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Ecological Service Assessment Model for Land Use Projects

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ABSTRACT

In this paper, we study the true economic cost of land use projects when considering the value of ecosystem services. We begin by establishing an ecological services valuation model to determine that the true economic cost of the land use project is the sum of construction costs and environmental costs. To calculate the true economic cost, we divided the value of ecosystem services into three categories: Material Supply Value, Environmental Regulation and Maintenance Value, Culture and Social Value, and 13 evaluation indexes are determined according to environmental economics theory to measure their ecological value function. We select real estate projects of the community, resource development projects with serious environmental damage, and large-scale national construction projects to apply our model and perform a cost-benefit analysis. The results show that the environmental costs of resource development projects and national construction projects exceed their construction costs. Additionally, to show how the model changes over time, we establish a NAR neural network time series prediction model based on analytic hierarchy process. The results show that the cost of ecosystem services has increased year by year, which proves that land use projects should incorporate the value of ecosystem services into the cost range. Our model has a certain reference value for calculating the true economic costs of land use projects when considering the value of ecosystem services.

Keywords: Ecosystem Services, Valuation, Cost Benefit Analysis, BP Neural Network

1. INTRODUCTION

Traditionally, the impact of ecosystem services is mostly ignored when land use projects are designed [1], which is based on the old classical economics [2]. Ecosystem services are provided by biosphere, which is expressed by maintaining a healthy and sustainable environment for human life in natural processes such as turning waste into food, water filtration and so on. The economic costs about ecosystem are often not included in the plan. In fact, individual activities like building a few roads, sewers, bridges, houses, factories and so on may show little effect to the total function of the biosphere. However, serious problems have a good potential to happen, impact the biodiversity and even cause environmental degradation, which should be put enough attention. Once Ecosystem Services Cost [3] are included in the cost-benefit ratio of the project, a true and comprehensive estimate of the project cost can be shown and evaluated to promote better management of land use project planners and managers. This kind of calculation about considering Ecosystem Services Cost should be applied in projects across a region, country, and the world [4].

1.1 Mathematical Meaning of Noun

- Land development [5] ： For unutilized land, including barren hills, wasteland, barren beaches, etc., or land that is not used to a high degree, through engineering or biological measures, transform it into land available or improve land use. It includes two aspects: First, it refers to the expansion of land use, that is, the development of unused land, such as converting unutilized barren hills, barren beaches, sea shoals, etc. into usable land; second, the development of land use depth. For example, the existing areas that are not yet fully utilized, with low production efficiency and the urban areas that are not equipped with urban infrastructure will be reconstructed and constructed to make full use and improve efficiency. It is mainly divided into first-level development and first-level and two-level development. According to the different status of participating entities, it is subdivided into government leading, government platform companies, enterprise leading and etc.
- Ecosystem Services: The many benefits and assets that humans receive freely from our natural environment and a fully functioning ecosystem.
- Environmental Degradation: The deterioration or compromise of the natural environment through consumption of assets either by natural processes or human activities.
- Period of project life [6]: Refers to the planned project from construction to operation of the end of life all the time. Include construction period and operation period two parts.

1.2 Projects Selection

In order to measure the effectiveness of the ecological service assessment model in this paper, we selected three different scale land development projects in China as examples. Its scale is from small to large, and the land area and investment amount of development are shown in Table 1.

Table 1 Basic information on three land development projects

Type of Development	Real estate project	Resource development project	Large national construction project
Project	Ao-Yuan Community	Coal mine development	Construction of the Qinghai-Tibet Railway
Land Area(Km2)	8.00	86752.00	4053.36
Cost of Land Development(Billion)	79.43	204.49	11.80
Scale	Small	Medium	Large
Geographical Position	Foshan City, Guangdong Province	Ordos City, Inner Mongolia	Qinghai Province to Tibet Autonomous Region

Since it takes a lot of time to collect relevant data of the whole section of qinghai-tibet Railway, and in order to ensure the integrity of data such as environmental detection, we only select the section of Golmud to Nanshankou as a representative section of this Railway as a development project. The complete Qinghai-Tibet Railway is 1956km long and the Golmud to Nanshankou is 30km long. At the same time, coal mine development is selected as an example. Because of the large pollution of coal mines, it can significantly highlight its ecological costs. The geographic location of the three development projects is shown in Figure 1.

Figure 1 Geographical location of three land development projects

It is hoped that through the analysis of these three development projects, we can provide a reference for the measurement of the impact of different land development projects on the ecological environment.

1.3 Data Collection

In the data of this study, the cost per unit area of forests and grasslands for scientific research and education and the value of biological habitat per unit area from the study of Costanza R[7]. Aoyuan Development Project data comes from the Anjuke website[8], yearbooks in Foshan[9], Foshan population and natural resources statistical yearbook[10] and the study of Wu Guangbing[11]. The data of the Ordos coal mine development project comes from the Ordos Statistical Yearbook[12], China Statistical Yearbook[13], Ordos Coal Bureau Announcement[14], China coal industry yearbook[15], China environmental statistics yearbook[16]. The data of the Qinghai-Tibet Railway Development Project comes from Qinghai-Tibet Railway Development Project data from Golmud Yearbook[17], China Statistical Yearbook[18] and the study of Zhang Lili[19].

2. METHODS

2.1 Ecological Services Valuation Model[20]

2.1.1 Theoretical Basis for Evaluation

The cost-benefit ratio assessment of Land Use Projects should take into account the impact of ecosystem service value. Traditional economic theory often ignores or weakens the impact of its decisions on the biosphere. This has serious environmental consequences and is even fed back to humans in the form of natural disasters. The concept of Ecosystem Services Value comes from environmental economics. Environmental economics is a paradigm of neoclassical economics.

Under this concept, the cost-benefit ratio of Land Use Projects depends not only on the value of goods and services in the market, but also the value of non-market goods and services from the resource and environmental systems, the value of ecosystem services. Therefore, identifying and evaluating the value of ecosystem services in land use projects is a measure of their economic value. At the same time, human-centered ecosystem service value assessment does not exclude concerns about the survival and development of other species. Based on this, we will establish an ecological service assessment model to measure the value of the ecological service lost in the land use project, namely the environmental cost.

2.1.2 Evaluation Method

Assessing the value of ecosystem services means estimating the economic value of ecosystems in a monetary manner. The specific methods of measurement mainly include: Market Value Method, Carbon Tax Measurement method, Afforestation Cost Method, Expense Payment Method, Alternative Cost Method, Shadow Engineering Method, Travel Cost Method and Contingent Valuation Method. The method is briefly described as follows

(1) **Market Value Method**[21]. This is a way to evaluate ecosystem products and functions with market prices. This method is based on the market value of the goods or services provided by the ecosystem. This approach is applicable to the estimation of the economic value of ecosystems without cost but with market value.

(2) **Carbon Tax Measurement Method and Afforestation Cost Method**[22]. The carbon tax is the tax levied by countries on greenhouse gas emissions. This method uses the photosynthesis formula to calculate the fixed amount of carbon dioxide and other gases based on the dry matter production, and uses the international emission charge standard to calculate the fixed amount of economic value.

(3) **Expense Payment Method.** This is a way to estimate the economic value of an ecosystem from a consumer perspective. This approach usually represents the economic value of the ecosystem in terms of people's expenditure on the ecosystem.

(4) **Alternative Cost Method**[23].This method mainly uses the average of international research education and the average value of habitat protection cost standards to replace the scientific research education of ecosystems and the functional value of biological habitats to measure the economic value of ecosystems.

(5) **Shadow Engineering Method**[24].This method is a special form of the replacement cost method. When it is difficult to directly measure the value of a natural ecological environment, the cost of constructing a project is artificially replaced by the cost of the ecological function or the originally destroyed ecological function. replacement cost method refers to the cost of restoring the natural ecological environment to its original state as a proof of the economic value of the ecosystem.

(6) **Travel Cost Method**[25].This method is often used to evaluate the economic value of natural landscapes or environmental resources without market prices. This method calculates the economic value of the ecosystem based on all the expenditures and expenses of the tourists in the tourism activities, including the transportation expenses, food and beverage expenses, tickets, accommodation fees and travel time value of the tourists.

2.1.3 Determination of evaluation indicators

The application of these methods will be divided into these three aspects to discuss and determine the evaluation indicators: Material Supply Value, Environmental Regulation and Maintenance Value, Cultural and Social Value.

(1) Material Supply Value

Material Supply Value (MSV) is the value that humans get from the ecosystem. Different ecosystems have different MSV. For example, wetland ecosystems have the value of transportation and shipping, and the value of water storage and water supply, while forest ecosystems do not have these values; At the same time, the same geographical area is often a mixture of multiple ecosystems. For example, a riverside area may include multiple ecosystems with forest land, rivers, and grasslands as the main components. Therefore, in order to model the nature of things, it is assumed that the land is a nature-oriented ecosystem before development. That is to say, the primary industry is the main industry, ignoring the secondary and tertiary industries. Then we take the generic MSV, including the output of agricultural products, forest products, animal products, fishery products and their economic value. The specific value evaluation methods are the Market Value Method and Contingent Valuation Method.

(2) Environmental Regulation and Maintenance Value

The Environmental Regulation and Maintenance Value (ERMV) refers to the value of human beings in obtaining various benefits from the regulation of ecosystems. The regulation of ecosystems includes atmospheric regulation, purification of water quality, and maintenance of biodiversity. Taking into account the specific CO2 emission charging standards, industrial oxygen production costs, reservoir construction cost standards, etc. of the international or a country, the biomass, water quality, and air quality involved in these processes can be used as an economic value estimate for the ecosystem. The specific value evaluation methods are the carbon Tax Measurement Method, the Industrial Oxygen Production Method, the Shadow Engineering Method, and the Alternative Cost Method.

(3) Cultural and Social Value

Cultural and Social Value (CSV) refers to the Value of intangible benefits such as intellectual development and aesthetic experience obtained by human beings from the ecosystem. People usually obtain these immaterial values through leisure and entertainment methods such as tourism or scientific research and education methods such as field trips. The economic value of the ecosystem can be estimated by combining the standard average of international or national scientific research and education costs and habitat protection costs. The specific value evaluation methods are travel cost method and price substitution method.

To sum up, the economic Value of the ecosystem can be estimated from three categories of ecosystem services, namely Material Supply Value, Environmental Regulation and Maintenance Value, Cultural and Social Value. The three categories, Ecological Service Value Classification, Ecological Service Value Function and Evaluation Index are summarized in Table 2.This is the ecological services valuation model we built.

Table 2 ecological services valuation model

Ecological Service Value	Ecological Service Value Function	Evaluation Index
MSV	Supply Product Value	The Value of Agricultural Output
		The Value of Forest Product Output
		The Value of Animal Husbandry Production
		The Value of Fishery Production
ERMV	Water Purification Value	Total Amount of Sewage Discharged
	Biodiversity Maintenance	Total Area of Forests and Grasslands
	Atmospheric Regulation Value	Carbon Dioxide Absorption
		Oxygen Release
		Industrial Exhaust Emissions
CSV	Tourism Leisure Value	Tourist Times
		Tourism Income
		Number of Days Traveled
	Scientific Research Value	Area Available for Research and Education

2.2 Three Land Use Projects

Using the model, we conduct cost-benefit evaluation of three different scale land development projects. These three projects are Foshan Ao-Yuan Real Estate Development Project, Ordos Coal Industry Development Project, and Qinghai-Tibet Railway Golmud Section Development Project. The Ao-Yuan project represents a small community development. The coal project represents land development with serious environmental damage (coal emissions are more serious to the environment). The railway project represents land development for large national projects. Limited to the time, we only selected the section of Golmud to Nanshankou of the Qinghai-Tibet Railway as a development project. The complete Qinghai-Tibet Railway is 1956km long and the Golmud to Nanshankou is 30km long, which means the sample size is about 1.5% of the entire project. The raw data for each index has been given in the previous model preparation.

Considering that the land use project is progressive to some of Ecosystem Services, we divide the development cycle into a construction period and an operation period. In order to get a preliminary understanding of the trend of various indexes, some of the data collected during the construction period is standardized and then plotted as a bar chart as shown in Figure 2.

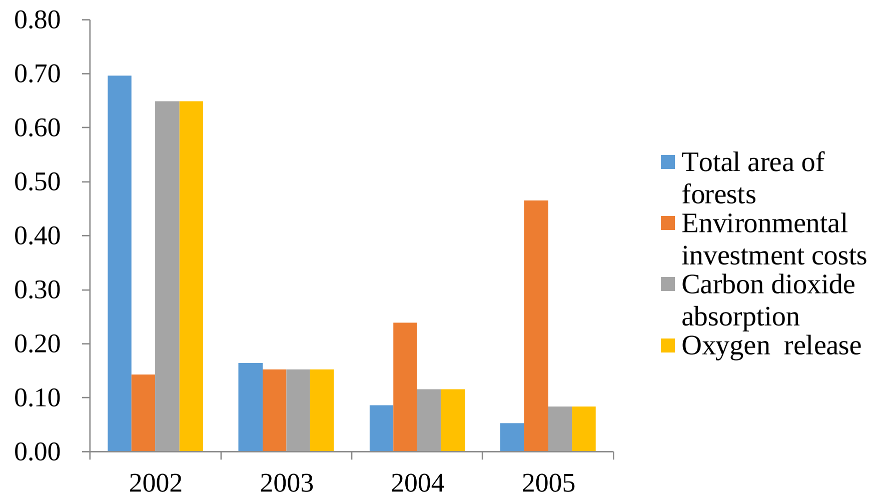

Figure 2 Raw data for resource development projects

It can be seen from Fig.2 that during the construction period, the environmental investment costs have increased significantly with the development of land use projects. Forest area, carbon dioxide uptake and oxygen release are significantly reduced. We can conclude that the coal project in Ordos has caused significant damage to the environment. Therefore, when calculating the cost of the land use project, the value of the destroyed Ecosystem Services Cost should also be calculated into account.

A comprehensive cost-benefit analysis of three land use projects chosen is provided below.

2.2.1 Cost-Benefit Ratio Calculation

The true project profit is the elimination of the environmental cost based on the original project profit.

Where:

Ecosystem Services Cost = Pre-development Ecosystem Services Value - Post-development Ecosystem Services Value

True Profit in first year after construction = Project Income in first year - Construction Cost - Ecosystem Services Cost

Real profit from second year after construction to the nth year after construction = Project Income in the nth year - environmental cost (n>=2)

$$Total\ \ cost = Construction\ Cost + Ecosystem\ Services\ Cost \quad (1)$$

$$Cost - benefit\ \ ratio = \frac{Net\ \ profit}{Total\ \ cost} * 100\% \quad (2)$$

We assume that true profits are their net profit, that is, the effects of taxes and the like are ignored. We conducted a cost-benefit analysis of the operating periods of 3 projects over the previous decade.

2.2.2 Ecosystem Service Function Value Calculation[26]

The ecosystem has many service functions and is of great value to human life. Its service value usually includes Supply Product Value, Water Purification Value, Biodiversity Maintenance, Atmospheric Regulation Value, Tourism Leisure Value, and Scientific Research Value.

$$V = \sum_{i=1}^{n} V_i \quad (3)$$

Where:

V = Ecosystem Services Value

$V_1 \sim V_6$ = Supplying Product Value, Water Purification Value, Biodiversity Maintenance, Atmospheric Regulation Value, Tourism Leisure Value, and Scientific Research Value.

Costanza R et al. proposed that the forest unit area value of 3 projects is 969 US dollars, the grassland unit area value is 906 US dollars, and the biological habitat unit value is 307 US dollars[27].

(1) Supply Product Value Calculation

For Supply Product Value (agricultural products, forest products, animal husbandry products, fishery products), Market Value Method can usually be used for calculation.

$$V_1 = \sum_{i=1}^{n} G_i P_i (1+x) \tag{4}$$

Where:

V_1 = Supply Product Value

G_i =Substance Production of Category i

P_i = Market Price of Category i

x = Price Growth Factor

n = Category of Substance Production

(2) Water Purification Value Calculation

Ecosystem has the function of purifying water quality, and Water Purification Value can usually be calculated by Expense Payment Method.

$$V_2 = \sum_{i=1}^{n} Q_i P_i (1+x) \tag{5}$$

Where:

V_2 = Water Purification Value

n = Category of Contaminant, which means Chemical Oxygen Content, Nitrogen Content, Phosphorus Content

Q_i = Release Amount of Category i

P_i = Unit Processing Cost of Category i

x = Price Growth Factor

(3) Biodiversity Maintenance Calculation

Ecosystem provides a valuable habitat for creatures and maintains biodiversity. Biodiversity Maintenance can be calculated using price substitution methods.

$$V_3 = PS + \sum_{i=1}^{n} C_i N_i \tag{6}$$

Where:

V_3 = Biodiversity Maintenance

P = Value of biological habitat per unit area

S =Area of biological habitat

C_i=Market Price of some kind of rare species

N_i=Quantity of the corresponding kind of rare species

n= The kind Of Rare Species

(4) Atmospheric Regulation Value Calculation

Vegetation in ecosystem absorbs greenhouse gases such as carbon dioxide and industrial waste gas. Next it releases oxygen, purifies the environment, and regulates the atmosphere. For its Atmospheric Regulation Value, Carbon Tax Measurement Method and Afforestation Cost Method are used to calculate.

$$V_4 = V_{CO^2} + V_{O^2} + V_{IEE} \quad (7)$$

Where:

V_4= Atmospheric Regulation Value

V_{co^2} = Absorption Value of CO^2

V_{O^2} = Release Amount Value of O^2

V_{IEE} = Absorption Value of Industrial Exhaust

$$V_{CO^2} = Q_{CO^2} P_{CO^2} \quad (8)$$

$$V_{O^2} = Q_{O^2} P_{O^2} \quad (9)$$

Where:

Q_{CO^2} = The absorption of CO^2

Q_{O^2} = The release amount of O^2

P_{CO^2} = Carbon Tax unit price

P_{O^2} = Industrial oxygen price

(5) Tourism Leisure Value Calculation

Tourism Leisure Value is also one of the important values of Ecosystem Services Value. It is usual calculated by the Travel Cost Method, which includes travel expenses and travel time.

$$V_5 = (C_1 + C_2) TN (1 + CPI) \quad (10)$$

Where:

V_5= Tourism Leisure Value of the corresponding year

C_1 = The average daily cost per visitor

C_2 = Opportunity Income per unit of travel time per visitor

T = The average time each visitor travels a year

N = Number of tourists in the corresponding year

CPI = The Resident Price index for the corresponding year

(6) Scientific Research Value Calculation

Some of ecosystem can be used for research and education, and is often measured by price substitution methods.

$$V_6 = PS \tag{11}$$

Where:

V_6 = Scientific Research Value

P = Scientific Research Value of unit area and for research and education

S = unit area and for research and education

(7) Present Time Value of Money Calculation

In order to eliminate the impact of inflation during the construction period and the ten-year operation period, we have converted the profit and cost of the three projects into the present value of 2001. The calculation formula is

$$P_0 = F\left(1+i\right)^{-n} \tag{12}$$

Where:

P_0 =Present Value

F =End Value

i =the annual interest rate of the People's Bank of China in the corresponding year[28].

Table 3 Construction period and operation period of three projects

	Ao-Yuan project	Coal mine project	Railway project
Building period	2001 to 2006	2002 to 2004	2002 to 2005
Operation period	2007	2005 to 2014	2006 to 2015

Since Ao-Yuan project is basically sold out during the first year of the operation period, we only select profit data in 2007 for calculation.

2.2.2 Ecosystem Service Values of Three Programs

The Ecosystem Services Costs of three projects obtained by calculation are shown in Table 4 below.

Table 4 Calculation results of three projects

	Ao-Yuan project	Coal mine project	Railway project
Material Supply Value	64.38	11.25	0.12
Environmental Regulation and Maintenance Value	13.15	5584742.61	136358.45
Cultural and Social Value	-9.74	-173383.42	-2028.17
Total Environmental Costs	67.80	5411370.43	134330.40
Total Construction Cost	794257.46	2044859.00	118000.00
Real Cost	784131.55	7397053.01	249832.08
Ratio of Environmental Costs to Total Costs	0.0085%	72.5852%	53.2359%
Real Profit	86453.95	7377698.18	-249127.06
Cost-Benefit Ratio	11.03%	99.74%	-99.72%

Unit: 10,000 yuan

In Table 4, Profits of Ordos Coal Industry Development Project and Qinghai-Tibet Railway Golmud Section Development Project are the sum of incomes within ten years after the completion of the construction. And Profits of Foshan Ao-Yuan Real Estate is from the sale of real estate in the corresponding year (2007). Its total cost and true profit have been converted into the present value of 2001.

CBA (Cost-Benefit Analysis) is a policy evaluation method. It quantifies the value of its policies to all members of society in the form of money[29]. From the results of Table 5, the characteristics of 3 projects are different.

1. Ecosystem Services Costs of Foshan Ao-Yuan Real Estate accounts for 0.0085% of the total cost, which is relatively small. The ratio of Ecosystem Services Costs of Ordos Coal Industry Development Project and Qinghai-Tibet Railway Golmud Section Development Project to the

total cost is 72.5752% and 53.2359%, respectively, which is relatively high. Therefore, the damage to Ecosystem by real estate is relatively small, and the damage to Ecosystem caused by coal mine development and railway construction is relatively large.

2. The cost-benefit ratio of Ao-Yuan Project is 11.03%, and the cost-benefit ratio of Ordos Coal Project and Qinghai-Tibet Project is 99.74% and -99.72%, respectively. Therefore, the cost-benefit ratio of Ordos Coal Project is the largest, followed by Aoyuan Project, and Qinghai-Tibet Project is the smallest and negative.

3. In summary, Coal Project has the highest cost-effectiveness, but the damage to Ecosystem is also relatively large. Qinghai-Tibet Project is the least cost-effective and negative, but its economic benefits and additional benefits as the poverty line and the diplomatic line should be put more attention. The line strengthens the exchange of people, goods and funds between Tibet and the Mainland, brings great convenience to the people's life because of the agglomeration effect, expands economic exchanges between China and South Asian countries and creates favorable conditions for the development of the western region and the integration of the Belt and Road Initiative[30].

4. From the perspective of investment, real estate land use projects are worth investing, but the changes in the country's political and economic environment shouldn't be ignored. In terms of the ten-year operation period, Coal Projects have higher returns, but Ecosystem Services Costs are relatively high, as shown in Figure 3. The changes of its Profits over the decade are shown in Figure 3. When the 2008 financial crisis and the 2012 economic downturn were removed, their operation was relatively stable or slightly reduced.

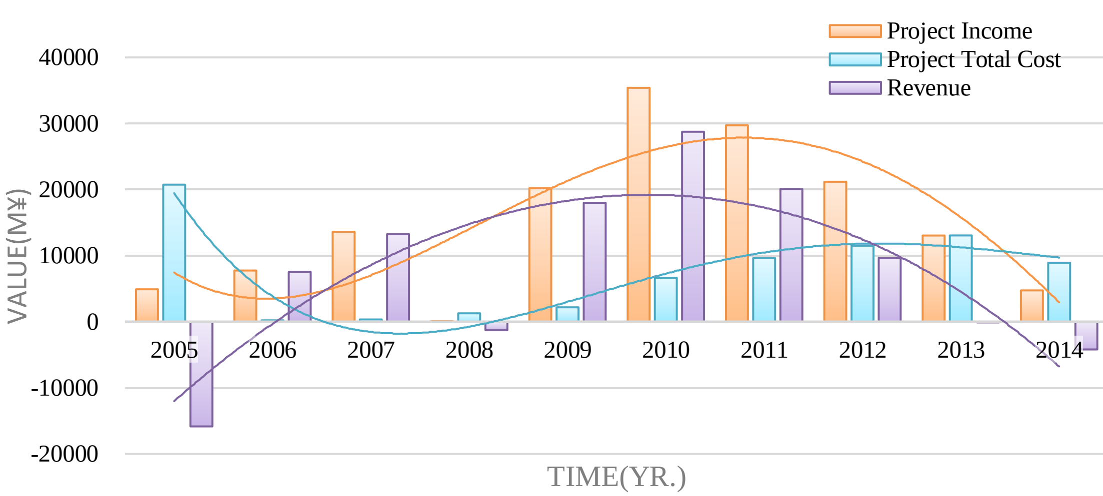

Figure 3 Trends in revenue, cost and profit of coal mine projects

2.3 NAR Neural Network Model Based on Analytic Hierarchy Process

Ecological Services Valuation Model is relatively static. According to common sense, Ecosystem Services Cost is a dynamic value, which means its MSV, ERMV, CSV should be dynamic. MSV, ERMV, and CSV will change every year, and they will show trends after several years. An upward trend means that it becomes more important as time goes by; or a downward trend means that it becomes relatively unimportant as time goes by. Therefore, we establish NAR Neural Network Model based on Analytic Hierarchy Process to estimate the trend of Ecosystem Services Cost over time. Steps are listed as follows

（1） Using AHP, we determine the weight of MSV, ERMV, CSV

（2） According to the ordering weights, we adjust MSV, ERMV, CSV

（3） Utilizing NAR Neural Network Model, we predict the situation of MSV, ERMV, CSV in the next decade.

2.3.1 Analytic Hierarchy Process (AHP)

(1) Establish A Hierarchy Diagram

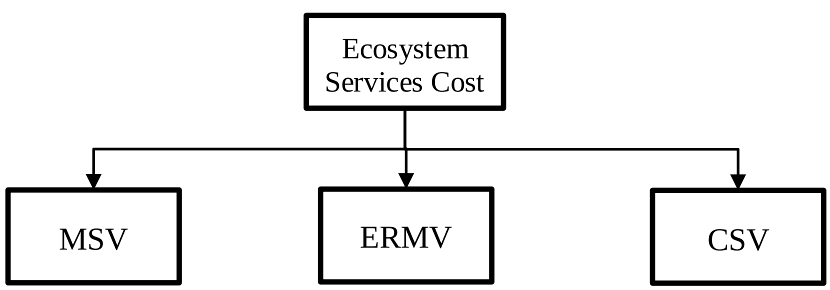

Figure 4 Hierarchical analysis structure

(2) Standardize Data

Standardize MSV, ERMV, CSV

$$S_x = \frac{x - \min}{\max - \min} \tag{13}$$

It is known from the above formula that the normalization coefficient is the difference between the parameter and the minimum data of the data set divided by the difference between the maximum data of the data set and the minimum data.

(3) Establish A Comparison Matrix

Establishing a comparison matrix on Ecosystem Services Cost

$$A = \begin{matrix} & C_1 & C_2 & C_3 \\ C_1 & 1 & 1/3 & 2 \\ C_2 & 3 & 1 & 4 \\ C_3 & 1/2 & 1/4 & 1 \end{matrix} \tag{14}$$

Where:

$a_{12} = 1/3$ means MSV C_1 and ERMV C_2 to the sub-goal of Ecosystem Services Cost O is $1:3$

$a_{13} = 2$ means MSV C_1 and CSV C_3 to the sub-goal of Ecosystem Services Cost O is $2:1$

Due to space limitations, the remaining comparison matrix is detailed in Appendix 3.

(4) Solving Weights and Making Reference Value

Based on the ordering of weights, we can draw a preliminary conclusion: Environmental Regulation and Maintenance Value is the most important in the Ecosystem Service Cost System, followed by the Material Supply Value and finally the Cultural and Social Value. As time goes, ERMV will become more important, and CSV becomes relatively unimportant. Therefore, we set MSV as a basis (MSV remains unchanged), ERMV of the 3 projects will become 2.62 times the original value, and the CSV will become 0.57 times the original value.

2.3.2 NAR Neural Network Model

(1) Model Establishment

ANN[32] (Artificial Neutral Network） is a complex network system in which a large number of simple basic components (neurons) are connected to each other, and information is processed by simulating human brain nerves for parallel processing and nonlinear transformation. We use NAR Neural Network Model based on BP Neural Network. Through the training of sample data, we constantly modify the network weights and thresholds so that the error adjustment direction always proceeds along the direction of the fastest error reduction, thus approaching the desired output. BP Neural Network is a widely used neural network model, which is mostly used for function approximation, model recognition classification, data compression and time series prediction.

(2) Model Solving

Step 1: Network Structure Design

A three-layer dual-input and single-output BP neural network is used to establish a predictive model, in which the number of hidden layer selection neurons is 10.The network structure topology is shown as Figure 5.

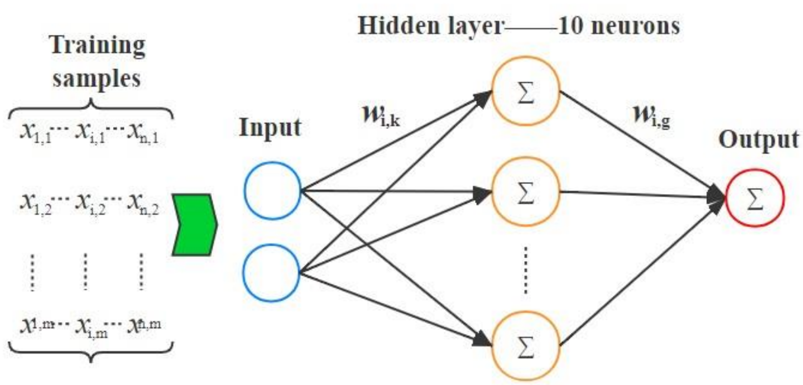

Figure 5 2*10*1 Three-layer BP neural network structure topology

Step 2: Model realization

The prediction uses the neural network toolbox in MATLAB to train the network. Specific implementation steps of the model are as follows:

- After training sample data, we input them to network.
- The excitation function **tansig** is set for the hidden layer; the excitation function **logsig** is set for the output layer. The training function is **travelingdx**; the performance function is **mse**.
- The network iteration number epochs is set to 5000 times. The expected error is 0.00000001; the learning rate LR is 0.01.

Step 3: Model improvement

We use two known data in as the input value. After the network runs once, we get a predicted value, and take a predicted value obtained from the operation and the previous known value as input values for the next operation. Considering the limitation of the length, we select environmental investment cost and income of the coal industry development project in Ordos City to predict. We obtain the time series prediction dataset of two variables by solving the model twice.

(3) Model Results

Using the time series prediction dataset of environmental investment cost and income, we can calculate the time series prediction dataset of total cost, revenue, and profit, as shown in Figure 6. Combined with the calculation results in Section 2.2.2, we know that the profit was extremely high at the beginning of the return period, and then gradually decreased. The results show that the total cost continues to increase after 2015. The income fluctuates and will tend to decline. The profit will be negative sooner or latter and continue to decrease. This result is due to the rising environmental costs after the development of the coal project. Therefore, we can conclude that the land use project should incorporate the value of ecosystem services into the cost range and fully consider the trend of the value of ecosystem services, so as to develop a reasonable land development plan.

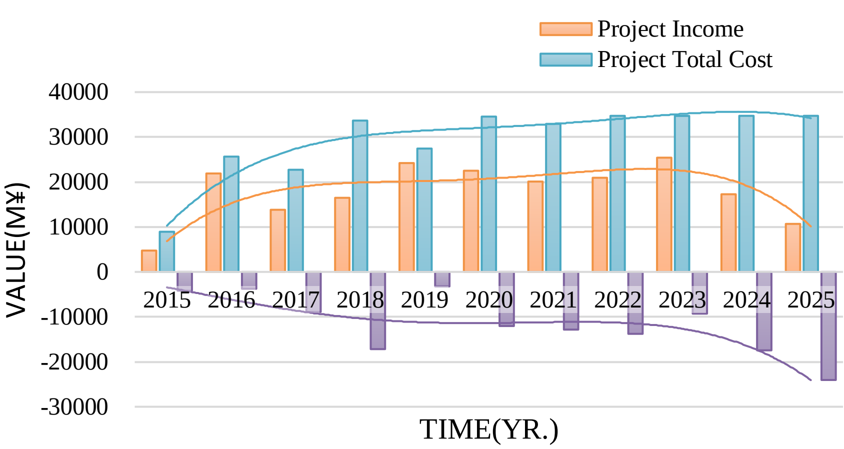

Figure 6 Time series prediction data set

2.4 Sensitivity Analysis

We took Ordos City Coal Industry as an example and increased Industrial Exhaust Emissions (IEM) by 10% (Figure 7). The Atmospheric Regulation Value (ARV) rate of change is 7.25% between 2005 to 2014. We can reach a conclusion that the calculation model is robust.

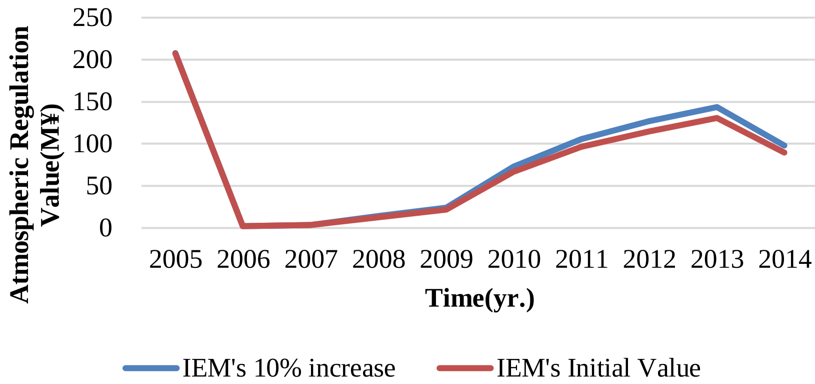

Figure 7 IEM increased results by 10%

3. CONCLUSIONS

We study the true economic costs of land use projects when considering the value of ecosystem services. We begin by establishing an ecological services valuation model through valuation methods such as market value method and shadow engineering method. Using this model, we determine that the true economic cost of the land use project is the sum of construction costs and environmental costs.

To calculate the true economic cost, we then divide the value of ecosystem services into three categories: Material Supply Value, Environmental Regulation and Maintenance Value, Culture and Social Value. Different categories have different value functions, and 13 evaluation indexes are determined according to environmental economics theory and previous studies to measure their ecological value function.

We select three different types of land use projects to apply our model and perform a cost-benefit analysis. The three projects represent the real estate projects of the community, resource development projects with serious environmental damage, and large-scale national construction projects. The results show that the environmental costs of resource development projects and national construction projects exceed their construction costs, so the value of ecosystem services cannot be ignored.

Additionally, we establish a NAR neural network time series prediction model based on analytic hierarchy process to show the model changes with time. The results show that the cost of ecosystem services has increased year by year, which proves that land use projects should incorporate the value of ecosystem services into the cost range.

Finally, we performed a sensitivity analysis on the model, and the results were in line with common sense and practical experience. Our model has a certain reference value for calculating the true economic costs of land use projects when considering the value of ecosystem services.

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