Environmental cost assessment model of land use Project

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Abstract. With the improvement of human understanding of ecological environment, scientists at home and abroad have established a series of models to assess the environmental costs of land use projects. Most of the domestic research is based on the ecosystem of Xie Gaodi’s Static value model. His model mainly considers the value of the ecosystem occupied by the project. However, on the basis of this model, this paper will construct the environmental degradation model from another angle. The new model takes into account not only the value of the ecosystem occupied by the project, but also the continued loss of the project to the external environment. This model is a more comprehensive assessment of the cost of environmental losses for land-use projects.

Keywords: Environmental cost, Ecosystem services, Differential equations.

1. Introduction
After a project is completed, it will not only destroy the ecosystem within its scope, causing the loss of its own ecological service value, but also affect the external ecosystem area, leading to the degradation of the overall environment. This point cannot be ignored in analyzing the impact of the project on the ecological environment.

We analyzed the above Xie Gaodi’s model— Static value model (SVM), and found that it only evaluated the value of the ecosystem within the scope of the project, ignoring the continuous impact of the project on the rest of the ecosystem. This results in a loss of the ecological service value of the assessed project that is lower than its actual loss. So, we thought about the following optimization model: the environmental Dynamic Degradation Model (DDM). Its main purpose is to assess the loss of environmental degradation of the external ecosystem caused by a project.
2. Establishment of DDM

According to biological knowledge, ecosystems have the ability to self-regulate which is the self-effect when an increase in a species’ abundance decreases its per-capita growth rate. Sources of self-regulation include intraspecific interference, cannibalism, time-scale separation between consumers and their resources, spatial heterogeneity and nonlinear functional responses coupling predators with their prey. According to the literature[4], the self-regulation ability of ecosystem is related to biodiversity: the stronger the biodiversity is, the stronger its self-regulation ability is.

According to the hypothesis, there is a positive correlation between biomass and ecosystem service value, so we construct an ecosystem self-regulatory factor $R$:

$$R = \frac{V}{V_0}$$

In the above formula: “$R$” is a self-regulating factor that reflects the strength of the ecosystem's self-regulation. “$V$” is the value of existing ecosystem services. “$V_0$” is the value of ecosystem services at the initial moment.

We also need a new variable $W$:

$$W = \frac{S}{S_T}$$

In the above formula: “$W$” is the damage index, reflecting the ability of the project to destroy its surrounding ecosystem. “$S$” is the area occupied by the project. “$S_T$” is always the area of the entire ecosystem.

After constructing the variables, we analyze the relationship between the two variables and get the following results:

- The stronger the adjustment ability is, the faster the damage index declines. We use the formula to express this relationship:

$$\frac{dW}{dt} = -R$$

- The stronger the damage index is, the faster the adjustment ability declines. We use the formula to express this relationship:

$$\frac{dR}{dt} = -W$$

- We get a comprehensive formula:
\[
\begin{align*}
W &= W_0 - Rt \\
R &= R_0 - Wt
\end{align*}
\]

\(W_0\) is the damage index at the initial moment \\
\(R_0\) is self-regulating factor at the initial moment

**Figure 2.** Trends in W and R

Calculation method

- **Calculation formula of environmental cost of SVM**

\[ V_{SVM} = X \cdot Y \]

“\(X\)” is project occupancy Area.

“\(Y\)” is value of ecosystem services per unit area

- **Calculation formula of environmental cost of DDM**

\[ V_{DDM} = V_0 \cdot \Delta R \]

“\(V_0\)” is the value of ecosystem services at the initial moment.

“\(\Delta R\)” is the amount of change in R

- **Calculation formula of environmental cost of Overall model**

\[ V_W = V_{SVM} + V_{DDM} \]

“\(V_W\)” is environmental cost of Overall model

**3. Model Analysis**

In the model analysis, we found that when we change the value of \(W_0\), the value of \(R\) will also change with the change of it. Based on this phenomenon, we explore the impact of a land use project on the stability of the entire ecosystem. And then we found some interesting phenomena.
We select a specific ecosystem for research, that is, the total area of the ecosystem is constant. Next, we analyze the impact of the project on the overall ecosystem value by changing the footprint of the project.

a) When $S$ is extremely small, that is, the project area is small, $W_0$ is extremely small and much smaller than $R$. At this point, the damage index will quickly drop to “0”, and the decline in the adjustment factor is not obvious.

b) When $S$ gradually increases, the area of the project gradually increases, and $W_0$ gradually increases. At this time, the descending speed of $W$ is slowed down, and the decrease of the adjustment factor is increased.

c) When $S$ is extremely large, that is, the area of the construction project is close to the area of the ecosystem we are studying, $W_0$ is close to “1”. In this case, $W$ and $R$ are nearly synchronously falling. When $W$ falls to “0”, $R$ is greatly reduced.

4. Conclusion

Our optimized model is more comprehensive than the scope covered by the base model. Our model not only considers the value of the ecosystem used by the project, but also considers the impact of the project on the external ecosystem. So, it can get more accurate the value of the ecosystem. But the model is too simplistic and does not take into account the different environmental damage capabilities of different project types. This model is only a primary model and needs to be perfected in subsequent research.

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