Environmental Pollution Cost Model for Land Development Projects

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Abstract. The environmental pollution cost is a measure of the extent of damage to the environment of land development projects. It should be an important part of corporate decision-making. Environmental pollution cost refers to economic losses caused by environmental pollution, including environmental degradation cost and pollution control cost. First, we use the market value method to establish the cost equations for water, energy and land environmental degradation. In addition, we use principal component analysis to select two main factors affecting environmental control cost: environmental pollution level and corporate environmental management level. We use the entropy weight method and the analytic hierarchy process to normalize the management level, and then establish an equation for accounting for the pollution control cost of the project. Enterprise environmental pollution cost accounting system is conducive to the enterprise to accurately calculate the environmental pollution cost of land development projects. Reasonable control of environmental pollution is conducive to the sustainable development of the economy and society.

1. Introduction

The contribution of environmental resources to human welfare is mostly in the form of pure public goods. They do not accumulate directly into humans through money. In many cases, people even ignore their existence, such as clean air, water, soil, climate regulation, waste disposal, aesthetic value and health. In fact, environmental resources are an important manifestation of the earth’s well-being for humanity. However, with the development of the economy, environmental resources have been increasingly severely damaged. Many land development projects have developed the economy at the expense of the environment. Since establishing a systematic and completing ecological civilization system have been proposed, the cost of environmental pollution has received more and more attention. The environmental pollution cost refers to the economic loss caused by environmental pollution, including the environmental degradation cost and the pollution control cost. The environmental degradation cost refers to the actual damage caused by the pollutants discharged during production and consumption to the environmental function, that is, the irreversible polluted resources, such as non-recyclable sewage generated, consumed energy, and non-cultivable land. Pollution control cost refers to the cost required to convert all pollutants discharged into the environment into uncontaminated conditions. Since the introduction of environmental cost, many scholars have studied various economic losses caused by environmental pollution. After incorporating human capital method, market value method and other methods into the environmental cost accounting system, Erik Gómez-Baggethun et al. estimated the economic losses of air pollution, agriculture, animal husbandry and forestry. The results show that after adding the above costs, the actual profit will be greatly reduced.
James Tobin et al. used the pollution loss method to calculate the national environmental degradation cost in 2004. The results showed that the total cost of environmental degradation in the year was $32.6 billion. Wu Qiong and other scholars used the environmental cost accounting system in the preparation of natural resources balance sheet to calculate the environmental cost of Huzhou City from 2010 to 2015. The results show that Huzhou is still in the stage of pollution debts. Compared with the national environmental pollution control cost results, the average environmental control cost of the administrative district is 2.017 billion yuan.

Many scholars have done a lot of research on environmental cost accounting, but most of them are based on the accounting of environmental cost in the whole region. The accounting of environmental pollution cost of individual enterprises has not yet formed a complete system. However, the environmental pollution cost accounting of enterprises is very necessary. It is a measure of the degree of environmental damage to land development projects and should be an important criterion for land project review. It should be an important part of corporate decision-making. Based on the existing research, we establish the enterprise environmental pollution cost accounting model by establishing the accounting equations of environmental degradation cost and environmental control cost as a unit. This model provides a precise accounting method for enterprise project evaluation and makes up for the gap in the enterprise environmental pollution cost accounting system. Incorporating the enterprise environmental pollution cost accounting system into the approval system of land development projects is conducive to forcing enterprises to accurately calculate the environmental pollution cost of land development projects. Reasonable control of environmental pollution is conducive to the sustainable development of the economy and society.

2. Model construction
The environmental pollution cost of a land development project is the sum of environmental degradation cost and environmental control cost. Among them, the environmental degradation cost includes the non-reusable water and energy consumed by the enterprise in the production process and the land that irreversibly affects the vegetation. The environmental control cost refers to the conversion of the pollutants discharged to the environment into the uncontaminated state. The environmental pollution cost is related to the degree of pollution to the environment and the control level.

To calculate the environmental degradation cost, we introduce the value of natural resources being utilized in land development activities, including the value of consumed water, energy and land. The environmental degradation cost of the land development project is obtained by summing the consumption of the consumed resources and the corresponding values thereof.

At the same time, we use principal component analysis to select the main factors affecting the environmental pollution degree and control level of the enterprise and regard them as variables. The entropy weight method and the analytic hierarchy process are used to normalize the control level, and then the control cost equation is established.

2.1. Calculation of environmental degradation cost of land development projects based on market value method
The environmental degradation cost can be divided into water consumption reduction cost, energy consumption reduction cost and land resource consumption reduction cost. Below we will calculate from these three points.

2.1.1. Calculation of water consumption depletion cost. The water resource consumption reduction cost is calculated by multiplying the consumption of different water quality resources of the land development project and its corresponding price during the accounting period. Therefore, the key to calculating the cost of water resources degradation cost is to determine the water consumption reduction and the value of water resources.
At present, there are two main ideas for calculating the water resources consumption reduction cost. One is to replace the consumption reduction with total water consumption, but the idea ignores the characteristics of water resources circulation. The second is to calculate the amount of consumption according to the stock of water resources. This ignores the consumption reduction of different water resources quality. Based on the above two aspects, we consume the water consumption that cannot be returned to the nature as the water resource consumption reduction. Then we calculate the water resource consumption cost by combining the water resources value under different water quality. The specific formula is as follows.

\[ C_W = \sum_{i=1}^{n} V_i Q_i \]  

(1)

In formula (1), \( i \) is the water quality of water depletion resources, which is divided into class I to V. \( C_W \) is the water depletion cost. \( V_i \) is the value of the \( i \) th water quality of water resources. \( Q_i \) is the consumption reduction of the \( i \) th water quality of water resources.

2.1.2. Calculation of energy consumption and reduction cost. According to the characteristics of energy consumption, three types of energy, coal, crude oil and natural gas are selected. Due to the high degree of marketization of energy prices and the relatively perfect market trading mechanism, the market value method is used to calculate energy consumption and reduction cost. The basic accounting ideas are as follows.

\[ C_E = \sum_{i=1}^{n} P_i Q_{Ei} \]  

(2)

In formula (2), \( C_E \) is the energy consumption cost. \( P_i \) is the price of the \( i \) th type of energy consumption. \( Q_{Ei} \) is the consumption reduction of the \( i \) th type of energy.

2.1.3. Calculation of land resource depletion cost. The depletion of land resources is mainly reflected in the irreversible impact of land development projects on land vegetation. Here we use the land vegetation price to measure. Because the land development project location is different, the price of land vegetation is not the same. We use the unit average market price of the land vegetation where the project is located. Based on this, the calculation formula for the cost reduction of land resources is as follows.

\[ C_L = \sum_{i=1}^{n} P_i S_i \]  

(3)

In formula (3), \( C_L \) is the land resource depletion cost. \( P_i \) is the unit average market price of the \( i \) th type of vegetation where the project is located. \( S_i \) is the depletion area of the \( i \) th type of vegetation.

Therefore, the total cost of environmental degradation is as follows.

\[ C_N = C_W + C_E + C_L \]  

(4)

In formula (4), \( C_N \) is the total environmental degradation cost. \( C_W \) is the water resource consumption reduction cost. \( C_E \) is the energy consumption reduction cost. \( C_L \) is the land resource consumption reduction cost.

2.2. Calculation of environmental control cost based on entropy weight method and analytic hierarchy process

Environmental control cost refers to the cost of returning varying degrees of water, air and land to an uncontaminated state. We use principal component analysis to determine the two main factors affecting environmental control cost, the degree of environmental damage and the level of corporate
environmental control (the selection process is not elaborated). The degree of environmental damage includes the degree of water, air and land pollution. The level of corporate environmental control includes the level of environmental treatment machinery technology, environmental management level and environmental protection level.

2.2.1. Determination of the environmental damage degree. When determining the environmental damage degree, firstly we divide the environmental damage type into the degree of water, air quality and the extent of land damage. Then we use the most commonly used methods and indicators to measure the degree of pollution. The level of environmental damage is shown in Table 1.

Table 1. Environmental Pollution Classification

| Degree of environmental damage | Environmental type | Pollution level | Index       |
|--------------------------------|--------------------|----------------|-------------|
| Water                          | I                  | Good           | $P \leq 0.21$ |
|                                | II                 | Better         | $0.21 < P \leq 0.40$ |
|                                | III                | Mild pollution | $0.41 < P \leq 0.70$ |
|                                | IV                 | Heavier pollution | $0.71 < P \leq 1.00$ |
|                                | V                  | Heavy pollution | $1.01 < P \leq 2.00$ |
|                                | VI                 | Serious pollution | $P > 2.00$ |
| Air                            | I                  | Good           | $0 \leq \text{API} < 50$ |
|                                | II                 | Better         | $51 \leq \text{API} < 100$ |
|                                | III(1)             | Slight pollution | $101 \leq \text{API} < 150$ |
|                                | III(2)             | Mild pollution | $151 \leq \text{API} < 200$ |
|                                | IV                 | Moderate heavy pollution | $201 \leq \text{API} < 300$ |
|                                | V                  | Severe pollution | \(\text{API} \geq 300\) |
| Land                           | I                  | Clean          | $P \leq 0.7$ |
|                                | II                 | Warning line   | $0.7 < P \leq 1.0$ |
|                                | III                | Light pollution | $1.0 < P \leq 2.0$ |
|                                | IV                 | Medium Pollution | $2.0 < P \leq 3.0$ |
|                                | V                  | Heavy pollution | $P > 3.0$ |

When measuring the degree of water pollution, we selected the Nemerow water pollution index $P$ as an evaluation index, considering temperature, color, transparency, pH value, E.coli number, total dissolved solids, suspended solids, total nitrogen, alkalinity, chlorine, iron, manganese, sulfate, dissolved oxygen as calculation parameters of water pollution index.

When measuring the degree of air pollution, we choose API (air pollution index) as a variable. It uses total suspended particulate matter, respirable suspended particulate matter (floating dust), nitrogen dioxide, sulfur dioxide, carbon monoxide, ozone, volatile organic compounds and other pollutants as indicators to measure the degree of air pollution. The greater the value of the air pollution index is, the more severe the pollution is.

When measuring the degree of land pollution, we use the Nemerow comprehensive index method for soil heavy metal pollution grading standards to classify contaminated land. According to pollution sources and evaluation purposes, heavy metals, organic poisons, acidity and other non-metallic poisons are generally selected as basic evaluation parameters. The soil comprehensive pollution index $P_c$ is measured by regional soil background value or regional soil background value as the evaluation standard.

2.2.2. Dynamic coefficient correction model based on subjective and objective comprehensive weighting. Another factor influencing the environmental control cost is the company's environmental management level, including the level of environmental protection machinery and environmental management. The level of environmental protection machinery of enterprises is measured by the price of environmental protection equipment purchased by the company. The level of environmental
management is measured by the product of the environmental management manager and environmental protection personnel’s number and their corresponding wages.

We refer to the pollution control cost of the company’s location, combining the local unit average control cost with the technical level of the company. Then we construct the following equation.

1) Water resource control cost

\[ C_{wr} = \sum(P_{iw} \times Q_{iw}) \]  

In formula (5), \( C_{wr} \) is the water resources control cost. \( P_{iw} \) is the unit average market price of the enterprise that the enterprise manages to restore the water resources of the \( i \) th type to the unpolluted state. \( Q_{iw} \) is the amount of water in the \( i \) th type of corporate pollution.

2) Air resource control cost

\[ C_{ar} = \sum(P_{ia} \times Q_{ia}) \]  

In formula (6), \( C_{ar} \) is the air resource control cost. \( P_{ia} \) is the unit average market price that the enterprise locally manages when the air resources polluted to the \( i \) th type are restored to the uncontaminated state. \( Q_{ia} \) is the amount of \( i \) th air resources polluted by the company.

3) Land resource control cost

\[ C_{lr} = \sum(P_{il} \times S_{il}) \]  

In formula (7), \( C_{lr} \) is the land resource control cost. \( P_{il} \) is the unit average market price that the enterprise manages when it restores the land resources of the \( i \) th to the unpolluted state. \( S_{il} \) is the area of the \( i \) th type of land resources polluted by the enterprise.

Therefore, the average local environmental control cost of the enterprise is as follows.

\[ C_r = C_{wr} + C_{lr} + C_{ar} \]  

In formula (8), \( C_r \) is the cost of environmental control including water control cost \( C_{wr} \), air resource control cost \( C_{ar} \) and land degradation cost \( C_{lr} \).

Here, in order to reflect the impact of each company’s environmental control technology and management level on environmental control cost, we introduce the dynamic coefficient \( A \). The influencing factors of \( A \) are the price of environmental treatment equipment and the level of corporate management. The level of management is determined by the product of the number of managers and environmentalists and the corresponding wage level. Therefore, an equation about the dynamic coefficient \( A \) can be constructed.

\[ A = f(t, g, e) \]  

In formula (9), the factors affecting the dynamic coefficient \( A \) are \( t \)—enterprise environmental control equipment price, \( g \)—enterprise environmental management level and \( e \)—enterprise environmental protection level. Their weights are \( w_1, w_2, w_3 \), respectively.

Determination of the dynamic coefficient \( A \)

The weight of each index is determined by AHP method. The weight of the indicators is greatly influenced by human factors. Although the weight of each index determined by the entropy method has strong scientific theoretical basis, it lacks the intention of human intention. Therefore, both the subjective and objective weighting methods have certain defects. In order to compensate for the defects, we combine the principal and objective weight vectors and take the comprehensive weights.

\[ W_i = \frac{(W_i^p)^{1-a}(W_i^o)^{1-b}}{\sum_{i=1}^{n}(W_i^p)^{1-a}(W_i^o)^{1-b}} \]  

\[ s \]
\( \alpha \) and \( \beta \) respectively indicate the relative importance of objective weight and subjective weight.

1) Subjective weighting method: AHP model
Step 1 Get a pairwise comparison matrix of order \( n \).
Step 2 Consistent analysis.
Step 3 Normalize the matrix \( \tilde{X} \) that conforms to the consistency check.
\[
W = (w_1, w_2, w_3)
\] (11)

2) Establishment of information entropy decision model
Step1 Build a decision matrix \( U \).
Step2 Normalize attributes. Find the normalized matrix \( R \) of the decision matrix. \( r'_{ij} \) is an element in \( R \).
Step3 Normalize matrix \( R \).
Step4 Calculate the information entropy of the output of attribute \( u_j \).
\[
E_j = \frac{1}{\ln n} \sum_{i=1}^{n} \tilde{r}_{ij} \ln \tilde{r}_{ij}
\] (12)
Step5 Calculate attribute weight vector.
\[
w_j = \frac{1 - E_j}{\sum_{i=1}^{m} (1 - E_i)}
\] (13)
Step6 Calculate the composite attribute value \( z_i \).
\[
z_i = \sum_{j=1}^{m} r_{ij} w_j
\] (14)
Step7 Sort and prioritize scenarios using the size of \( Z_i \).

Model solving
According to the actual data of various industries in the past three years, after determining the dynamic coefficient \( A \) and the unit equipment cost \( w_1 \), the cost of the unit management level \( w_2 \) and the cost of the unit environmental protection level \( w_3 \), the final weight is as follows.
\[
Z_i = (0.6123, 0.1103, 0.2774)
\] (15)
The normalized dynamic coefficient is \( A_i = w_1 x_i \) \( (i = 1, 2, 3) \), where \( x_i \) is the actual price of the company's corresponding item.
After normalization
\[
A = \frac{\text{Max}_{A1} - \text{Min}_{A1}}{\text{A} - \text{Min}_{A1}}
\] (16)
After adding the impact of management technology differences, its environmental control cost is as follows.
\[
C_r' = A(C_{aw} + C_{br} + C_{ar})
\] (17)

2.3. Overall calculation equation for environmental pollution cost
Based on the above environmental degradation cost and environmental control cost, the total cost of corporate environmental pollution is as follows.
\[
C = C_n' + C_r'
\] (18)
In formula (18), \( C \) is the total environmental pollution cost of the land development project. \( C_n' \) is the environmental degradation cost. \( C_r' \) is the environmental control cost of the enterprise under the current technical level.
3. Conclusion
Since the introduction of environmental pollution cost, many experts and scholars have explored the environmental pollution cost accounting system. This paper combines the environmental cycle's recyclability and non-recyclability characteristics to construct an environmental pollution cost accounting system based on different characteristics of environmental resource trying to improve the accuracy and operability of enterprise environmental pollution cost accounting. The establishment of the environmental pollution cost accounting system makes the land project review more operational, which is conducive to the enterprise to strengthen its own review and make accurate evaluation of the land development project to determine the feasibility of the project. It has guiding significance for the enterprise's environmental management and laid a foundation for promoting the sustainable development of the economy and society. It is of great significance for the establishment of a systematic and complete ecological civilization system and an important strategy for green development.

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