A Cost Analysis Model Based on Ecosystem Service Value Assessment

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Abstract: With the continuous deterioration of the ecology, traditional economic theories have exposed more and more defects. To alleviate the crisis, we establish a calculation and evaluation system based on the value of the ecosystem services. According to the Ecological Economics, we establish the Economic Value of Ecosystem Services (EVES) model to estimate the total ecosystem assets in monetary terms. Through data processing and theoretical analysis, we determine the economic value per unit area of ecosystems, deriving the computing formula of EVES. Moreover, the true economic costs of the land project is a combination of Ecological Economic Costs (EEC) and non-ecological economic costs. And the former is defined as the reduction of EVES before and after the project. Furthermore, our model provides theoretical support and reference standards for decision makers. Most importantly, a mechanism is offered for cost analysis, which has great practical guiding significance. In addition, as the time goes, our models will change mainly in the EVES model, where the prices of natural resources will change within certain limits. In general, our model can provide planning and guidance for cost calculation of a land project.

1. Introduction

Ecosystem services refer to life-supporting products and services obtained directly or indirectly through the structure, processes and functions of ecosystems [1]. In 1997, Costanza published "The Value of the World's Ecosystem Services and Natural Capital", which calculates 17 kinds of service functions of the global ecosystem [2]. This is the first assessment of the economic value of the global ecology, and it has been recognized that the ecology has enormous economic value. At the same time, Westman proposed the concept of “nature’s services” and its value assessment. Daily's "Nature Service--Social Dependence on Natural Ecosystems" has opened up a new situation in the study of the value of ecosystem services [3]. In 1992, Canadian ecological economist Wiliam.R first proposed an ecological footprint model. And in 1996, it was perfected by Wackenagel as a measure of how humans use natural resources and how nature provides life support services to humans [4]. Based on the existing research results, this study proposes a method for estimating total ecosystem assets in monetary form, and creatively incorporates eco-economic costs into the actual cost of land projects. Our model provides a cost analysis mechanism that can effectively analyze the cost of land projects and the environmental impact of project implementation.

2. The Ecological Economic Costs Model

2.1 Construction of Evaluation System

Referring to the classification method of Millennium Ecosystem Assessment [6], the ecosystem service functions of the area are divided into four types: provisioning service, regulation service, maintenance service and cultural service. By summarizing the generally accepted classification results [2, 5-7] and referring to existing studies [8, 9], I chose 13 second-class indicators, which are shown in the Tab.1.

2.2 The Economic Value of Ecosystem Services Model

In order to estimate the Economic Value of Ecosystem Services (EVES) comprehensively, we select the widely used ecological service accounting standards and unit price system [10]. The accounting methods we adopt are Market Value Method, Alternative Cost Method, Shadow Engineering Method and so on [11]. And the detailed processes are as follows:

2.2.1 The economic value accounting of various services

a) The value accounting of indicators in provisioning services

●The value of material: $V_1 = \sum S_i P_i$ [12], where S_i is the area of different ecosystems in the researched region; P_i is the market value of the corresponding substances provided for the ecosystem per unit area.

●The value of water resources: $V_2 = C * P$, where C is the market price per unit water resources; P is the total amount of water resources in the region.

b) The value accounting of indicators in regulating services

●The value of the water conservation: $V_4 = \sum (X_i - E_i) P_i$, where X_i is the total amount of water stored in each ecosystem; E_i is the total evaporation; P_i is the cost of reservoir construction per unit volume.

●The value of climate regulation: $V_5 = \Delta T * P_t + \Delta H * P_h$ [11], where ΔT is the reduced temperature over time; P_t is the cost of reduced temperature per unit; ΔH is the increased humidity over time; P_h is the cost of increased humidity per unit.

●The value of carbon fixation: $V_6 = (0.445 * Q + Q_t) * P_c$, where Q is the total amount of dry matter produced by plants in the ecosystem; Q_t is the soil carbon sequestration; P_c is the cost of carbon fixation per unit.

In photosynthesis, 0.445g of carbon can be fixed per 1g of dry matter produced. So we use a coefficient of 0.445 in the formula above.

●The value of atmospheric regulation: $V_7 = Q_1 * P_1 - Q_2 * P_2$, where Q_1 is the amount of oxygen produced by the ecosystem; Q_2 is the amount of oxygen consumed by the ecosystem; P_1 and P_2 are the corresponding costs.

c) The value accounting of indicators in maintenance services

●The value of biodiversity: $V_8 = \sum S_i P_i$, where S_i is the total area of each ecosystem; P_i is the value of ecosystem diversity per unit area.

●The value of soil conservation: $V_9 = S * (1 - B) \sum P_i K_i M_i$, where S is the soil area; B is the soil erosion rate; P_i is the inorganic substance content in soil; K_i is the price conversion ratio of pure inorganic matter and chemical fertilizer; M_i is the corresponding fertilizer prices.

d) The value accounting of indicators in cultural services

●The value of leisure: $V_{11} = STI$, where S is the total ecosystem area, T is the time of the period; I is the profit per unit time.

●The value of scientific research: $V_{12} = P_1 * M_1 + P_2 * M_2 + P_3$, where P_1 is the number of papers related to ecosystem; P_2 is the number of patents related to ecosystem; M_1 and M_2 are the corresponding cost of the research; P_3 is the value created by applying the results to other aspects.

●The value of artistic creation: $V_{13} = P_1 * M_1 + P_2$, where P_1 is the number of artworks created based on the ecosystem; M_1 is the average cost per piece of artwork; P_2 is the value created by applying the works to other aspects.

2.2.2 Index weights of EVES

We choose a number of different ecosystems with representative ecological characteristics in different regions. As the ecosystem services value may not be easily traceable through markets, or may not show up in markets at all [2]. So the effective way to obtain the economic value of second-class indicator per unit area or mass is data processing and theoretical analysis. The value is shown in the Table 1.

Table 1. The accounting table of ecosystem service value

First-class Indicators	Second-class Indicators	Forest/*C1*	Farmland/ *C2*	Wetland/ *C3*	Water system/ *C4*	Unit
Provisioning Service (PS)	Water volume	4.48 [13]				yuan/ *t*
	Forest products	2300.6				yuan / hm^2
	Mineral products	46897.7				yuan / hm^2
	Marine products				61538.5	yuan / hm^2
Regulation Service (RS)	Water conservation	2831.5	531.9	13615.2	18233.2	yuan / hm^2
	Climate regulation	3497.0	462.4	1492.7		yuan / hm^2
	Carbon fixation	2379.6	794.5	15267.9	407.0	yuan / hm^2
	Atmospheric regulation	1687.7	420.3	1965.6	1673.8	yuan / hm^2
Maintenance Service (MS)	Biodiversity conservation	3386.9	454.3	1686.2	1726.5	yuan / hm^2
	Soil retention	2843.6	637.2	2312.6	2203.3	yuan / hm^2
Cultural Service (CS)	Leisure	340.2	0.3	1256.8	1456.8	yuan / hm^2
	Scientific research	473.5	4.2	2301.5	1357.9	yuan / hm^2
	Artistic creation	323.6	1.5	1489.1	1120.4	yuan / hm^2

2.2.3 The formula of EVES

Through the processes above, the formula of EVES can be defined as:

$$EVES = 4.48M_1 + \sum (S_i * c_i) + 5.49M_2 \, .$$

Where M_1 is the total quantity of water resources in the region; M_2 is the emissions of pollutants in the region; S_i is the area of each ecosystem.

2.3 The Formula of Ecological Economic Costs

EEC is defined as the reduction of *EVES* before and after the project and the formula is as follows:

$$EEC = EVES_1 - EVES_0 \, ,$$

Where $EVES_0$ is the economic value of ecosystem services before the construction of land use projects; $EVES_1$ is the economic value of ecosystem services after the construction.

2.4 The Formula of the True Economic Costs

The True Economic Costs (TEC) of the land project is a combination of Ecological Economic Costs (EEC) and Non-ecological Economic Costs (NEC). The formula is as follows:

$$TEC = EEC + NEC \, .$$

The costs of manufacturing and marketing are not the true economic costs, but just the physical costs. Adding some cost accountings of ecology, which are defined as environmental burdens of a project on the basis of its construction, the total costs are called TEC. With the obsolescence of original economic theory, EEC is of vital importance to TEC.

3. Evaluation of the Selected Projects

In this section, we use our model to perform cost-benefit analysis on land use projects of Erhai Villa, by the way, examining the practical value of our model.

3.1 Erhai Villa

"Erhai Villa" is luxurious villa group built in Dali Erhai Park, with a total investment of 240 million yuan, covering an area of more than 300 acres. And it plans to build more than 300 sets of seascape villas. The actual scene is shown in the Fig.1.

Figure 1. The Panorama of Erhai villa (Picture source: Google)

Before the construction of the project, the park covers an area of 864 acres, with a water area of 1065 acres and 340 acres of forest. However, after the construction of the project, more than 30 acres of water and 20 acres of forest were destroyed.

Through consulting public government websites, databases and references, we collect a certain amount of data. However, due to the limited amount of data, the direct use of the model may lead to certain errors. So first we use the Grey Prediction Method to expand the amount of our data, and then we use our model for evaluation and value accounting.

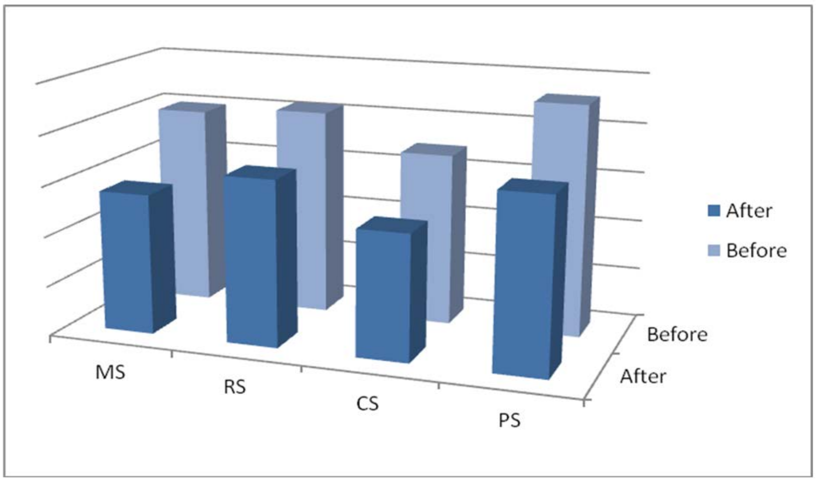

Figure 2. Local ecological service value before and after the project

Table 2. The index value of the 'Erhai Villa'

Original *EVES*	Later *EVES*	*EEC*
56.34	25.63	25.63

From the results shown in the Fig.2, we can see that after the project, the four ecological service values in the area around Erhai have all decreased.

In other words, as is shown in the Tab.2, even though the economic benefits of the project are considerable, *EEC* of it is too high to be ignored. So in the long run, the project will seriously damage the local ecological environment, so we have every reason to regard the project as unqualified.

4. Changes of Model over Time

As the time goes, my method will change mainly in the EVES model, where the prices of natural resources will change within certain limits. The main analysis are as follows:

- Human demands are increasing while the ecological resources are limited, so prices of them will increase.

For example, according to UN research, the world's demands for food crops and water are expected to increase by 30 - 85% in the next 50 years.

- As more and more substitutes can be created by human beings in the future, the increase degree of prices is limited.

For example, the price of woods will decrease, because mankind will use more clean energy such as light energy and natural gas.

- In EVES model, the economic value of second-class indicator per unit area or mass will fluctuates over time, which will have an impact on EEC and cost-benefit ratio.

5. Conclusion

To effectively estimate the ecological and economic costs brought by land projects, I established a calculation and evaluation system of the Ecological Economic Costs (EEC) based on the value of the ecosystem services. On this basis, we can estimate the changes in the total ecosystem assets in monetary terms to further analyze the ecological cost of land projects. In conclusion, this method is highly operable and reliable, which can be applied to practice to provide guidance and planning for the budget and implementation of land projects.

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