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Application Research of ELECTRE Method in Ecological Environment Assessment

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Abstract*:* Since the concept of sustainable development was put forward, environmental assessment has always been one of the focuses of all parties in the society, and the methods of environmental assessment have gradually moved from the previous unilateral evaluation to the comprehensive evaluation. Environmental assessments must take into account many aspects, and comprehensive evaluations can just do that. The comprehensive evaluation method can reflect the evaluation of environmental conditions through various means, it can also improve the accuracy and comprehensiveness of the evaluation. This paper mainly uses a simple evaluation method based on ELECTRE, which uses the province as the evaluation object to comprehensively evaluate the ecological environment. This method can mainly get the difference of the status of each evaluation object, that is, the overall evaluation value and ranking of each province in a certain period. I hope that the article can provide some help for the comprehensive evaluation of the application of ecological environment assessment.

Keywords Environmental assessment, Comprehensive evaluation method, ELECTRE

INTRODUCTION

Comprehensive evaluation method is to use models, algorithms and other ways to analyze and research various environmental indicators, to achieve the objective evaluation of environmental quality. (Dinda, *et. al.*, 2004) In recent years, there are three kinds of environmental comprehensive assessment methods that are widely used. (Brito, *et. al.*, 2010) Considering the uncertainty of the environment, fuzzy evaluation method can be used in the environmental evaluation, that is, the corresponding indicator membership set can be established according to the environmental data to form a matrix, and the final result can be obtained by multiplying each determined environmental indicator with its corresponding weight. Or use gray evaluation to solve some problems of monitoring results with uncertain gray concept data, treat the environment as a gray system to use gray clustering and gray correlation methods for environmental evaluation. (Anita, *et. al.*, 2015) Another method is to use the analytic hierarchy process to analyze each element in the evaluation system layer by layer. The above layer is the standard for a certain layer to make a comparative judgment, the weights of all elements are obtained through calculation, and the environmental status is obtained according to the maximum weight.

The main content of this paper is to establish an ecological environment indicator system based on clear data, take provinces as units, determine the weight of each indicator, and apply the simplified ELECTRE ranking model to evaluate and rank the ecological environment of several provinces. This paper describes ELECTRE sorting model at first. And then determines the indicator system with province as the unit, carries out the practical application of the model, and draws corresponding conclusions. Using clear data to evaluate and rank the ecological environment of evaluation objects.

ELECTRE SORT MODEL

ELECTRE (elimination et choice translation reality) was proposed by Benayoun, and then Roy applied this method to decision-making. ELECTRE is a method to solve the multi-objective decision-making of limited solutions. The basic idea is to eliminate inferior solutions and reduce the solution set until satisfactory solutions are selected by constructing weakly dominant relations. Its advantage lies in that the principle is easy to understand, the logic relation is clear, the calculation can be programmed, and the information in the decision matrix can be fully used. This method uses threshold to avoid the original multi-objective evaluation index weighting method for some higher and hides the shortcomings of some low index, also known as a good multi-criteria decision making method. The ELECTRE is divided into many types in the development, among which ELECTRE II deals with the problem of sorting the scheme of data into clear data. This paper uses the simplified ELECTRE sorting model. The advantage of this model is to solve the problem that traditional ELECTRE method relies too much on subjective threshold in multi-criterion decision making.

The basic steps are as follows

1) Firstly, there are m evaluation objects (the evaluated provinces) and n evaluation indexes (the established ecological environment indexes).The jth evaluation index value of the ith evaluated object record as x_{ij} （ i =1, 2， …， m ; j =1, 2, …, n）. Determine the original evaluation index matrix $X=(x_{ij})_{m\times n}$.

2) Establish a standardized decision matrix and standardize the original matrix. The standardized matrix is as follows: $X'=(x'_{ij})_{m\times n}$.

3) Determining Index Weight Vector $W=(w_1, w_2, \ldots, w_n)^T$.

4) Calculate the weighted normalized matrix

$$Y=(y_{ij})_{m\times n}, \quad y_{ij}=x'_{ij}w_j,$$

（i =1，2，…，m ; j =1, 2, …, n）

5) Determining the Advantage Set and the Disadvantage Set

In Weighted Normalization Matrix Y .Comparing the line i and the line l of two evaluated objects for any index J（l=1,2,…,m;）.If the y-value preference of line i is higher than that of line l, then j is classified as advantage set C, otherwise it is classified as disadvantage set D. C_{il} represents the relative advantage index of the evaluation object i over the evaluation object l.

6) The advantage matrix is determined, and the index weights of each element in each dominance set are added together to obtain the dominance matrix C.

$$C=(c_{il})_{m\times m},$$

$$c_{il}=\frac{\sum_{j\in C'_{il}} w_j+0.5\sum_{j\in C''_{il}} w_j}{\sum_{j=1}^{n} w_j}$$

$c'_{il}=\{j|y_{ij}>y_{lj}\}$represents that the y value of row i of column j is higher to the y value of row l of column j. $c''_{il}=\{j|y_{ij}=y_{lj}\}$ represents that the y value of row i of column j is equal to the y value of row l of column j.

7) Determining the Disadvantage Matrix

The relative disadvantage index can be obtained by dividing the maximum difference of the weighted index values of the two schemes corresponding to the elements in each disadvantage set by the maximum difference of all the weighted index values of the two schemes.

$$D=(d_{il})_{m\times m}, \quad d_{il}=\frac{\max_{j\in D'_{il}}|y_{ij}-y_{lj}|}{\max_{j\in S}|y_{ij}-y_{lj}|},$$

$$D'_{il}=\{j|y_{ij}<y_{lj}\} \quad S=\{1, 2, \cdots, n\}$$

d_{il} represents relative disadvantage index of scheme i over scheme l. It is the difference between the weighted index values, which contains not only the weight information, but also the index value information. c_{il} only included weight information ,so there is no complementarity between relative advantage index and relative disadvantage index.The larger the d_{il} is, the greater the degree of scheme i may be inferior to scheme l.

8) Modified Disadvantage Matrix

Redefining inferiority matrix $D'=(d'_{il})_{m\times m}$,

$d'_{il}=1-d_{il}$

The modification of disadvantage matrix means that the direction of numerical judgment of matrix is changed. The larger the d'_{il} , the smaller the degree of scheme i may be inferior to scheme l.

9) Computing the Aggregate Matrix

Because the elements in the matrix are the same as those in the dominant matrix after the disadvantage matrix is revised, and the larger the value of the elements, the higher the degree of preference. So the revised disadvantage matrix can be multiplied by the elements corresponding to the position of the dominant matrix, and the weighted aggregate matrix can be obtained.

$$A=(a_{il})_{m\times m}, \quad a_{il}=c_{il}d'_{il}$$

10) Computing the Comprehensive Evaluation Value

Computing the comprehensive evaluation coefficient is to calculate the net advantage value, and the net advantage value is taken as the comprehensive evaluation value.

$$f_i=\sum_{\substack{q=1\\q\neq i}}^{m} a_{iq}-\sum_{\substack{l=1\\l\neq i}}^{m} a_{li}$$

f_i is the sum of weighted aggregate advantages of scheme i over other schemes subtract the sum of the weighted aggregate advantages of other schemes over the scheme i, reflecting the weighted net advantage value of scheme i. The larger the f_i , the better the scheme.

11) Ranking according to the comprehensive evaluation value

The larger the f_i , the better the scheme.

ECOLOGICAL ENVIRONMENT EVALUATION AND ANALYSIS OF THREE PROVINCES

In this part, we select Beijing, Shandong and Hebei provinces as ecological environment evaluation objects, select evaluation indicators, collect data, calculate numerically, get the comprehensive evaluation values and ranking results of the evaluation indicators.Finally I evaluate and analyze them.

Selection of Evaluation Objects and Evaluation Indicators

Considering the principle of data collection and index construction, five important factors are selected from many factors affecting ecological environment evaluation: Forest coverage, Green coverage of built-up areas, The proportion of wetland area to the area under jurisdiction, Industrial pollution control investment as a share of GDP, Forestry investment as a share of GDP. The selection of evaluation objects is based on provinces, while the selection of evaluation indicators takes into account the issues of data collection and indicators representativeness.

Three subjects were evaluated: Beijing, Shandong and Hebei. There are five evaluation indicators: Forest coverage, Green coverage of built-up areas, The proportion of wetland area to the area under jurisdiction, Industrial pollution control investment as a share of GDP, Forestry investment as a share of GDP.

Data collection

Data are from China Statistical Yearbook or calculated from China Statistical Yearbook (2017).

Table 1 Basic Data Table

Indicator	Beijing	Shandong	Hebei
Forest coverage（%）	35.8	16.73	23.41
Green coverage in built-up areas（%）	48.4	42.1	41.8
The proportion of wetland area to the area under jurisdiction（%）	2.86	11.07	5.04
Industrial pollution control investment as a share of GDP（%）	0.0559	0.1557	0.1008
Forestry investment as a share of GDP（%）	0.74	0.42	0.36

Calculation results

1）Empowerment of five Indicators by subjective empowerment method. The weight vector of the index is

$$W=(0.28,0.28,0.28,0.08,0.08)^T$$

2）According to the simple ELECTRE sorting model in part2, the original evaluation index data are processed. The original matrix is

$$X=\begin{bmatrix}35.08 & 48.40 & 2.86 & 0.0559 & 0.74\\ 16.73 & 42.10 & 11.07 & 0.1557 & 0.42\\ 23.41 & 41.80 & 5.04 & 0.1008 & 0.36\end{bmatrix}$$

The standardized matrix is

$$X'=\begin{bmatrix}0.4664 & 0.3658 & 0.1507 & 0.1789 & 0.4868\\ 0.2224 & 0.3183 & 0.5836 & 0.4984 & 0.2763\\ 0.3112 & 0.3159 & 0.2657 & 0.3227 & 0.2368\end{bmatrix}$$

The advantage matrix is

$$C=\begin{bmatrix}0.50 & 0.64 & 0.36\\ 0.36 & 0.50 & 0.72\\ 0.64 & 0.28 & 0.50\end{bmatrix}$$

The disadvantage matrix is

$$D=\begin{bmatrix}0 & 1 & 0.70\\ 0.58 & 0 & 0.28\\ 1 & 1 & 0\end{bmatrix}$$

Modify the disadvantage matrix to

$$D'=\begin{bmatrix}1 & 0 & 0.30\\ 0.42 & 1 & 0.72\\ 0 & 0 & 1\end{bmatrix}$$

The aggregate matrix is

$$A=\begin{bmatrix}0.5000 & 0 & 0.1080\\ 0.1512 & 0.5 & 0.5184\\ 0 & 0 & 0.5\end{bmatrix}$$

The ecological environment of the three provinces in 2017 was comprehensively evaluated by using ELECTRE sorting model. The comprehensive evaluation values of the ecological environment of the three provinces can be obtained and ranked.

Table 2 Comprehensive Evaluation Value and ranking of Eco-environment in 2017

Object of evaluation	Comprehensive evaluation value	Rank
Beijing	-0.018	2
Shandong	0.6696	1
Hebei	-0.6264	3

Results analysis

From the standardisation matrix, the wetland area and investment in industrial pollution control in Beijing are relatively inadequate. Shandong Province has relatively large deficiencies in forest coverage and investment in forestry, while Hebei Province has relatively large deficiencies in wetland area and investment in forestry and agriculture. These are the

comparisons among the three provinces, so each province should make more improvements in its own shortcomings.

From the final evaluation value, the evaluation results show that when the ecological environment of Shandong, Beijing and Hebei ranks from the following five indicators: forest coverage, green coverage of built-up areas, the proportion of wetland area to the area under jurisdiction, industrial pollution control investment as a share of GDP, forestry investment as a share of GDP, the order from good to bad is : Shandong, Beijing, Hebei. And Hebei's ecological environment disadvantage is greater, while Shandong's ecological environment advantage is greater.

It also proves that ELECTRE evaluation method can be applied to environmental assessment. The simple ELECTRE ranking model used in this paper can reflect the environmental evaluation values and ranking results of each evaluation object within a fixed period of time (see Table 2). It can also reflect the comparison of the merits and demerits among the evaluation objects.

CONCLUSIONS

The ELECTRE evaluation method used in this paper is a static evaluation method, which can reflect the evaluation value of the evaluation object at a certain point. It uses two-dimensional data to reflect the comparison of the current situation of ecological environment evaluation. Based on the simple ELECTRE ranking model, the evaluation value and ranking of eco-environment among provinces and regions in China can be established. And it is a simple application of comprehensive evaluation method in environmental assessment. The disadvantage of this method is that it can only reflect the difference degree of each evaluation object index, but can not reflect the change degree of its growth. So there is no way to carry out dynamic evaluation and analysis, which can not reflect the overall trend of the indicators of each evaluation object, and therefore can not make judgment and decision on the trend of environmental evaluation. On the other hand, the indicators used in this paper are selected on the basis of convenient data collection. The method of empowerment adopts subjective empowerment method, and the data used are also accurate real numbers. But the main characteristic of the environment is strong uncertainty, and most of the environmental indicators and standards also have strong ambiguity.

Therefore, there are two main points in my suggestions. The first point is that when applying the comprehensive assessment method to environmental assessment, we should adopt the evaluation method which can reflect both static and dynamic changes, and improve it on the basis of existing methods. The second point is that when choosing the method of empowerment, we can use the method of subjective and objective integrated empowerment as far as possible, and integrate the weights of the two methods synthetically. We can further study the environmental evaluation methods with some evaluation indexes as fuzzy numbers and interval numbers, so as to broaden the application of comprehensive evaluation methods in environmental evaluation.

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