major part of the cost of degradation.

Finally, we can get the income of land use projects in 1998, 2008 and 2016 to be 1,107,073.291 billion yuan, 385,214,839 million yuan and 10,641,093.93 billion yuan respectively.

Based on the annual land type area and the annual ecosystem service value data from 1998 to 2016, we conducted a principal component analysis method to evaluate the impact of each land type on the value of ecosystem services (ecological benefits). The principal component regression equation is as follows:

$$y = 1969056.002198 + 6.012860x_1 - 2.135457x_2 + 13.403459x_3 - 4.341212x_4 + 2.360765x_5$$

In the regression equation, x_1 , x_2 , x_3 , x_4 , and x_5 represent the area of forest land, cultivated land, grassland, water area, and unused land, in units of hectares, and y represents the value of ecosystem services.

It can be seen from the regression equation that the proportion of forest land and grassland is large, that is, it has a great influence on the value of ecosystem service function. Therefore, we can avoid damage to forest land and grassland in the process of land project construction. It can improve the efficiency of the environment and increase the revenue of the final project. The project revenue increased from 1,210,302.291 billion yuan to 385,214,839.98 billion yuan and then to 1,641,093.93 billion yuan, rising year by year. At the same time, in the process of project implementation, the discharge of waste water and solid waste can be reduced, which can effectively reduce the environmental cost of land use projects and increase the cost-benefit ratio of the project.

For different scale land use projects, our models are still applicable. In the environmental cost accounting model, we only need to change the unit of each natural resource in the model according to the location of the project and the size of the project. The cost of rent, the unit cost of treatment for each pollutant, and the emissions of each pollutant can provide environmental costs for land-use projects of different sizes. In the model of ecosystem service value assessment, we only need to change the unit yield, planting area and total grain sowing of various crops in the model according to the actual scale of the project and the actual location of the project according to the size of the project and the location of the project. The area, the corresponding equivalent ecological service value, and the product's share of the ecosystem area can be used to obtain the ecosystem service value corresponding to different scale projects. Then, the land cost, construction cost, environmental cost, other cost, economic benefit, ecological benefit and other factors of different projects are combined to analyze the cost and benefit, and finally the optimal implementation plan of the project is designed.

9. Impact of the model on the planning and management of land use projects

This paper mainly establishes the model of environmental cost accounting and the model of ecosystem service value. The model can be used to evaluate the real economic cost of land use projects considering environmental costs. Through the above analysis of the cost of land use projects in Nanjing, we can make the following recommendations for project planning or management personnel:

1) Pay attention to environmental greening. The environment can be greened during the implementation of the project. For example, green leafy vegetation is planted around the project implementation site to increase the coverage of vegetation such as forest land and grassland, thereby improving environmental benefits.

2) Reasonably choose the construction site. Forest land and grassland have a great impact on ecological benefits. In the process of land use projects, the destruction of forestry grassland and other ecosystems should be reduced. Therefore, the project construction site should not be selected in forests and grasslands.

3) Use an environmentally friendly project plan. In the process of project implementation, pollutants will inevitably occur, causing environmental degradation and increasing environmental costs. The project's planning or management personnel can design and adopt more environmentally friendly project plans to reduce pollutant emissions, reduce the environmental costs of land use

projects, and increase the cost-benefit ratio of the project

10. Evaluation of Model

10.1 Strength

In the calculation of environmental degradation cost, the governance benefit formula modified by the difficulty of governance is adopted, which is based on the original governance benefit multiplied by a governance difficulty coefficient to better characterize the relationship between the difficulty of pollutant treatment and the treatment cost.

Our model is universal. The model of this paper is mainly used to measure the real economic cost of land use projects, mainly considering environmental costs and ecological benefits. The indicators to be collected are the average grain price of the project construction area, the land area occupied by the project, and the amount of pollutants discharged by the project. And the cost of pollution control, these indicators not only exist in land use projects, but also in any industrial production and environmental impact projects, so the model established in this paper can also assess the environmental costs of other projects. The real economic cost of ecological benefits, and then cost-benefit analysis of the project to optimize the project plan and improve the economic benefit ratio.

In the cost-benefit analysis of land use development projects, the ecological benefits are included in the cost and benefit components, making the comprehensive assessment of the project more accurate and reliable.

10.2 Weakness

Due to the inability to find a large amount of data, the model has some limitations.

In the calculation model of environmental degradation cost based on the virtual governance cost method, only the environmental cost caused by industrial pollution in a certain area is converted, so it is not comprehensive to use it for cost-benefit analysis of land projects.

11. Conclusion

In summary, the research in this paper has drawn a valuable inspiration for ecological environment protection in the comprehensive assessment process of land use projects. Studies have shown that in order to make the assessment of a project as comprehensive as possible, the value of ecosystem services must be taken into account. At the same time, it is known that only by continuously strengthening the protection of ecological resources during the construction of the project and rationally allocating the cost of environmental treatment, can the real project benefit be maximized under the conditions of environmental protection.

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