Emergy: The Bridge between Ecosystem Services and Currency

Yaxin Guo

North China Electric Power University, Baoding 071000, China.

1294541890@qq.com

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Abstract: With the development of economy, the impact of land use projects on ecosystem services has been widely concerned. The traditional economic system can no longer satisfy the evaluation of ecosystem services. In this context, this paper creates an ecological services valuation model to understand the true economic costs of land use projects when ecosystem services are considered.

1. Introduction

With the rapid development of economy, many human behaviors are changing the ecosystem, which may limit or remove the ecosystem services. Ecosystem services are the many benefits and assets that humans receive freely from our natural environment and a fully functioning ecosystem. The Millennium Ecosystem Assessment (MA) delineated the four categories of ecosystem services: provisioning, regulating, supporting and cultural. [1] When humans alter ecosystems through behavior, such as changing land-use patterns, these effects may seem trivial, but they add up to impacts on biodiversity and environmental degradation.

At present, economic theory tends to ignore its impact on the biosphere, and most land use projects do not consider the impact of, or account for changes to, ecosystem services. But the environment is facing the terrible consequences of degradation, such as soil erosion, soil salinization, Water degradation, Biodiversity loss and so on.

In order to analyze the cost-benefit of land use development projects, and to enable the land use project planners and managers to make correct decisions, we need to include ecosystem services in the cost of land use projects to understand the real economic cost of land use projects.

2. Ecological Services Valuation Model

2.1 Assumptions before Establishing the Model

In order to simplify the complex situation of real life, we made the following assumptions before establishing the model. Assuming that the ecosystem we study has limited resources, before the implementation of the project, the ecosystem has been in a stable state without significant disaster impact, the ecosystem service valuation of each indicators within the same ecosystem is uniform, and the emergy to money ratio is constant over a short period of time.

2.2 Ecological Services Valuation Model

Based on our assumptions, we follow the general classification criteria of The Economics of Ecosystems and Biodiversity (TEEB), but combined with the actual situation made some adjustments [2]. We select 12 suitable ecosystem service indicators from the four major categories of provisioning, regulating, supporting and cultural. As is shown in figure 1.

$$E = Q \cdot UEV \tag{1}$$

In formula (1), E represents the emergy of an indicator, Q represents the quality of the indicator, and UEV represents the transformity.[3]

Drawing on previous studies, we simplify some of these indicators based on our assumptions, and evaluate the ecosystem services valuation of the indicators we selected.

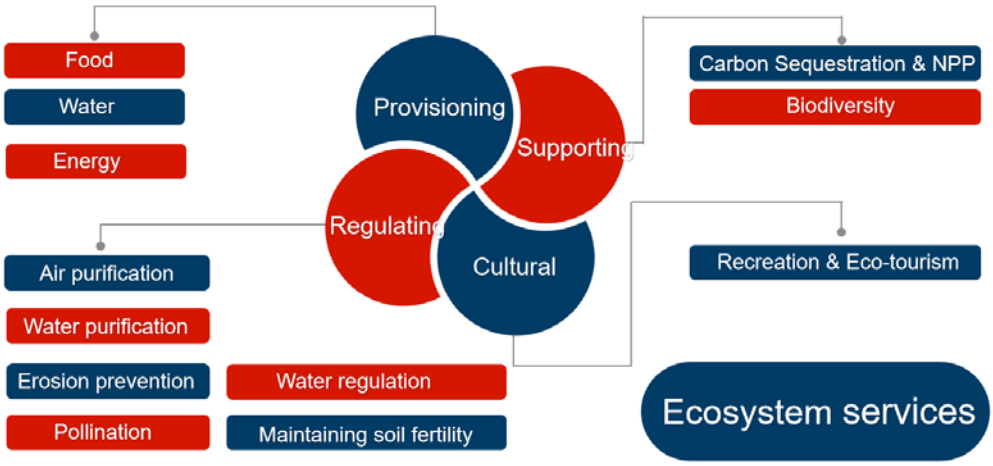

Fig. 1 The 12 indicators of ecosystem services

3. Application of Ecological Services Valuation Model

3.1 Applications in Different Size Areas

3.1.1 Application in Guangdong

Guangdong province, located in the south of the Chinese mainland and the east Asian monsoon region, is one of the regions with the most abundant light, heat and water resources in China. The main ecosystems of Guangdong province are forests, grasslands, cropland and wetland.

By applying the model to Guangdong province, China, corresponding emergy of 12 indicators in the ecosystem of Guangdong province and their proportion can be calculated, as shown in figure 2.

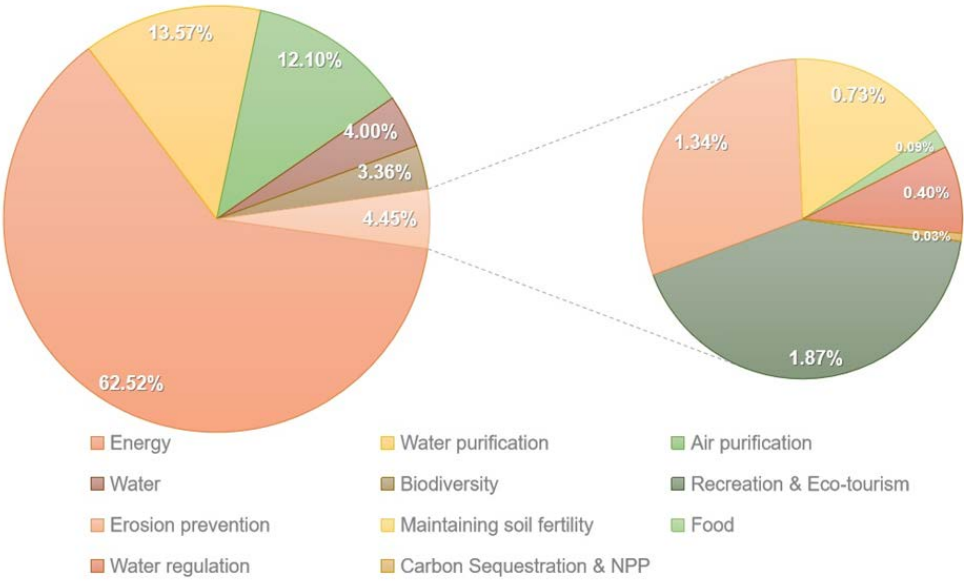

Fig. 2 The emergy proportion of the 12 indicators in Guangdong

Then, we use fuzzy comprehensive evaluation (FCE) method [4] to evaluate the unit value of four ecosystem services in Guangdong province. According to the emergy of 12 indicators and the actual situation, we obtained the expert judgment matrix of four ecological services, and assigned weights to the ecological types corresponding to each indicator. The economic value and proportion of

ecological services per unit area of each ecosystem can be obtained through the emergy to money ratio, as shown in figure 3.

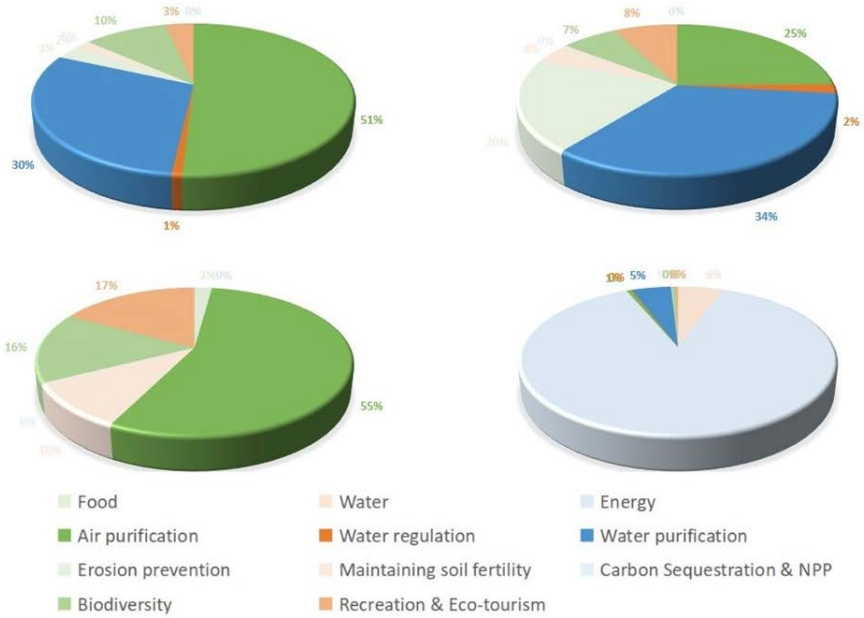

Fig. 3 The proportion of unit value of each indicator in the four ecosystems

3.1.2 Application in Zhanjiang Mangrove Forest

Zhanjiang mangrove forest, located in the southernmost part of the Chinese mainland, is a national nature reserve in China. It is located in the transition zone from tropical monsoon to subtropical monsoon. The peninsula is relatively flat, with a complex coastline and rich natural resources.

Similar to the calculation method of ecosystem service emergy in Guangdong province, we collect relevant data from Zhanjiang statistical yearbook and various literature, then calculate emergy and the proportion of emergy of each indicator, as shown in figure 4.

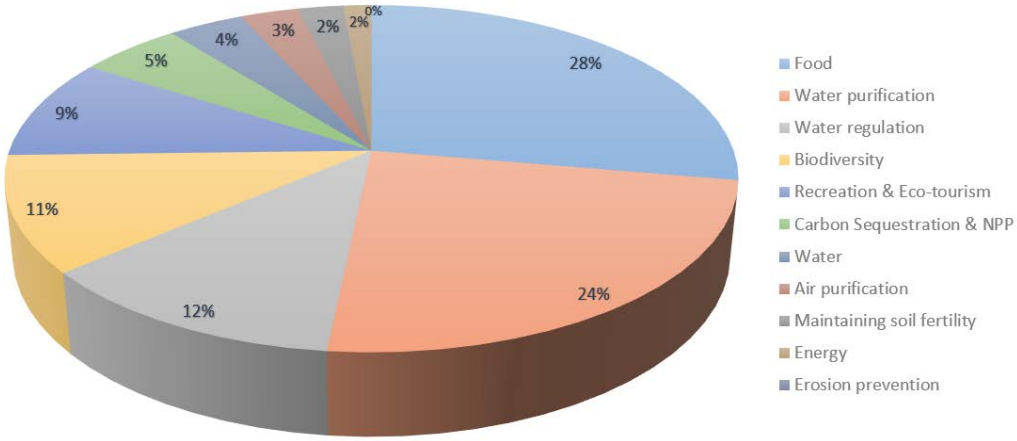

Fig. 4 The proportion of emergy of each indicator

Table 1. The cost of Zhanjiang ecosystem degradation

Total area of Zhanjiang Mangrove National Nature Reserve	9258 hm^2
Unit land price of Zhanjiang ecological wetland	2659.75 dollars/hm^2
The area damaged by railway construction	9100 m^3

Ecological cost	$24203.62

$$T_C = A \cdot U \quad (2)$$

In formula (2), *U* represents the cost per unit area, (the data of *U* comes from table 1, *A* represents the total area of the ecosystem, T_C represents the total cost of ecosystem degradation.

According to formula (2), we can calculate the total cost of the destruction of Zhanjiang Mangrove National Nature Reserve by building the railway, is also the ecological cost of Zhanjiang Mangrove National Nature Reserve. As shown in table 1.

3.2 Evaluation of the Model

Based on our model, we can calculate the general ecological cost, so land use project planners and managers such as mayor, land and resources bureau chief, they can reference for land development project decision-making using our model calculated the ecological degradation of costs, combined with the expected return on the project, considering whether to put into the project.

If the benefits of the project are much greater than the costs of ecosystem degradation, for example, the difference of one order of magnitude or more, then the project can be considered for implementation. If the difference is not particularly large, then it is inappropriate.

Because the indicators we consider are not comprehensive, and the emergy of some indicators will constantly change, and some data are not particularly accurate, but we have referred to a lot of literature and data, and the indicators we consider are very important and occupy a very large proportion, so they are of certain reference value for planners and managers.

4. Summary

We refer to the previous research, reference the MA and TEEB estimates the ecological value classification method of ecosystem services from four categories of chose 12 indicators, using emergy to estimate the ecosystem service value and studying the ecosystem service value of forest, grassland, cropland, desert and wetland.

Based on previous assumptions, the emergy to money ratio and transformity of some indicators are constant in a short time, but the transformity of each indicator will change with time and the change of ecosystem in the coming decades.

According to the current social development trend, with the gradual development and use of clean energy and the low-carbon economic transformation in recent years through consultation and cooperation among various countries, we predict that the emergy to money ratio of developed countries and some developing countries will gradually decrease.

At the same time, the ecological environmental value will be higher and higher in the future, which is reflected in our model that the transformation of each indicator will increase, so that the calculated ecosystem value per unit area will also increase. So, what we need to do is adjust the transformation so that the calculated ecosystem valuation will be realistic.

References

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