Environmental Assessment Model Based on the Back Propagation Neural Network

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Abstract. With the continuous development of economy and society, the problem of environmental pollution is becoming more and more serious. However, people's demand for a better environment is increasing. Under this background, it becomes particularly important to effectively evaluate the quality of the environment. So we use the Back Propagation Neural Network (BPNN) to establish a weight model. The model mainly includes Driving force, Pressure, Status, Influences, Response indicators and has strong practicability. Subsequently, we examined the impact of land development projects on the environment and conducted an analysis of land development projects taking into account environmental costs. Finally, we use our model to evaluate the Three North Shelter Forest project. Through the evaluation, we can find that the project has greatly improved the local ecological environment, making it a great project. To sum up, the model we have established can effectively evaluate the quality of ecological balance and has certain practical guiding significance.

1. Introduction
At present, with the impact of environmental protection on human sustainable development, how to take a sustainable development path under the influence of resource and environmental constraints has become a hot topic in human research. Marco Trevisan took (2000) Cremona province in Italy as an example, used non-point source agricultural risk index (NPSA-HI) and GIS technology to evaluate the impact of agricultural behavior on urban ecological environment in a hierarchical manner [1]. Matthew A (2001) combines human ecological footprint model and ecosystem process model to identify the limiting factors of urban ecosystem development [2]. Qi Hao Weng (2001) evaluated from the perspective of environment and resources, linking remote sensing technology with GIS technology and research on urban hydrological distribution model [3]. On the basis of predecessors, this paper uses the Back Propagation Neural Network (BPNN) to establish a practical weight model to evaluate the quality of ecological environment. In addition, we have studied the impact of land development projects on the environment, and introduced environmental factors into the cost-benefit analysis of land development projects to evaluate the actual value of land development projects more comprehensively.
2. Model Construction by the BP Neural Network

In order to effectively evaluate the quality of the ecological environment (EEQ), we introduce the Back Propagation Neural Network (BPNN), which is a multilayer perceptron, namely the architecture of a typical feed forward neural network. Its network structure is shown in the Fig.1.

![Fig.1 Schematic diagram of the Back Propagation Neural Network](image)

In order to obtain the weight of each evaluation index, we adopt the neural network technology. First, we must determine the number of each neural network unit. The specific parameters of each neural network are shown in Table 1. The number of hidden layer neural units can be set by yourself. Generally speaking, the more complicated the problem is, the more hidden layer units are needed, but it should not be too many, otherwise the calculation amount will increase. In this paper, the number of neurons in the hidden layer is determined according to the following rules: the number of neurons in the hidden layer is larger than half of the sum of the number of neurons in the input layer and the output layer, and smaller than the sum of the number of neurons in the input layer and the output layer [4].

| model parameter                      | Number of neural units in input layer | Number of neural units in output layer | Number of hidden layers | Number of neural units in hidden layer |
|--------------------------------------|---------------------------------------|----------------------------------------|-------------------------|----------------------------------------|
| Ecological environment neural network| 5                                     | 1                                      | 1                       | 4                                      |

The purpose of establishing neural network algorithm is to determine the weights of EEQ. In order to obtain the decision weight of input factors to output factors, it is necessary to analyze the weight of each neuron [5]. Therefore, the following indicators in Table 2 are used to describe the relationships between input factors and output factors.

For fitting calculation, we use Driving force, Pressure, Status, Influences, Response as input factors of input layer. Through calculation, we obtain the influence weight of each evaluation factor on EEQ. The results are shown in the Table 3.
### Table 2 Relevant explanations and formulas of indicators

| Symbol | Explanation                                | Formula                                                                 |
|--------|-------------------------------------------|-------------------------------------------------------------------------|
| \( r_{ij} \) | Correlation Significance Coefficient     | \( r_{ij} = \sum_{k=1}^{n} \omega_{kj} \left( 1 - e^{-x} \right) \div \left( 1 + e^{-x} \right) \), \( x = \omega_{ji} \) |
| \( R_{ij} \) | Correlation Index                        | \( R_{ij} = \frac{1 - e^{-y}}{1 + e^{-y}} \), \( y = r_{ij} \)          |
| \( S_{ij} \) | Absolute Influence Coefficient           | \( S_{ij} = \frac{R_{ij}}{\sum_{i=1}^{m} R_{ij}} \)                   |

### Table 3 Weights determined by the BP Neural Network

| Indicator name | Driving force | Pressure | Status | Impact | Response |
|----------------|---------------|----------|--------|--------|----------|
| Weights of BPNN | 0.2214        | 0.2134   | 0.2023 | 0.2109 | 0.1520   |

The following is a brief explanation of the meaning of these five indicators:

- **Driving force [6]**
  It mainly include population growth rate, GDP per capita growth rate, population density, Engel coefficient, etc. These factors drive the environment to develop in a good or bad direction.

- **Pressure**
  It indicates the load borne by the environment, mainly including water consumption of 10,000 yuan GDP, energy consumption of 10,000 yuan GDP, industrial distribution density, carbon emissions of 10,000 yuan GDP, etc.

- **Status**
  It is a relatively static indicator used to assess the current environment, which includes the growth rate of construction land, natural disaster environment index, per capita water resources, water environment water quality compliance rate, etc.

- **Impact**
  It is a dynamic index with certain predictive properties, mainly including the biological loss in flooded areas, the number of pollution accidents and the average life of the population.

- **Response**
  It describes the anti-interference capability of the environment, mainly including comprehensive energy consumption per capita GDP, centralized treatment rate of domestic sewage, recovery rate of degraded land, etc.

3. **Cost-benefit Analysis of Ecology and Economic**

Through the process above, we have built a relatively perfect evaluation system. Next, we will analyze the impact of land development projects on the environment and make a life cycle cost-benefit analysis of land development projects considering environmental costs.

Since the study on the cost-benefit analysis of the original life cycle has been quite in-depth, we will only make a brief introduction here. And the focus of our discussion is the environmental cost of land development projects.

The original Life Cycle Costs (LCC) is consisted of Costs of Investment (CI), Costs of Operation (CO), Costs of Maintenance (CM), Costs of Fault (CF) and Costs of Disposal (CD) [7].

Now our improved LCC not only considers these costs, but also includes Costs of Environment (CE). The improved LLC is shown in the Fig.2.
In addition, for most projects, original benefit analysis on the project only considers economic benefits. But in this paper, environmental benefits are also considered. There is no essential difference between ecological benefits and costs. They are equal in value except for the opposite sign.

The formulas of the present value of Life Cycle Costs ($TC_0$) and the present value of life cycle benefits ($TI_0$) are as follows:

$$TC_0 = CI_0 + CO_0 + CM_0 + CF_0 + CD_0$$

If $EVEE_i \geq EVEE_0$, we can get

$$TI_0 = EB_0 + \frac{EVEE_i - EVEE_0}{(1 + r)^t}.$$

If $EVEE_i < EVEE_0$, we can get

$$TC_0 = CI_0 + CO_0 + CM_0 + CF_0 + CD_0 + \frac{|EVEE_i - EVEE_0|}{(1 + r)^t}$$

$$TI_0 = EB_0.$$

There are several explanations about EVE. EVE is called the economic value of ecological environment. The evaluation and research on the value of ecosystem services abroad can be traced back to 1925 when Drumar of Belgium took the expenditure on wildlife recreation as the economic value of wildlife for the first time [8]. Subsequently, environmental economics was born in the 1950s. Combining environment and development is the foundation of environmental economics. The two environmental revolutions made the development of economics advance by leaps and bounds [9]. After decades of research, the accounting methods of eco-environmental economic value have been greatly expanded, mainly including cost expenditure method, market value method, recovery and
protection cost method, shadow engineering method, etc. In this paper, shadow engineering method is used to calculate the economic value of ecological environment.

4. The Three North Shelter Forest Project
In this section, we use our model to analyze the Three North Shelter Forest project, mainly studying the environmental impact of the project and making cost-benefit analysis to test the effectiveness and actual value of our model.

The Three North Shelter Forest is a forest belt built by the government of China in the three northern regions of China (namely, northwest, north and northeast) to slow down the process of desertification and soil erosion [10]. The schematic diagram of the Three North Shelter Forest Project is in the Fig.3.

![Fig.3 Overall layout of ‘Three North Shelter Forest’](image)

Before the construction of the shelterbelts, the forest coverage in the three areas was only 5.0%. Until 2016, the forest coverage rate of 4.06 million square kilometers in the three northern regions has reached 12%. Using our model to evaluate the Three North Shelter Forest project, the results are shown in the Fig.4 and Table 5.

![Fig.4 Local ecological service ability before and after the project](image)
Table 5 The index value of the ‘Three North Shelter Forest’

|                | Original EEQ | Original Status | Later EEQ | Later Status |
|----------------|--------------|-----------------|-----------|--------------|
| Original Driving force | 0.281268   | Original Impact | 0.381728  | Later Driving force | 0.527173 | Later Impact | 0.562727 |
| Original Pressure  | 0.376517   | Original Response | 0.223545  | Later Pressure  | 0.492728  | Later Response | 0.593292 |

\[ T/I_0 \]
327.36

From the results, we can see that the Three North Shelter Forest project has improved the quality of the ecological environment in northwest, north and northeast China.

Although the Three North Shelter Forest Project costs a lot of labor and material resources, it has made outstanding contributions to the improvement of the ecological environment. Therefore, considering all aspects, the Three North Shelter Forest Project is a great engineering.

5. Conclusion

In order to cope with the increasingly severe environmental problems and people's growing demand for a better environment, we use the BPNN to establish an environmental evaluation system. The system includes five indicators, which can summarize most factors affecting the environment. In order to strictly examine land development projects, we have improved the cost-benefit analysis method on the premise of considering environmental costs. Finally, we evaluated the three-north shelterbelt project with the model and found that although it cost a lot of manpower and material resources, it is a great project due to its outstanding contribution to the environment. At the same time, the validity and practicability of the model have also been verified.

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