Ecological Assessment Model for Estimating Environmental Costs

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Abstract: The ecosystem provides us with many benefits directly or indirectly. In the long-term human activities, we have not considered the damage caused by these activities, and the environment has become worse and worse. Protecting the environment is an urgent task. In this paper, I designed an ecological assessment model for estimating environmental costs for environmental pollution generated in land use projects. It is possible to calculate the environmental costs incurred by different types of land use projects. I hope that I can provide some suggestions in future land use projects.

1. Introduction

This model calculates the environmental costs of five major pollutions in land use projects. I divided the environmental costs of these pollutions into loss costs and governance costs, and calculated them separately. In calculating the cost of loss, I used the analytic hierarchy process to calculate the weight of several losses in the five pollutions. Then I monetized the cost of loss and the cost of governance, and finally quantified the environmental cost in the form of price, making the results more intuitive.

2. Hypothesis and rationality analysis

In the real world, we need to make the necessary assumptions before building a model, and our assumptions are as follows:

- The environmental pollutions generated by land use projects mainly consider five categories: water pollution, air pollution, soil pollution, light pollution and noise pollution. After consulting the data, the main pollutions generated by the land use projects are the above five types. The proportion of other pollution is very small and can be ignored.
- Losses from environmental pollution are measured only in terms of money, regardless of other factors. Because the target is the cost of loss, it is mainly considered from the economic benefits, it is reasonable to use the price to measure.
- The types of losses caused by five kinds of pollution are loss of human health, loss of agriculture, loss of industry, loss of water quality, loss of forestry. The types of losses caused by the five types of pollution we studied are mainly the above points, and other losses have little impact and are ignored here.
- After the completion of the land development project, it will be treated according to the level of pollutant control of general industrial enterprises. For pollution control, the measures taken are mostly the same, and the calculation methods are similar, and we have more research on the pollution control of industrial enterprises, and it is easier to obtain data.
- The cost of soil pollution control is calculated by in situ phytoremediation; the advantages of phytoremediations and physicochemical remediation and microbial remediation are more obvious. It can not only achieve the purpose of controlling organic matter polluted soil but also greening the surrounding ecological environment. This method is effective. This method is widely used.

• The cost of pollution treatment is ignored in this paper. After the investigation, the cost of noise pollution control is small, and a large part of pollution can be reduced by human control, so we do not consider its treatment cost here.

• When using monetary to quantify environmental costs, I use the RMB.

3. Calculation of loss cost

3.1 Composition of the model

I have obtained the weight of the five types of pollution in the total pollution in the principal component analysis method. $w^{(2)} = w_1^{(2)}, w_2^{(2)}, \dots, w_5^{(2)}$ are water pollution, air pollution, soil pollution, solid waste pollution and noise pollution respectively corresponding to the weight of the loss cost Weight Vector. The weight of each type of loss in the five types of pollution is recorded as $X_{ni} = x_{n1}, x_{n2}, \dots, x_{ni}, i = 1,2,3,4,5$ and the economic cost of each loss is set to $X_1' = x_1', x_2', \dots, x_n'$, then we can directly get the weight of each loss type in the total loss cost as $w_n = W_1, W_2, \dots, W_n$. Using the weighted average method, we can get loss cost is:

$$H = W_1 * x_1' + W_2 * x_2' + W_3 * x_3' + W_4 * x_4' + W_5 * x_5' \tag{1}$$

3.2 Model establishment

3.2.1 Pairwise comparison matrix

We use the analytic hierarchy process to calculate the weight of various types of losses in the five types of pollution. When calculating by analytic hierarchy process, make a pairwise comparison matrix of losses for each kind of pollution, and set them as B_1, B_2, B_3, B_4, B_5. (using 1-9 comparative scales to construct pairs of pairs) Choose two factors in the loss P_k, P_j,$(k, j = 1,2,3,4,5)$. The element$b_{kj}^{(i)}$ in the matrix $B_i (i = 1,2,3,4,5)$ is a measure of the loss of P_k and P_j for a certain type of pollution $c_i, i = 1,2,3,4,5$.

3.2.2 Consistency test

$$CI = \frac{\lambda - z}{z - 1} \tag{2}$$

(a) CI is defined as the consistency index
(b) λ is the largest eigenvalue of B_i
(c) When $CI = 0$, B_i is consistent array
(d) The greater the CI, the more inconsistent the B_i is.

3.2.3 Weight vector

After obtaining the uniform matrix, the eigenvector (normalized) corresponding to the maximum eigenvalue λ of B_i is used as the weight vector$w_i^{(3)}$, that is, $w_i^{(3)}$satisfies:

$$B_i * w_i^{(3)} = \lambda * w_i^{(3)} \tag{3}$$

Then we can get the combined weight vector for each loss type and loss cost.
n represents the number of loss types.

3.2.4 Combined consistency test

Assuming the consistency index of the loss type layer be $CI_1, CI_2, \dots, CI_5$, and the random consistency index is$RI_1, RI_2, \dots, RI_5$, definition:

$$CI = [CI_1, CI_2, \dots, CI_5] * w^{(2)} \tag{4}$$

$$RI = [RI_1, RI_2, \dots RI_5] * w^{(2)} \tag{5}$$

• The condition of the combined consistency test is $CR < 0.1$;

• If the test passes, the decision can be made according to the result represented by the combined weight vector. Otherwise, it is necessary to reconstruct the pairwise comparison matrix with larger consistency ratio CR.

3.3 Estimation of governance costs

The way we look at the data to obtain the economic costs of various losses under each type of pollution is calculated as:

3.3.1 The loss of human health

$$H_1 = E_1 * GDP_{pco} * \sum \frac{(1+\alpha)^t}{(1+r)^i} \tag{6}$$

$$t = \frac{\sum e_x * d_x}{\sum d_x} \tag{7}$$

Where:

- $H1$ is the economic loss caused by pollution (100 million yuan)
- $E1$ is the number of premature deaths caused by pollution (person)
- GDP_{pco} is per capita GDP (yuan/person)
- t is the number of years of per capita loss of life due to early death (year)
- α is the annual growth rate of GDP per capita
- r is the social discount rate
- e_x indicates the age-specific life expectancy (year)
- d_x indicates the number of deaths of each disease age
- i is the product of the age-specific death rate of each disease and the average age of the population.

3.3.2 The loss of agricultural

$$H_2 = P * Q_1 \tag{8}$$

Where:

- $H2$ is the loss of production of a crop caused by water pollution (100 million yuan)
- P is the price of a crop (yuan / 50 kg)
- Q_1 is the actual production reduction for a crop (10,000 tons)

3.3.3 The loss of industrial

$$H_3 = F * L \tag{9}$$

Where:

- H_3 is the pollution loss that protects certain environmental media and species;
- F is the cost of protecting certain environmental media and species
- L is the total amount of environmental media and species that are contaminated.

3.3.4 The loss of water quality

$$H_4 = R * Q_S * \left(W_s - W_y\right) * k \tag{10}$$

Where:

- H_4 is the economic loss caused by water pollution (RMB 10,000)
- R is the coefficient reflecting the value of water resources per unit and pollution loss
- Q_s is the amount of polluted water resources (Billion/m3)
- W_s is the total amount of pollutants entering the river
- W_y is the allowable emission of major pollutants in the river
- k is the dimensionless dimension parameter

3.3.5 The loss of Forestry

$$H_5 = S_1 * S_r * P * A \quad (11)$$

Where:
- H_5 is a direct economic loss of forest
- S_1 is the area of forest death or victim
- S_r is the normal forest rate of forest
- P is the loss rate of forest volume
- A is the price of wood

4. Governance cost calculation

We only calculate the total environmental cost from the cost of loss is a little one-sided, we have to start from the governance aspect, fully to consider.so we estimate the actual governance cost and emissions related to the virtual treatment costs related to the amount of pollutant removal.

4.1 Water pollution virtual governance cost accounting

$$V_1 = \sum(PI_i \times QI_i) \quad (12)$$

Where:
- i is a pollutant type,a total of five kinds, including heavy metals, cyanide, chemical oxygen demand, petroleum and ammonia nitrogen
- V_1 is the virtual treatment cost of construction wastewater
- PI_i is the unit treatment cost of the i-th pollutant of c onstruction wastewater
- QI_i is the discharge of the i-th pollutant of construction wastewater;

4.2 Air pollution virtual governance cost accounting

$$V_2 = \sum(PA_i \times QAE_i) \quad (13)$$

Where:
- i is a type of pollutant, a total of 4 kinds, including sulfur dioxide, soot, dust and nitrogen oxides
- V_2 is the virtual treatment cost of construction waste gas; PA_i is industrial

4.3 Soil pollution virtual governance cost accounting

$$V_3 = S * P\ BI \quad (14)$$

Where
- V_3 represents the virtual treatment cost of soil pollution
- S represents the area to be repaired
- $P\ BI$ represents the repair cost per unit area (approximately 0.12 6 yuan/m2);

4.4 Solid waste pollution virtual governance cost accounting

$$V_4 = QW_e \times PW_t + QW_r \times (PW_t - PW_r) \quad (15)$$

Where:
- V_4 is the cost of industrial solid waste virtual treatment
- QW_e is the solid waste discharge during the construction process
- PW_t is the solid waste unit disposal cost
- QW_r is the solid waste storage capacity during the construction process
- PW_r is the solid waste unit storage cost

Therefore, the total cost of governance is:

$$V = X_1 * V_1 + X_2 * V_2 + X_3 * V_3 + X_4 * V_4 \quad (16)$$

In summary, we can get the environmental cost of unit pollution caused by land use projects.

$$Z = H + V \tag{17}$$

5. Conclusion

The model divides the environmental costs that may be generated during the land use project into loss costs and governance costs. It is considered more comprehensive and highly implementable. And ultimately, the cost of environmental degradation is directly measured in the form of money. The results are clear and easy to use.

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