The Accounting of Project Cost with the Cost of Environmental Degradation

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Abstract: Economic activity and environment are interrelated, but traditional economic theory often ignores its influence on biosphere. This attitude is causing serious consequences for the environment. Measure the environmental degradation costs of each economic project and incorporate them into the economic costs. Then, re-analyzing their cost-effectiveness can promote the development of green economy. In this paper, we made a comprehensive analysis of the environmental degradation cost from the two aspects: stock and flow.
Firstly, according to the classification of the value of natural resources and ecological services, the environmental degradation costs are calculated one by one from the aspects of stock and flow, and include them into the economic cost of the project. Then, we used the net present value model to re-analyze the costs and benefits of projects. It is found that if the environmental degradation cost of the project is too high, the net present value of the project may be greatly reduced or even negative.
Then, as time goes by, in order to avoid repeated accounting, the projects only need to pay for the flow value of natural resources and the cost of environmental governance after the completion of the project which established in the original ecological land and arable land, and do not need to calculate the natural resource stock value. Therefore, we improved the model and used the new model to calculate the cost of environmental degradation that is just enough to restore the environment after making up for the value of ecosystem services.
Finally, we gave the implications of our modeling to the project planners and managers. Project managers can promote green economy by levying environmental degradation fees and building special funds for environmental governance. Project planners should try to reduce the cost of environmental degradation by selecting urban lands or lands where the environment has been damaged to carry out the project construction.

Keywords: The cost of environmental degradation; The stock value; The flow value; Net present value model

1. Introduction

1.1. Background Introduction

Economic activities and the environment are interrelated. The pollution emitted by economic activities degrades the environment, which in turn restricts economic development and causes losses. In the process of industrialization, people only see the development of the world economy, but ignore the damage to the environment. As a result, most projects do not take the cost of environmental degradation into account. Correspondingly, the huge annual environmental governance costs are ignored, and the production value is often overestimated.

With the increasingly prominent environmental pollution problem, the economic accounting of ecological service value and environmental degradation cost has become one of the hot issues in research. We can maintain economic development while protecting the environment only by forming a complete theory of environmental cost, and formulating relevant policies to internalize environmental benefits. Most of the current theoretical studies only consider from the perspective of flow, but we make a comprehensive analysis of the environmental degradation cost from two aspects: stock and flow.

1.2. Significance of research

The study of environmental cost and ecological service assessment has both theoretical and practical significance. Environmental cost assessment of integrated ecological services reveals the state of sustainable development. Thus, it helps us to understand the impact of economic activities and projects on sustainable development. Fundamentally, environmental cost assessment concerns the interests of the whole mankind.

Correct the cost benefit appraisal idea of traditional land use and development project. In traditional assessments, project fees ignore the economic costs of mitigating the negative consequences of land-use change. Considering the environmental cost will gradually make people aware of the resource consumption and environmental damage caused by economic activities. It will help raise people's awareness of environmental protection, and change the extensive economic growth model.

It has a certain effect on the land use project planners and managers. The ecological service assessment model reveals the real economic cost for the project planners. The theory of environmental cost accounting has fundamentally changed the way of environmental governance of project managers. Combining economic development and environment is advantageous to the development of green economy.

2. Analysis and Solution of Problem

2.1. Problem Analysis

In the traditional economic model, the relationship between cost and benefit is mainly measured according to the net present value of the future cash flow of an investment project, and decisions are made accordingly. In general, when the net present value is positive, the decision maker will invest in the project. Otherwise, the project is not worth investing in. Environmental costs reflect costs associated with actual or potential deterioration of natural assets as a result of economic activity. Due to the strong externality of environmental costs, the cost accounting in this economic model does not include environmental costs, or only includes the environmental costs directly involved in market transactions such as land, which is extremely unreasonable.
According to ecological value, we divide project land into original ecological land, arable land and urban land. At the same time, we classify natural resources to find out the environmental costs that are not included in the project cost, and subdivide the service value of the ecosystem. Then, according to the above classification results, we divide the cost of environmental degradation into the stock value of natural resources, the flow value of natural resources and the cost of environmental governance, and find out their monetary value measurement formulas respectively. Finally, find out the environmental degradation costs contained in various project lands and sum them by using the above monetary measurement formulas. Then add the calculated costs into the original economic model to re-measure the project costs and benefits.

2.2. Problem solving

2.2.1. Classification of land types

In generally, according to ecological value, we can divide land into original ecological land, arable land and urban land. Most projects are not built in extreme environments such as tundra, wasteland, and rarely in lake, river, or ocean, but rather in existing prairie, woodland, wetland, arable land, or urban land. Therefore, the original ecological land mainly includes prairie, woodland and wetland, and the ecological service value is the highest. The ecological service value of urban land is the lowest.

2.2.2. Classification of natural resources

The environmental cost not included in the traditional economic model is mainly the damage to natural resources. According to the manual on integrated environmental and economic accounting (SEEA), the classification of natural resources is shown in the figure 1.

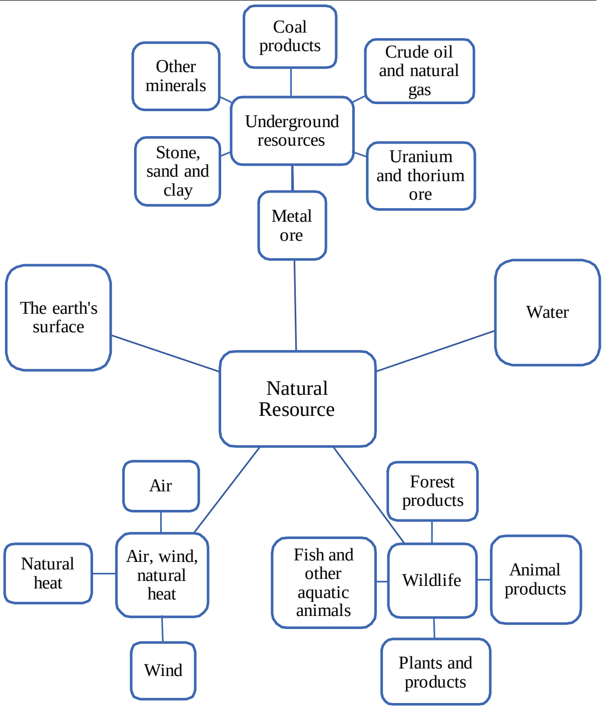

Figure 1. The classification of natural resources

In the above classification results of non-productive natural resources, only the mining industry uses underground resources, and both underground resources and surface land resources are reflected in the land rent and have been included in the project cost. Rivers and lakes may be distributed in all types of land and there is a risk of contamination. Wind and natural heat are not easily destroyed, so we do not have to consider the environmental costs.

2.2.3. Classification of ecosystem service functions

According to the classification method of Millennium Ecosystem Assessment[1], we have divided ecosystem service functions into four service types: supply service, regulating service, support service and cultural service. Among them, supply service mainly refers to material function, regulating service is subdivided into water conservation, climate regulation, atmospheric regulation and carbon sequestration function, support service is subdivided into biodiversity and soil conservation function, and cultural service is mainly tourism and leisure function. Draw the above classification into a relational diagram, as shown in the figure 2.

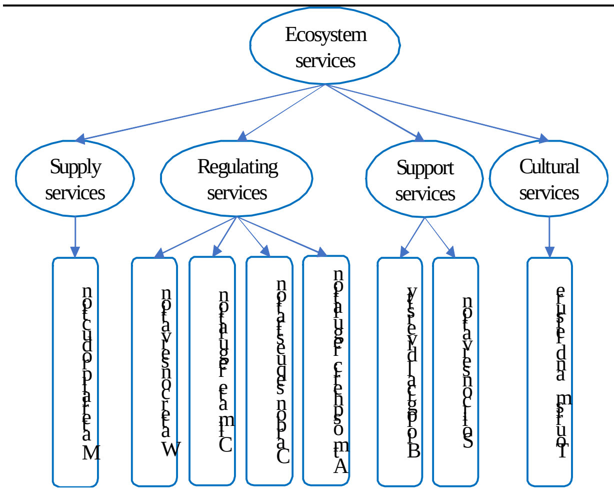

Figure 2. The classification ecosystem service functions

2.2.4. Major pollution types

At present, the main environmental problems we are facing are atmospheric pollution and water pollution. Air and water are indispensable resources for human survival, and their quality is directly related to human health. The environmental governance of government mainly focuses on these two aspects. Air pollution control and water pollution control directly constitute the cost of environmental governance.

2.2.5. Cost assessment of environmental degradation

If the project construction takes up the existing land ecological environment such as prairie, wood land, wetland, it caused by environmental degradation value includes not only the value of the amount of land available natural resources (the stock value of natural resources), also includes the potential to create the ecological service value each year (the flow of natural resources value), and the environmental treatment cost of emissions from waste gas and waste water (environmental costs). If the project construction occupies the existing urban land, the environmental degradation value caused by it only includes the environmental treatment cost brought by the emission of waste gas and water. Therefore, we calculate the cost of environmental degradation from the following three aspects.

(1)Stock value of natural resources

①Plants and their products

The stock value of plants and their products is equal to the product of the existing stock amount of plants times the price, that is:

$$V^{0}_{plant}=\sum_{p=1}^{n}S_{p}P_{p}L_{p} \quad (1)$$

Where, V^{0}_{plant} is the value of plants and their products. is the area covered by plants. is the price of plants, which is equal to the purchase price of plants minus the procurement cost per cubic meter of plants. is the plant accumulation level. is the plant category.

②Terrestrial animals and their products

According to the market price method, the stock value of terrestrial animals and their products is equal to the product of their corresponding market price times output, that is:

$$V'_{MP}=\sum P_{i}Q_{i} \quad (2)$$

③ Fish and other aquatic organisms

Aquatic organisms are divided into cultivated resources and non-cultivated resources. According to the market price method, the stock value of aquatic organisms is equal to its corresponding market price times its output, that is:

$$V^{0}_{aquatic}=\sum_{b=1}^{n}P_{b}Q_{b}+\sum_{nb=1}^{m}P_{nb}Q_{nb} \quad (3)$$

Where, $V^{0}_{aquatic}$ is the stock value of aquatic organisms.P is the price. Q is the amount of aquatic organism. b represents the cultivated resource category. nb represents the non-cultivated resource category.

(2)Flow value of natural resources

①Material production

Natural ecosystems are extremely productive. Prairie products mainly include wildlife and animal husbandry products, woodland products include edible plants and fruits, wetlands and other waters are rich in aquatic products such as fish, shrimp and crabs, while the main products of arable land are crops. Before the construction of the project, we should fully evaluate the annual output Qi of various products covering the project area and the price Pi of corresponding products. i represents the product i. Then, the annual material production value of the project area is V'_{MP}, that is:

$$C=\sum_{i=1}^{n}C_{i}Q_{i} \quad (4)$$

②Water conservation

Ecosystems have the capacity to store water. For example, rivers, lakes and wetlands can accumulate excess rainfall and release it slowly, so that the rainfall can be redistributed in time and space. The water conservation function is divided into two parts: one is the surface runoff of rivers and lakes, and the other is the vegetation covered wetlands and artificial wetlands. If the project construction leads to the destruction of rivers, lakes or wetlands, the water conservation function will be lost. According to the shadow engineering method, the water conservation value V'_{WC} is equal to the total water resource volume V times the unit cost of building the reservoir, that is:

$$V'_{WC} = VP \quad (5)$$

③Climate regulation

Evapotranspiration of water in the ecosystem has a certain cooling and humidifying effect on the regional air, and then has a regulating effect on the regional microclimate. Functions of climate regulation include: water cycle of plants and change of atmospheric composition to regulate local temperature, humidity and rainfall.

According to the annual average evaporation of water resources published in the regional water resources bulletin of the project, we calculate the total heat required for annual water evaporation based on the heat of water evaporation at 100℃ and 1 standard atmosphere, which is $2260.Okj \bullet kg^{-1}$. Evaporation reduces the air temperature according to the air conditioning refrigeration consumption, thus we converts the water resources evaporation amount into the electricity quantity[2].Water surface evaporation increases the value of air humidity, which is calculated according to the electricity consumption of humidifying household humidifiers in the market. Therefore, we use the corresponding electric quantity times the electric charge to achieve the goal of monetization of cooling and humidifying functions.

According to the alternative cost method, the value of climate regulation V'_{CR} is equal to the sum of the product of the ecosystem cooling amplitude times the cost of cooling P_t and the product of the humidifying amplitude $\triangle M$ times the cost of humidifying P_M, that is:

$$V'_{BD} = IS \quad (6)$$

④Carbon sequestration

The vegetation of an ecosystem can absorb and fix large amounts of carbon dioxide through photosynthesis, and soil also contains a lot of carbon[3]. Therefore, the carbon sequestration function is divided into two parts: vegetation carbon sequestration and soil carbon sequestration. According to the photosynthesis equation, plants produce 1.00 gram of dry matter will absorb 1.63 grams of carbon dioxide, namely a fixed amount of pure carbon 0.44 grams. According to the Carbon Tax Law, the value of carbon sequestration V'_{CS} is :

$$V'_{CS} = P_c(Q_{veg} + Q_{soil}) = P_c\sum(0.44N_iS_i + S_iC_i) \quad (7)$$

Where, is the carbon sequestration value of the wetland, is the carbon tax rate, is the net plant production per unit area of the -type land, is the corresponding soil area, and C_i is the carbon density per unit area of the soil.

⑤Atmosphere regulation

The vegetation of prairie, woodland and wetland can absorb carbon dioxide and release oxygen through photosynthesis, which can improve the climate. According to the photosynthesis equation, 1.00 gram of dry matter produced by a plant releases 1.19 grams of oxygen. Suppose the net plant production per unit area of type-i is N_i and the price of oxygen is P_{O2}, then the value of atmospheric adjustment V'_{AR} is:

$$V'_{BD} = 1.19N_iP_{O_2} \quad (8)$$

⑥Biological diversity

Prairies, woodlands and wetlands are rich in animal and plant species, and sound ecological environment is an important basis for their survival and reproduction. Take the average value of biodiversity protection unit as the unit value of biodiversity, the project covers an area of S, and the biodiversity value V'_{BD} is:

$$V'_{SC} = V_e + V_f \quad (9)$$

⑦Soil conservation

Prairies, woodlands and wetlands all have the function of retaining soil, its value includes two aspects: the value of reducing soil erosion V_e and the value of reducing soil fertility loss V_f .Then, the value of maintaining soil V'_{SC} is:

$$V'_{water} = P_wV \quad (10)$$

Suppose the soil erosion modulus reduced by different vegetation is A_i, the average yield of grain per unit of land is B, and the average thickness of arable land is . Soil fertility is mainly reflected in nitrogen, phosphorus and potassium. The content of nitrogen, phosphorus and potassium in soil of different land types is , the price of fertilizer is Pi, and the content of nitrogen, phosphorus and potassium in different fertilizers is R_i . According to the shadow pricing method, we can calculate

$$V'_e = \frac{A_iB}{H}; V_f = \sum\frac{A_iN_iP_i}{R_i} \quad (11)$$

⑧Tourism and leisure

Prairies, woodlands and wetlands have beautiful scenery, unique landscape and fresh air, which are good places for tourism and leisure. According to different natural scenic area of tourism income and scenic area ratio, we respectively calculate the annual tourism value of unit area of different natural scenic spots p_i (i represents the type of project occupation), measure the project occupation area S, then the tourism and leisure value V'_{TL} of the project occupation area is :

$$V'_{TLL} = P_iS \quad (12)$$

(3)Environmental governance cost

①Water pollution governance

Suppose the total amount of water in polluted waters is V and the unit price of tap water is A. According to the shadow pricing method, we use the price of tap water to replace the governance cost of water pollution, so the annual governance cost of water resources V'_{water} is:

$$V'_{water} = P_w V \quad (13)$$

②Atmospheric pollution governance

Suppose the annual emission of project pollution gas is Q_i, the average unit gas governance cost is $\bar{C}_i$, and the air governance cost C is :

$$C = \sum_{i=1}^{n} C_i Q_i \quad (14)$$

Where, i represents the pollutant category.

2.2.6. Environmental degradation cost accounting for different types of project land

⑴Original ecological land

When the project land occupies the original ecological land, the cost of environmental degradation includes the stock value $C^{Urban}_{Stock} = V^{o}_{aquatic}$ of natural resources, the flow value $C^{Arableland}_{Flow} = V'_{MP} + V'_{CR} + V'_{AR}$ of natural resources and the cost $NP = \frac{R_1 - C_1 - C^{Urban}_{Govern}}{1+r} + \sum_{i=2}^{t} \frac{R_i - C_i - C^{Urban}_{Govern}}{(1+r)^i}$ of environmental governance.

①Stock value of natural resources

The original ecological land contains abundant plant resources and terrestrial animal resources. When the project occupies the original ecological land, these natural resources are destroyed completely. If the project pollutes the surrounding waters, the fish and other aquatic life in the water become inedible and no longer have economic value. Therefore, the stock value of natural resources destroyed by it includes plants and their products, terrestrial animals and their products, fish and other aquatic animals:

$$C^{Ecology}_{Stock} = V^{0}_{plant} + V^{o}_{animal} + V^{o}_{aquatic} \quad (15)$$

②Flow value of natural resources

If the original ecological land is not occupied, it will continuously provide us with ecological service value under the circulation and regeneration function of the ecosystem. The natural resource flow value of the original ecological land includes material production, climate regulation, carbon sequestration, atmospheric regulation, biological diversity, soil conservation, tourism and leisure. If the project involves land reclamation, it should also include water conservation:

$$C^{Ecology}_{Flow} = V'_{MP} + V'_{WC} + V'_{CR} + V'_{CS} + V'_{AR} + V'_{BD} + V'_{SV} + V'_{TL} \quad (16)$$

③Environmental governance cost

If the project discharges waste gas and water, the cost of environmental governance includes water pollution governance and atmospheric pollution governance.

$$C^{Ecology}_{Govern} = V'_{water} + C \quad (17)$$

⑵Arable land

The cost of environmental degradation of arable land also includes the stock value C^{Arable}_{Stock} of natural resources, the flow value C^{Arable}_{Flow} of natural resources and the cost $NP = \sum_{i=1}^{t} \frac{R_i - C_i - C^{Arableland}_{Flow} - C^{Arableland}_{Govern}}{(1+r)^i}$ of environmental governance.

①Stock value of natural resources

When a construction project pollutes the waters around arable land, the fish and other aquatic products in the water will no longer have economic value.And the project should bear the corresponding cost of environmental degradation.

$$C^{Arableland}_{Stock} = V^{o}_{aquatic} \quad (18)$$

②Flow value of natural resources

The main function of the arable land is to provide us with agricultural products. Before harvest, crops can also play their role as ecological services, absorbing carbon dioxide and releasing oxygen to adjust the climate. When a project occupies arable land, it will lose its material production function, climate regulation function and atmospheric regulation function.

$$C^{Arableland}_{Flow} = V'_{MP} + V'_{CR} + V'_{AR} \quad (19)$$

③Environmental governance cost

If the project discharges waste gas and water, the cost of environmental governance includes water pollution governance and atmospheric pollution governance.

$$C^{Arableland}_{Govern} = V'_{water} + C \quad (20)$$

⑶Urban land

If the new project is built on the existing urban land, it bears the environmental degradation cost that only includes the natural resource stock value C^{Urban}_{Stock} and the environmental governance cost C^{Urban}_{Govern}.

①Stock value of natural resources

When a construction project pollutes the waters around arable land, the fish and other aquatic products in the water will no longer have economic value. And the project should bear the corresponding cost of environmental degradation.

$$C^{Urban}_{Stock} = V^{o}_{aquatic} \quad (21)$$

②Environmental governance cost

If the project discharges waste gas and water, the cost of environmental governance includes water pollution governance and atmospheric pollution governance.

$$C^{Arableland}_{Govern} = V^{'}_{water} + C \tag{22}$$

2.2.7. Project value assessment that includes the costs of environmental degradation

Suppose, before the cost of environmental degradation is included, the annual cost input is C_i, the annual cash income is R_i, the expected rate of return is r, and the investment period of the project is t. In the traditional economic model, we use formula $NP = \sum_{i=1}^{i}(R_i - C_i)/(1+r)^i$ to calculate the net present value of a project to judge whether it is worth investment, which is extremely unreasonable. Now we include the cost of environmental degradation into the project cost, then calculate the new net present value formula.

(1)Original ecological land

In the first year of construction, the original ecological environment will be destroyed in one time, making it lose all the value of natural resources. Starting from the second year, the cost of environmental degradation should include the value of all-natural resource flows and the cost of environmental governance. That is:

$$NP = \frac{R_1 - C_1 - C^{Eco\log y}_{Stock} - C^{Eco\log y}_{Flow} - C^{Eco\log y}_{Govgrn}}{1+r} + \sum_{i=2}^{t} = \frac{R_i - C_i - C^{Eco\log y}_{Flow} - C^{Eco\log y}_{Govrn}}{(1+r)^i} \tag{23}$$

(2)Arable land

Supposing that when the project occupies arable land, it pollutes the surrounding waters in the first year (zero if it does not pollute the waters), resulting in the loss of economic value of fish and other aquatic organisms. Starting from the second year, the cost of environmental degradation should include the value of all-natural resource flows and the cost of environmental governance. That is

$$NP = \frac{R_1 - C_1 - C^{Arableland}_{Stock} - C^{Arableland}_{Flow} - C^{Arableland}_{Govgrn}}{1+r} + \sum_{i=2}^{t} = \frac{R_i - C_i - C^{Arableland}_{Flow} - C^{Arableland}_{Govrn}}{(1+r)^i} \tag{24}$$

(3)Urban land

When the project occupies urban land, supposing that the project pollutes the surrounding waters in the first year (zero if no water pollution), which will result in the loss of economic value of fish and other aquatic organisms. Starting from the second year, the cost of environmental degradation only includes the cost of environmental governance. That is:

$$NP = \frac{R_1 - C_1 - C^{Urban}_{Govern}}{1+r} + \sum_{i=2}^{t} \frac{R_i - C_i - C^{Urban}_{Govern}}{(1+r)^i} \tag{25}$$

In this way, all the costs of environmental degradation are included in the cost of project construction. Obviously, we use the new economic model to judge the feasibility of a project is more consistent with the requirements of green economy and sustainable development. However, in order to make decisions according to the new economic model, we must convert the virtual cost of environmental degradation into the real project cost. Therefore, the government should formulate relevant regulations and policies to levy environmental degradation fees from projects according to the calculated environmental degradation costs. And government should use the funds it receives to set up an ecological protection fund to govern environmental exclusively.

2.3. Problem improvement

At present, the management of the ecological environment is a function of the government, and government also bears all the management costs. The developers of the project can get profits from it without paying for the ecological environment they destroy. They only have the right to make profits but do not bear the responsibility. Obviously, this does not accord with the consistency of responsibility and right. We should accurately measure the cost of environmental degradation caused by the project and levy environmental degradation fees from the project developers. In this way, we can transform the virtual cost of environmental degradation into the real cost of the project. Then, we can make an objective evaluation of the real benefits and costs of the project.

However, if government levies excessive environmental degradation fees, it is not conducive to economic development. If government levies too little environmental degradation fees, it does not protect the environment. The optimal amount of environmental degradation fees should be levied to maintain the ecological environment at least in its current state. Therefore, when new projects are established after the construction of original ecological land and arable land, we do not need to collect the stock value of natural resources and not just charge for urban land. We should collect the flow value of natural resources and the cost of environmental governance. In this way, project decision makers can choose urban land as much as possible in order to reduce costs. It is conducive to the protection of the original ecological land and arable land, as well as the restoration of the occupied original ecological land and arable land.

When the projects built on the original ecological land and arable land end, we only need to collect the natural resource flow value and environmental governance cost for the new projects, while do not need to change the environmental degradation cost of the projects built on the urban land.

(1)Original ecological land

$$NP = \sum_{i=1}^{t} \frac{R_i - C_i - C_{Flow}^{Ecology} - C_{Govern}^{Ecology}}{(1+r)^i} \quad (26)$$

(2)Arable land

$$NP = \sum_{i=1}^{t} \frac{R_i - C_i - C_{Flow}^{Arableland} - C_{Govern}^{Arableland}}{(1+r)^i} \quad (27)$$

3. Suggestion

3.1. The implications of the modeling on managers

The construction of each project will more or less cause damage to the ecological environment. The loss of value to ecological services from one project may be insignificant, but when countless projects are put together, they bring us all kinds of environmental problems. However, due to the strong externality of environmental problems, the government pays for ecological and environmental governance. Obviously, this does not accord with the consistency of authority and responsibility.

Our model provides an accurate measure of the cost of environmental degradation. As the project manager, the government should evaluate the loss of ecological service value it may bring before the project construction. Based on this, the government should levy environmental degradation fees from the project developers, and use the funds received to set up a special ecological protection fund, which is dedicated to environmental governance.

In this way, the government can at least maintain the ecological environment in its current state by using our model to levy the environmental degradation fees. In this way, the special funds can be used for the purpose of reducing fiscal expenditure for the government, and more funds can be used for livelihood projects. In addition, under the self-regulation effect of this model, only enterprises with high pollution and low income will be eliminated spontaneously. While protecting the ecological environment, it will not have too much impact on economic development.

For the project decision maker, when the government levies the environmental degradation fees from the project according to the model, they have to take the ecological service value into account in the project cost.

3.2. The implications of the modeling on land use project planners

When the government levies environmental degradation fees on projects according to our model, it means that project planners have to pay for the environmental problems they cause. In order to help project planners minimize the cost of ecological degradation, we propose the following suggestions based on our model:

From the perspective of natural resource stock value and natural resource flow value, if the project is located in arable land or original ecological land, it should not only pay for the one time damage to the environment, but also make up the flow value of natural resources. Project planners only need to pay for the flow value of natural resources in the destroyed cultivated land or the original ecological land. Therefore, project planners should try their best to select places with low natural resource stock value and natural resource flow value. In conclusion, the selection of urban land requires the lowest natural resource stock value. Then, project planners should choose the damaged places, as far as possible not to choose arable land and original ecological land for construction.

From the perspective of environmental governance costs, the less pollutants a project emits, the less environmental governance costs it has to bear. The project planners should improve the production method or introduce more advanced environmental protection equipment to reduce the pollution.Thus, they can reduce the environmental governance costs.

From the perspective of revenue, project planners should promote scientific and technological innovation and improve production efficiency. In this way, even if the high cost of environmental degradation needs to be paid, they can still obtain high benefits.

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