Evaluation of The Ecological Service Model

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Abstract: Based on a large number of remote sensing data, six types(including 11 sub-categories) of land use types are selected. With the help of Costanza's model, a three-layer index system(the first layer has 1 index, the second layer has 4 indexes, and the third layer has 11 indexes) is established to measure the value of ecosystem services.

In order to evaluate the effectiveness of the model, we measure it by analyzing the dependence of ESV on VC and the size of sensitivity index. We have verified that the model is effective.

Based on the model we have established, the plan previously chosen by the project planners and managers may no longer be the best one, and they will make changes to their own choices. The Goal Programming Method (GPM) is adopted to select the best scheme from different land use projects.

1. Introduction

Ecosystem Services means the many benefits and assets that humans receive freely from our natural environment and a fully functioning ecosystem. While, most land use projects usually don't consider impacts or changes on ecosystem services. In other words, they didn't take the economic costs of the ecosystem services which caused by land use projects into consideration. Thus, what they got was an incomplete and unspecified project cost. In this case, it is urgent to have a model that can estimate the missing environmental cost to take a real and comprehensive evaluation of the project.

Moreover, we are supposed to obtain the method to verify that whether the model is valid or not. As the environmental cost is taken into consideration, the increase of comprehensive economic cost is bound to bring a series of impacts to project planners and managers. Then, we will analyze them and give the conclusion.

1.1 Construction of Basic Equivalent Table (BET)

The basic equivalent of ecosystem service function value per unit area refers to the average annual value equivalent of various service functions per unit area of different types of ecosystems.

On one hand, it reflects the average annual value of different ecosystems and their various ecosystem services across the country.

On the other hand, **biomass** reflects the raw material production capacity of the ecosystem. At the same time, it also has an important impact on other services of the ecosystem in the process of biomass formation and accumulation. Therefore, this study assumes that biomass can largely reflect the differences in service functions between different types of ecosystems. Referring to the following calculation process, the basic equivalent table is obtained as table 1.

- ↗ Extraction and calculation of statistical data.
- ↗ The research results of ecosystem service function values directly corresponding to documents and data are calculated on average, and the ratio with standard equivalent is calculated as the basic equivalent of this kind of ecosystem service function
- ↗ Through literature data calculation, the service function quantity and the value quantity of the unit area ecosystem service function quantity are obtained, and then the service value of the unit area is calculated, and then compared with the standard equivalent value, the basic equivalent value of this type of ecosystem service function is obtained.

Table 1 Ecosystem service equivalent value per unit area

Ecosystem classification		**Provisioning service**			**Regulating service**				**Supporting service**			**Cultural service**
Primary classification	Secondary classification	**P1**	**P2**	**P3**	**R1**	**R2**	**R3**	**R4**	**S1**	**S2**	**S3**	**C1**
Farmland	**FA1**	0.85	0.40	0.02	0.67	0.36	0.10	0.27	1.03	0.12	0.13	0.06
	FA2	1.36	0.09	-2.63	1.11	0.57	0.17	2.72	0.01	0.19	0.21	0.09
Forest	**FO1**	0.22	0.52	0.27	1.70	5.07	1.49	3.34	2.06	0.16	1.88	0.82
	FO2	0.31	0.71	0.37	2.35	7.03	1.99	3.51	2.86	0.22	2.60	1.14
	FO3	0.29	0.66	0.34	2.17	6.50	1.93	4.74	2.65	0.20	2.41	1.06
	FO4	0.19	0.43	0.22	1.41	4.23	1.28	3.35	1.72	0.13	1.57	0.69
Grassland	**G1**	0.10	0.14	0.08	0.51	1.34	0.44	0.98	0.62	0.05	0.56	0.25
	G2	0.38	0.56	0.31	1.97	5.21	1.72	3.82	2.40	0.18	2.18	0.96
	G3	0.22	0.33	0.18	1.14	3.02	1.00	2.21	1.39	0.11	1.27	0.56
Wetland	**WE**	0.51	0.50	2.59	1.90	3.60	3.60	24.23	2.31	0.18	7.87	4.73
desert	**D1**	0.01	0.03	0.02	0.11	0.10	0.31	0.21	0.13	0.01	0.12	0.05
	D2	0.00	0.00	0.00	0.02	0.00	0.10	0.03	0.02	0.00	0.02	0.01
waters	**W1**	0.80	0.23	8.29	0.77	2.29	5.55	102.2	0.93	0.07	2.55	1.89
	W2	0.00	0.00	2.16	0.18	0.54	0.16	7.13	0.00	0.00	0.01	0.09

1.2 Conclusion

By introducing NPP, precipitation and soil conservation adjustment factors, and combining with the national average annual ecosystem service value scale, *an equivalent factor table for dynamic evaluation of ecosystem service value* is constructed to realize the dynamic value evaluation of ecosystem service in space and time, which provides an important premise and foundation for further evaluating the spatio-temporal dynamic changes of ecosystem service value in China.

Table2 The changes of ΔVC . A . BET . NET over time

		A_K	VC	**DET**	**BET**
Same location	Less than a year	Change	Change	Change	No change
	Over a year	Change	Change	Change	Maybe change
Different locations	Less than a year	Change	Change	Change	No change
	Over a year	Change	Change	Change	Maybe Change

2 Land Development and Utilization Cost (Co)

2.1 Classification

Land development and utilization costs can be divided into internal costs and external costs.

Table 3 The difference between external cost and internal cost

	External cost	Internal cost
Explanation	Monetary estimate of other environmental losses (negative external impacts) caused by land development	Direct expenses incurred by developers in land development and utilization
	eg.Reclamation of coastal tidal flats for agricultural use will destroy fishery resources in the intertidal zone	①Investment in land development; ②Operating expenses for land use
Value estimation	Value of lost productivity of affected resources	Direct expenditure of land developers
	Economic Loss of Fishery Production Caused by Decline of Fishery Resources Productivity	From statistical and accounting data

2.2 External Cost/Environmental Cost (EC)

$$EC = ESV_1 - ESV_2$$

where ESV_1 denotes ecosystem service value *before* land project development.

ESV_2 denotes ecosystem service value *after* land project development.

2.3 Total Cost

$$Co = EC + IC \tag{1}$$

3 Coefficient of Sensitivity (CS)

Ecosystem service value coefficient (VC) is one of the important influencing factors of ecosystem service value (ESV). It is obvious that VC has certain errors. The sensitivity of ESV to VC determines whether these errors can affect the effectiveness of the model.In order to verify the degree of influence, sensitivity index (CS) was used.

The analytical model method is to calculate the response of ESV to the unit price change of ecological value based on the determined service value coefficient adjusted up and down by 50%, and the calculation formula is

$$CS = \left| \frac{(ESV_j - ESV_i)/ESV_i}{(VC_{jk} - VC_{ik})/VC_{ik}} \right| \tag{2}$$

where i And j respectively denote the initial value and the adjusted value of ecosystem service value coefficient.

k is a land type.

3.1 Conclusion

If CS>1, ESV is elastic and sensitive to VC, and the effectiveness of the model is relatively low.

If CS<1, ESV is less elastic and sensitive to VC, and the effectiveness of the model is relatively high.

The higher the value of CS, the more critical the accuracy of VC is.[2]

With the example of Jiaxing city, we calculated CS<1, and then verified the validity of the model.

4. Practical Application Test of the Model

When applying the model we have built in actual projects, we have to consider the influence of time and space on the model. When the time or space changes, VC will change with the change of dynamic equivalent value table.

For example, the method of dividing large-scale national projects into small-scale community projects aims to eliminate the impact that the change of VC caused by long construction period. According to the hypothesis, the construction period of small-scale projects should not exceed one year. In other words, VC will not change in one year.

This example clearly shows the comprehensiveness and feasibility of taking time and space factors into consideration in the model we have established.

5.Impacts of Model

5.1 Assumptions and Analysis

Table 4 Variable Tables for Two Schemes

	Plan A	**Plan B**
RE	r_1	r_2
IC	i_1	i_2
PB	pb_1	pb_2
EC	e_1	e_2
PA	pa_1	pa_2

RE: Project Revenue

IC: Internal Cost

PB: Profit before considering environmental costs

EC: External/Environmental Cost

PA: Profit after considering environmental costs

Regulation:

$$e_1 > e_2$$

$$\left.\begin{aligned} r_1 - i_1 &> r_2 - i_2 \\ pb_1 &= r_1 - i_1 \\ pb_2 &= r_2 - i_2 \end{aligned}\right\} pb_1 > pb_2 \tag{3}$$

$$\left.\begin{aligned} pa_1 &= pb_1 - e_1 \\ pa_2 &= pb_2 - e_2 \end{aligned}\right\} pa_1 \gtreqless pa_2 \tag{4}$$

5.2 Impact on Project Planners and Managers

For project planners and managers, when environmental costs are not taken into account, choosing Plan A will bring greater benefits. However, when environmental costs are taken into account, it is hard to compare the benefits between Plan A and Plan B.

In other words, according to the model we have established, it may make project planners and managers change the project plan to obtain greater benefits.

5.3 Selection of Optimal Scheme

In the actual land project, we adopt the method of **Goal Programming** to choose the best scheme.

5.3.1 Definition of Optimal Scheme:

- Environmental cost less than national standard
- Maximizing benefits

5.3.2. Calculating

$$\begin{cases} \max P = RE - (IC + EC) \\ EC \le a \\ IC + EC \le b \\ RE \ge IC + EC \end{cases} \tag{5}$$

where a denotes the national standard of environmental cost.
b denotes the maximum value of investment funds.
P denotes profit after considering environmental costs.

5.3.3 Conclusion

Through Matlab calculation, the scheme with the maximum P is compared for the selection of project planners and managers.

6. Strengths and Weakness

6.1 Strengths

• Objectivity of Evaluation — the determination of the equivalent factors draw on the evaluation results based in part on the physical quantity method, avoiding or reducing the subjective assumption that is easily caused by merely scoring by experts' experience.
• Comprehensiveness of analysis — The dynamic equivalent value table has higher temporal resolution and spatial resolution than the basic equivalent value table.
• Convenience of comprehensive calculation—The method has few data requirements , simple application, easy operation, comprehensive evaluation, unified method and convenient comparison of results in practical application, and can be used as a quick accounting tool for ecosystem service value evaluation.
• High adaptability of the model — for any land use projects, as long as there is the area of each land type, the basic basic equivalent table during the development period and the annual average yield of crops per unit area,the environmental cost can be calculated.

6.2 Weakness

• Limitations of data — Due to the limitation of data and methods, the research results are only the results of evaluating the value of some ecosystem services.
• Fuzzy of classification — Due to the lack of relevant research, some types of ecosystem service function related parameters and results are lacking. In addition, due to the complexity of the ecosystem itself and the influence of environmental and biological conditions, it is impossible to further distinguish the ecosystem types and service function categories.

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