The Impact of Ecological Restoration on the Surrounding Environment in Saihanba Area

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Abstract: In order to study the impact of ecological restoration of Saihanba on the environment, based on the data of Saihanba from 1962 to 2021, including forest coverage area, forest volume, water storage, carbon dioxide absorption and oxygen release, the ecological environment evaluation system of Saihanba was constructed. By consulting the relevant literature, the relevant parameters are determined as the indexes of forest environment evaluation. The entropy weight method is used to give the index weight, and the TOPSIS method is used to analyze the advantages and disadvantages of the indexes. Because the score after restoration is significantly higher than that before restoration, the restoration effect of Saihanba ecological area is remarkable. The forest area of Saihanba was selected as an index to affect the surrounding environment, and the data of forest area of Saihanba from 2010 to 2020, as well as the data of dust weather days, gale days and green area in Beijing Statistical Yearbook in the same period were selected. Using the DEA-CCR model, the target rate of return is obtained, that is, the impact of the increase in the forest area of Saihanba on Beijing 's dust prevention capacity. The results show that with the increase of the forest area of Saihanba, the ability of wind and sand prevention in Beijing area is gradually enhanced.

Keywords: Entropy Weight Method; TOPSIS Model; DEA-CCR Model; Ecological Environment; Saihanba

1. Introduction

In recent years, China is increasingly concerned about ecological construction, and forest resources, as an important basic industry in China, play a pivotal role in the development of ecological civilization.

The fact that Saihanba was once a natural garden of fame, affected by human exploitation, coupled with the fact that Saihanba is located at the junction of monsoon and non-monsoon zones in China, with high altitude, low temperature and scarce rainfall, as well as frequent climatic events such as droughts, high winds and frost damage, makes the desertification of the soil in Saihanba intensify day by day. However, after several generations of unremitting efforts, Saihanba has created the "miracle of the world" of "turning desert into oasis", becoming another vivid example of promoting the development of ecological civilization.

There are many kinds of comprehensive ecological evaluation methods, such as hierarchical analysis, gray correlation analysis, fuzzy comprehensive evaluation method [1]. In the article, by profiling the environmental resource status of the Saihanba area and selecting appropriate indicators combined with entropy weighting method and TOPSIS model to score the ecological environment of Saihanba, the results indicate that the ecological environment of Saihanba has improved significantly. After that, the DEA-CCR method was applied to Beijing as an example, using the forest area of the Saihanba as an indicator, and it showed that the construction of the Saihanba has helped to improve the ecosystem function of Beijing. Although China has outstanding achievements in ecological environmental protection, there are still many problems that need to be solved in the process of achieving greening in China. As a successful case of ecological restoration, Saihanba is of great significance in establishing a more improved ecological and environmental protection system as well as promoting socio-economic development.

2. Construction of ecological environment evaluation system

2.1 Selection of evaluation indicators

The factors related to the ecological environment status are analyzed in a unified way to get the comprehensive ecological environment evaluation indexes of relevant forest areas. The ecological environment of the Saihanba forest area is analyzed in combination with the domestic ecological environment evaluation system to make targeted screening [2].Wu Tong [3] used vegetation cover to measure the growth of plants on the land surface, thus indirectly reflecting the degree of desertification in the area. Dai Xiaoqin [4] focused on two factors, forest cover area and forest cover ratio, in an ecological environment evaluation based on remote sensing data. Based on the above related literature, forest cover area, forest stock, water storage, carbon dioxide absorption and oxygen release were identified as key indicators for assessing the ecological restoration of Saihanba.

2.2 Establishment of evaluation system

2.2.1 Entropy method of assigning weights

Entropy method is an objective empowerment method in which entropy value is used to measure uncertainty in information theory. Based on the characteristics of entropy, the entropy value can be calculated to make a judgment on the randomness and disorder degree of an event. At the same time, the entropy value is used to judge the degree of dispersion of an indicator, and the greater the degree of dispersion of an indicator, the greater the weight of the influence of that indicator on the comprehensive evaluation, and the smaller its entropy value [5].

Firstly, the five influencing factors of the decision problem were listed, namely forest cover area, forest stock, water content, carbon dioxide uptake and oxygen release, and the corresponding data arranged in time series were used as key indicators for evaluation.

Each row of the matrix represents the time variables of Seyhan Dam in six-year increments, and each column corresponds to an indicator (area covered, forest stock, water content, carbon dioxide uptake, oxygen release) for weighting, so as to obtain the processing results.

For the input matrix, it is first normalized according to Equation (2.1), and all data are positive after normalization to obtain the matrix X.

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{bmatrix} \quad (2.1)$$

Then normalized, and then finally processed to obtain the non-negative matrix $\widetilde{Z}$。

$$\widetilde{Z} = \begin{bmatrix} \tilde{z}_{11} & \cdots & \tilde{z}_{1m} \\ \vdots & \ddots & \vdots \\ \tilde{z}_{n1} & \cdots & \tilde{z}_{nm} \end{bmatrix} \quad (2.2)$$

Compute the probability matrix *P* from $\widetilde{Z}$, where each element in *P* is P_{ij}.

$$P_{ij} = \frac{z_{ij}}{\sum_{i=1}^{n} z_{ij}}, i = 1,2,\ldots,n, j = 1,2,\ldots,n \quad (2.3)$$

Calculate the information entropy value e_i, easy to $e_i = 0.4393$.

$$e_i = -k\sum_{j=1}^{m} p_{ij} ln(p_{ij}), k = 1/ln(n) > 0, e_i \geq 0 \quad (2.4)$$

Calculating the information entropy redundancy,

$$d_i = 1 - e_i, i = 1,2,\ldots,n \quad (2.5)$$

Calculating the weights of the indicators,

$$\omega_i = \frac{d_i}{\sum_{j=1}^{m} d_i}, i = 1,2,\ldots,n \quad (2.6)$$

The total weight of each influencing factor in *P* was calculated according to the entropy weighting method, and the final results were summarized as shown in Table 1.

Table1 List of influencing factors weights

Evaluating indicator	Total weight
forest covered area	0.2223
Forest stock	0.6833
Water conservation	0.0003
Carbon dioxide absorption amount	0.0557
Oxygen release	0.0384

As can be seen from Table 1, forest cover area, forest stock and carbon dioxide uptake, which contain more information, are more indicative of the extent of ecological restoration in Seyhanba, while the two factors of oxygen release and water content are relatively less informative.

2.2.2 TOPSIS Model building

The indicator data scores were calculated, and the maximum and minimum values were defined as, respectively

$$\tilde{Z}^{+} = (\tilde{Z}_1^{+}, \tilde{Z}_2^{+}, \ldots, \tilde{Z}_m^{+}),\ \tilde{Z}^{-} = (\tilde{Z}_1^{-}, \tilde{Z}_2^{-}, \ldots, \tilde{Z}_m^{-}) \quad (2.7)$$

The *i* th evaluation object and the maximum distance are defined as

$$N_i^{+} = \sqrt{\sum_{j=1}^{m} (\tilde{Z}_1^{+} \ldots Z_{ij})^2},\ N_i^{-} = \sqrt{\sum_{j=1}^{m} (\tilde{Z}_1^{-} \ldots Z_{ij})^2} \quad (2.8)$$

The score of the *i* th evaluation object is calculated

$$G_i = \frac{N_i^{-}}{N_i^{-} + N_i^{+}} \quad (2.9)$$

Normalized scores

$$S_i = \frac{G_i}{\sum_{i=1}^{n} G_i} \quad (2.10)$$

The score S_i of the five indicators calculated by TOPSIS model is multiplied by the weight ω_i of the indicators obtained by entropy weighting method. F_i is the score of the ecological environment of Seyhanba from 1962 to 2021. F_i is calculated by R language software (omitted).

$$F_i = \omega_i \times S_i \quad (2.11)$$

The F_i data were visualized to obtain the curve of the change in rating values with year, as shown in Figure 1.。

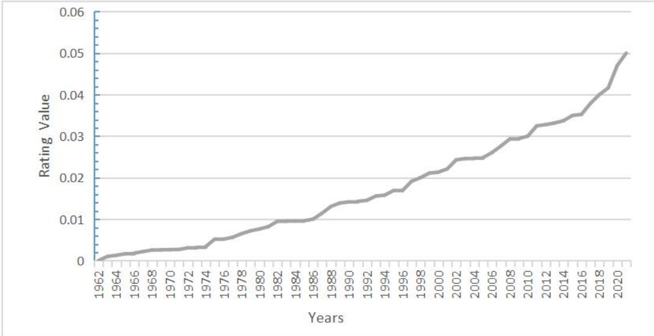

Figure 1 Change curve of evaluation scores from 1962 to 2021

2.3 Analysis results

Combining the entropy weight method and TOPSIS model, the evaluation system of the ecological environment of the Saihanba was constructed. It can be clearly seen from Figure 1 that with the change of time, the ecological environment score value of Saihanba keeps increasing and the rate of increase is gradually accelerated, indicating that there is a significant change in the restored area of Saihanba compared with the pre-restoration period. The data indicate that the Saihanba has gradually changed from a poor environment and severe desertification at the beginning to an area with abundant grasses and trees and enhanced ability to resist wind and sand, and has stabilized.

3. Analysis of the impact of the anti-sandstorm in Saihanba

3.1 Data Selection

Wang Dong [6] elaborated the important role of forests in water conservation, soil and water conservation, air purification, and maintenance of species diversity, and also played a positive role in promoting air purification, sand and water retention, and climate regulation. In this paper, we select the forest cover area as an indicator to analyze the data on the number of sandy days, windy days and green areas in Beijing.

According to the relevant statistical data of Beijing Statistical Yearbook, the relevant data from 2010 to 2020 are shown in Figure 2-3.

According to the relevant statistics of Beijing Statistical Yearbook, the relevant data for 2010-2020 are shown in Figure 2.

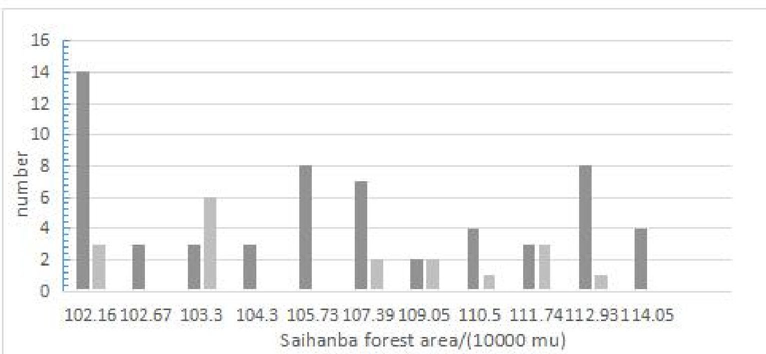

Figure 2 Map of changes in the number of dust storms and windy days in Beijing with the area of the Saihanba forest

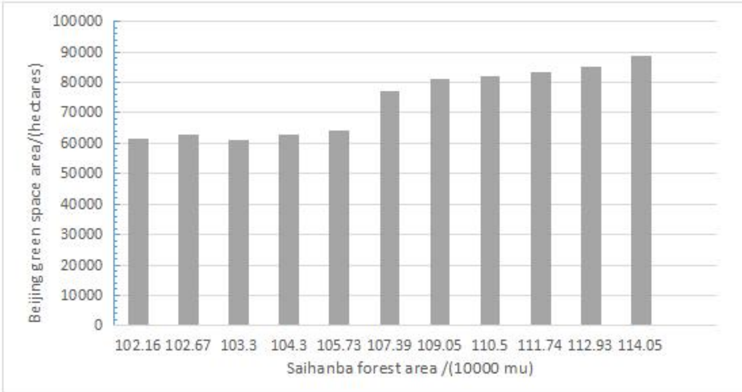

Figure 3 Map of green space area in Beijing with the change of Saihanba forest area

3.2 Build DEA model

DEA model as a multi-objective decision making method is a data analysis tool for estimating the performance of a decision unit, which focuses on the comparison between similar units, i.e. efficiency values. Technical efficiency refers to the extent to which the production process of a production unit reaches the technological level of the industry. In general, technical efficiency can be measured using the ratio of outputs to inputs, but this measurement is generally applicable only in the case of a single input and a single output [7]. If there is an input quantity (forest area of the Sekhangba greenland) and an output quantity (number of high wind days, number of dust storms, greenland area), the combined input-output situation can be determined using a weighted approach.

The **DEA-CCR** model is an economic system in which **DMU** (decision making units) is judged by the relative rationality and effectiveness of each unit through "inputting a certain number of factors of production and producing a certain number of products".

The efficiency evaluation index of decision unit j is defined as

$$h_j = (u^T Y_j)\big/(v^T X_j), j=1,2,...,n \quad (3.1)$$

For the above equation, the weight coefficients v and u can be properly evaluated, so that $h_j/leq1$, the efficiency of the j_0 decision unit can be evaluated. Generally speaking, the larger the h_{j0} indicates that DUM_{j0} can obtain relatively more output with relatively little input[8]. Therefore, only the maximum value can explore whether DUM_{j0} is relatively optimal in these n DUM.

$$\begin{cases} max\ h_{j0} = \frac{\sum_{r=1}^{n} u_r y_{rj_0}}{\sum_{i=1}^{n} v_i x_{ij_0}} \\ s.t. \frac{\sum_{r=1}^{n} u_r y_{rj_0}}{\sum_{i=1}^{n} v_i x_{ij_0}} \le 1, j = 1,2,...,n \\ u \ge 0, v \ge 0 \end{cases} \quad (3.2)$$

The input quantity is the Sekhangba forest area, and the output quantity includes the number of windy days in Beijing, the number of dust storms in Beijing and the green area in Beijing. The **EDA** for the number of windy days and the number of dust storms are expected outputs, with values between [0,1], and the larger the value, the higher the benefit obtained; the **EDA** for the green area is a non-expected output, with values between [0, 1], and the smaller the value, the higher the benefit obtained.

3.3 Analysis results

Table 2 Related Data

Year	(Non-desired output) EDA for number of high wind days and number of dust storms	(Desired output) EDA for green area	Wind and sand control gains
2010	1.000000000000000	0.776463722474423	
2011	0.213221277602304	0.784841713971450	Incremental
2012	1.000000000000000	0.758460264945472	Decreasing
2013	0.209889056293658	0.774980033133347	Incremental
2014	0.552134142222102	0.779942336453468	Incremental
2015	0.546402210013347	0.923434176017488	Incremental
2016	0.352811860003057	0.958613784277901	Decreasing
2017	0.283796078431373	0.955436276346203	Incremental
2018	0.516477537139789	0.960804647037056	Decreasing
2019	0.516932107120719	0.971002846950613	Incremental
2020	0.255927851193086	1.000000000000000	Incremental

According to Table 2, with the annual increase of the green area of Sehanba, the number of dust storms and windy days per year in Beijing showed a significant overall decreasing trend, and the environment gradually showed an optimization trend. Due to the possible influence of other environmental or human factors, individual years did not show a better improvement effect, and it is impossible to specifically exclude the interference of these factors in this paper. To sum up, the increase of forest area in Sehanba has increased the wind and sand control capacity, which in turn has led to the weakening of sandy green areas in Beijing and thus the trend of increasing green areas. This not only contributes to a good ecological environment, but also helps to improve the living standard and life satisfaction of the Beijing people and promote the social and economic development.

4. Conclusion

The analysis found that the ecological environment of the Seyhanba region showed a smooth recovery from 1962-2021, while making an important contribution to the mitigation of severe weather in Beijing. Therefore, the successful ecological restoration of the Seyhanba region has important practical significance. After a long history of development, the Seyhanba has gradually established a modern, scientific and efficient management system, and its successful experience in ecological restoration also provides valuable references for the construction of ecological civilization in China. A good ecological civilization is not only a valuable resource, but also concerns the economic lifeline of the whole society. It is a common proposition of today's society to accelerate the exploration of green economic development paths and to ensure the simultaneous development of economic development and environmental protection.

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