Evaluation model of anti sandstorm effect of Saihan dam based on TOPSIS good and bad solution distance method

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Abstract: This paper starts from the conditions of sandstorm formation, collected the relevant data of Beijing's air quality, strong wind weather, precipitation and other indicators in recent years, strong wind, dust volume, air state, water content, vegetation abundance, and environmental damage degree in surrounding areas were selected as the judging indexes, after data preprocessing, a factor analysis model was established to extract three comprehensive indicators: strong wind weather, air quality and dust volume, the comprehensive index was added into TOPSIS model to calculate the score. Finally, by comparing the score, the effect of the ecological environment restoration of Saihan dam on the sand storm resistance in Beijing was quantitatively obtained.

Keywords: TOPSIS; Saihan dam; Anti sandstorm; Function evaluation

1. Problem background

We put resources saving, protecting the environment, and restoring nature first, and firmly implemented sustainable development strategies. At present, with the help of government, the sahan dam stand has recovered from the desert to become an ecofriendly green farm with stable sand prevention functions.

The founders forested 1.12 million mu and planted more than 400 million trees on a plateau wasteland 400 km north of Beijing, creating it as the world's largest plantation. But the back of the honorary mission also ushered in new questions, and the goal of continuing development higher was to restore ecology.

2. Model assumptions

(1)It was assumed that the eco-environmental changes were not affected by the outbreak

Reason: the impact of the outbreak on the recovery of the ecological environment is only temporary, so the establishment of the model still has application value.

(2)It is assumed that the impacts of Sehan dam eco-environmental improvement on dust resistance in Beijing are evenly distributed

Reasons: climate conditions, precipitation, and air quality differ less among regions within Beijing, and may be negligible when discussing the effect of Sehan dam on the resistance to dust storms in Beijing.

3. Evaluate the role model of Saihanba in anti-sandstorm in Beijing

For resisting dust storms in Beijing of sihanba region ecological environment restoration quantitative evaluation of the problem, this article from the conditions of formation of sand-dust storm, gathered in Beijing's air quality in recent years, the strong wind weather, multiple indexes such as the related data, and preliminary selected multiple judgment index, after data preprocessing, setting up a comprehensive factor analysis model to extract the three indicators: Strong wind weather, air quality and dust amount were positively integrated into TOPSIS model to calculate the scores. Finally, by comparing the scores, the effect of the ecological environment restoration of Saihanba on the anti-sandstorm of Beijing was quantitatively obtained.

4. Index selection and data preprocessing

The topic requires to evaluate the role of Saihan dam in Beijing's anti sandstorm, and the indexes can be selected from the conditions of forming sandstorm. strong wind, amount of dust, air state, water content, vegetation abundance and degree of environmental damage in surrounding areas are preliminarily selected as judgment indicators.

4.1 Extract main indicators by factor analysis

4.1.1 Determine whether the original variables are suitable for factor analysis

This paper uses kmo and Bartlett's test to test the original data to judge whether the original data is suitable for factor analysis. After testing, the kmo value of the original data is 0.932 and the result of Barrett test is 0.204. The results show that the original data is suitable for factor analysis.

4.1.2 Construction factor variable

Construct the relationship between each index and common factors to obtain the following determinant:

$$x_1 = u_1 + a_{11}f_1 + a_{12}f_2 + \ldots + a_{1m}f_m + q_1 \quad x_2 = u_2 + a_{21}f_1 + a_{22}f_2 + \ldots + a_{2m}f_m + q_2$$

$$\ldots$$

$$x_3 = u_3 + a_{31}f_1 + a_{32}f_2 + \ldots + a_{3m}f_m + q_3 \#(1)$$

The sum of squares of row elements and column elements is

$$l_i^2 = \sum_{j=1}^{m} a_{ij}^2, \quad r_i^2 = \sum_{i=1}^{p} a_{ij}^2 \#(2)$$

4.1.3 Using rotation makes factor variables more interpretable

Since the factor load matrix is not unique, the factor load matrix should be rotated. The purpose is to make each variable have relatively high load on as few factors as possible, so that the load of a variable on a factor tends to 1 and the load on other factors tends to 0. That is, the square value of each column or row of the load matrix is polarized to 0 and 1.

4.1.4 Determining factor score

In this paper, through the turning point of the gravel map and the cumulative contribution rate of the variance interpretation table, the cumulative variance contribution rates of the three common factors are 82.835%, 10.127% and 4.327% respectively. The cumulative variance contribution rate of the first three common factors has reached 97.289%, that is, the first three common factors can contain 97.289% of the information of the original index, Therefore, the first three common factors are selected to reflect the data of the overall index.

4.1.5 Calculate the score of the factor variable

Factor analysis is to express variables as a linear combination of common factors and special factors. In this paper, the common factors can be inversely expressed as a linear combination of original variables to obtain factor scores. The generated component score coefficient matrix is shown in the table.

5. Evaluation model of Saihan dam in Beijing's anti dust storm based on TOPSIS good and bad solution distance method

Table 1. Component score coefficient matrix

Influence factor	Component		
	1	2	3
I_1	0.389	0.658	-0.298
I_2	0.576	0.183	0.482
I_3	-0.125	-0.356	0.197

Through the above factor analysis, three main indicators are obtained, namely, strong wind, dust volume and air state. Next, this paper quantitatively evaluates the role of Saihan dam in Beijing's anti dust storm through TOPSIS good and bad solution distance method.

5.1 Forward processing

Since the number of strong winds and the amount of sand and dust are very small indicators, they are first positively treated and transformed into very large indicators. The formula for transforming very small indicators into very large indicators is as follows:

$$\tilde{x}_i = \max - x \#(3)$$

Where, $\tilde{x}_i$ is the indicator data after the forward conversion of very small indicators, x is the original data, and max is the largest value among similar indicators.

5.2 Matrix standardization

The forward matrix is: $X = \begin{bmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{bmatrix} \#(4)$

The standardized matrix is marked as Z, the standardized matrix Z can be obtained.

5.3 Calculate the score and normalize it

Finally, the score is calculated and normalized, and the maximum value is defined as:

$$z^+ = (z_1^+, z_2^+, \ldots, z_m^+) = (\max\{z_{11}, z_{21}, \ldots, z_{n1}\}, \ldots, \max\{z_{1m}, z_{2m}, \ldots, z_{mm}\})$$

Define the distance between the I (I = 1,2,..., n) evaluation object and the maximum and minimum values as follows:

$$D_i^- = \sqrt{\sum_{j=i}^{m} w_j (z_j^- - z_{ij})^2}, \quad D_i^+ = \sqrt{\sum_{j=i}^{m} w_j (z_j^+ - z_{ij})^2} \#(5)$$

The TOPSIS score of Saihan dam in Beijing's anti sandstorm is: $S_i = \dfrac{D_i^-}{D_i^+ + D_i^-} \#(6)$

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