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Comprehensive Evaluation of Saihanba's Impact on its Surrounding Environment based on TOPSIS and its Model Promotion

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Abstract

Starting from the era concept of ecological protection, aiming at the impact of the construction of Saihanba on China's ecological environment, this paper innovatively uses the PSR model to construct an index system, and comprehensively uses the Topsis entropy method, Moran's I and other theories and methods to construct a comprehensive Benefit evaluation model. In addition, the ecological protection model of Saihanba is extended to the whole country, and its effect on the ecological environment and carbon neutrality is analyzed. Finally, feasible plans and suggestions are given in combination with the actual situation.

Keywords

Saihanba; Ridge Regression; Moran’s I; Stata; Geoda; TOPSIS.

1. Background Knowledge

1.1 Background

1.1.1 Background Introduction

After more than a century of hard work, the world's largest plantation forest has been built on the land of Saihanba. Saihanba has transformed from a small sapling into the largest plantation in the world, becoming a model of ecological civilization and beautiful China and an ecological barrier for the surrounding areas. played an important role.

1.1.2 Significance of Research

Ecological civilization is a new stage in the development of human civilization. It is a social form with the basic purpose of harmonious coexistence between people, people and nature, and people and society, national development, virtuous circle, and sustainable prosperity. With the concept of world ecological civilization and the great help of the Chinese government, Saihanba Forest Farm has become an eco-friendly green farm with stable sand control functions.

This paper accurately constructs an evaluation model of Saihanba's impact on the ecological environment, analyzes the impact of Saihanba's restoration on the local and surrounding environment, and reflects Saihanba's important role and outstanding contribution to the construction of ecological civilization. At the same time, based on the ecological model of Saihanba, it analyzes its role in promoting carbon neutrality in China and even in the Asia-Pacific region, and puts forward feasible plans and suggestions for the construction of ecological reserves.

1.2 Related Data

(1) 2005-2021 China Statistical Yearbook.

(2) FRED economic database related data.

(3) OECD Stat database.

1.3 Overview of Research Status

Literature [1] used one-way ANOVA and Tukeys multiple comparisons to explore the effects of different thinning intensities or seasons on soil physicochemical properties, microbial biomass and enzyme activities. The research results can provide theoretical basis for the management of larch plantation in North China.

Literature [2] uses the pixel binary model to process the three-period data of Landdsat in 1980, 2000 and 2019, and obtains that the average coverage rate in this area is relatively high, mainly medium and high coverage rates; not only analysis of human The effect of the activity on the vegetation cover change of Saihanba Mechanical Forest Farm has important reference value for the environmental regulation of this ecological area.

Literature [3] found that accelerating the construction of a nature protection system with national parks as the main body needs to vigorously promote the spirit of Saihanba as an important premise. Ecological civilization and the construction of a beautiful China are overall, leading, and iconic. The party and the country need to speed up the construction of a natural protection system and build a solid barrier for my country's ecological security protection.

Based on the above literature, the article finds that the construction of Saihanba ecological reserve is of great significance to the construction of ecological civilization in China and the world. Therefore, this paper establishes a comprehensive evaluation model to study the impact of ecological construction in Saihanba[5] on surrounding areas and extends it to the whole of China.

2. Establishment and Solving of the Model

2.1 Problem Analysis

We need to establish a mathematical model to construct an evaluation model for the impact of Saihanba Forest Farm on the ecological environment. First, we combined the PSR model to select 16 indicators from 2005 to 2020 in the pressure layer, state layer, and response layer to construct an indicator system; secondly, after standardization, the TOPSIS[6] model was used to calculate the comprehensive score[4] of the ecological environment in each year. And compare the results; finally, sort the scores, and evaluate the situation before and after the ecological environment restoration combined with the scores of each year.

Based on PSR model, the indexes are divided into pressure layer, state layer and response layer. Among them, there are 5 indexes of pressure layer, namely: I_1 person time (10000 persons), I_2 revenue (100 million), I_3 $t$otal resident population (person), I_4 $t$otal resident population (person), I_5 number of factories (PCs.); There are 6 indicators in the state layer, namely:I_6 Coverage area (10000 mu), I_7 forest volume (10000 m3), I_8water conservation volume (100 million m3), I_9 urban air quality standard days (better than grade II), I_{10} urban PM2.5 concentration (microgram per cubic meter), I_{11} surface water quality compliance rate (%); There are five indicators in the response layer: I_{12} forest coverage (%), I_{13} carbon dioxide absorption (10000 tons), I_{14} oxygen release (10000 tons), I_{15} artificial afforestation area (HA), I_{16} artificial renewal area (HA). The specific index system is shown in Figure 1.

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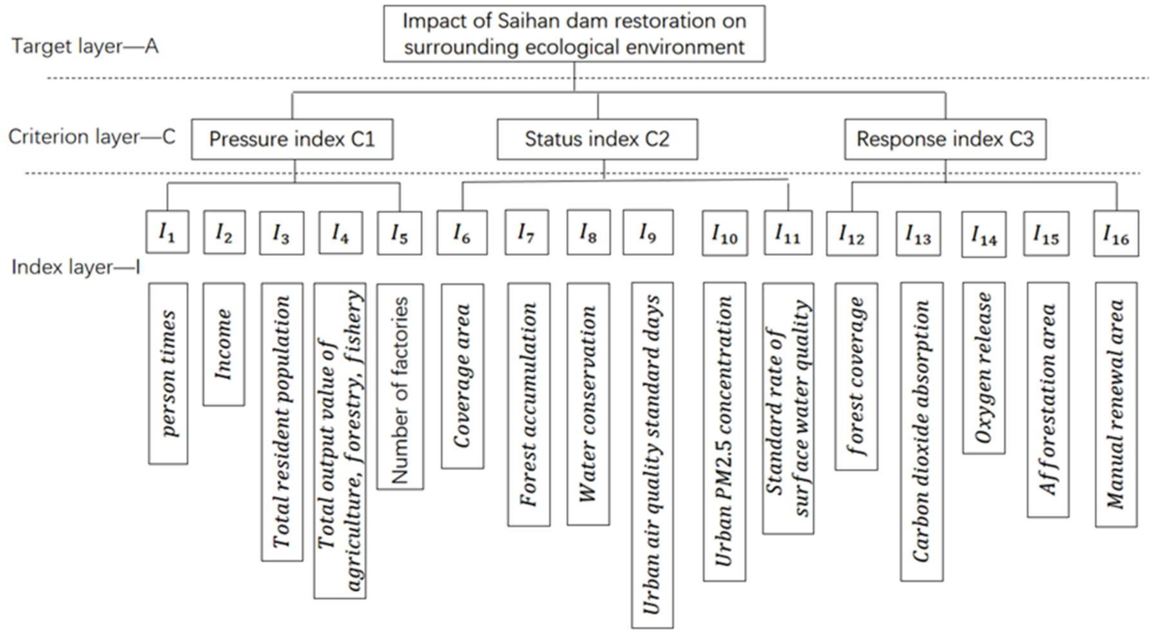

Figure 1. Hierarchy chart of sustainable development of Saihanba ecological environment

2.2 Problem Solved

2.2.1 Model Principle

The TOPSIS decision analysis model [7] is a method of sorting according to the proximity of the evaluation object to the idealized target, which is a comprehensive evaluation method of distance. The basic idea is to measure the distance between each sample and the positive and negative ideal solutions by assuming positive and negative ideal solutions, and obtain the relative closeness to the ideal solution to rank the pros and cons of each evaluation object.

2.2.2 Data Preprocessing

A major principle of applying the TOPSIS model is to carry out the weighted normalization decision matrix. Due to the differences in each index, it is necessary to normalize the original data.

That is to construct a normalized decision matrix $Z = \left(Z_{ij}\right)_{m*n}$.

$$\boldsymbol{Z_{ij}} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} {X_{ij}}^2}} \quad j = 1,2,\dots,n$$

2.2.3 TOPSIS Comprehensive Evaluation

Construct a weighted normalized decision matrix V, in which the element $V_{ij} = W_j Z_{ij}$, and then obtain the ideal solution and negative ideal solution, and its equation form is as follows:

Ideal solution:$V^+ = (\ V_1^+,\ V_1^+, \dots,\ V_m^+\ ) = \{maxV_{ij} \mid j = 1,2,\dots,m\}$.

Negative ideal solution: $V^- = (\ V_1^-,\ V_1^-, \dots,\ V_m^-\ ) = \{maxV_{ij} \mid j = 1,2,\dots,m\}$.

Then calculate the distance S_i^+ from each solution to the ideal solution and the distance S_i^- to the negative ideal solution. The equations are as follows:

$$S_i^+ = \sqrt{\sum_{j=1}^{m} \left(V_j^+ - V_{ij}\right)^2}$$

$$S_i^- = \sqrt{\sum_{j=1}^{m} \left(V_j^- - V_{ij}\right)^2}$$

Finally, the relative closeness of each scheme is calculated as follows:

$$C_i = \frac{S_i}{S_i^+ + S_i^-}$$

Where the value of proximity is C_i is between 0-1 when $C_i = 1$, the performance level is the highest and reaches the optimal state; When $C_i = 0$, there is no performance and it is in a state of high disorder. Finally, it is sorted according to the relative proximity, C_i The larger the value of I, the better the overall level.

The weight of each indicator is calculated through the TOPSIS decision analysis model, as shown in Table 1 below. The three indexes that have the greatest impact on the evaluation system are: I_{12} forest coverage (%), I_6 forest volume (10000 m3), I_{15} artificial renewal area (HA), I_{10} surface water quality compliance rate (%), I_{16} artificial renewal area (HA); The three indicators that have the least impact on the evaluation system are: I_{14} oxygen release (10000 tons), I_7 forest volume (10000 m3), I_9 urban air quality standard days (better than grade II).

Table 1. Indicator weight table

Indicator name	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8
T0PSIS Method	0.2013	0.2339	0.1011	0.0117	0.0099	0.0865	0.0022	0.0304
Indicator name	I_9	I_{10}	I_{11}	I_{12}	I_{13}	I_{14}	I_{15}	I_{16}
T0PSIS Method	0.0077	0.0796	0.0316	0.0865	0.0022	0.0022	0.0834	0.0531

Through the calculated weight of each secondary index, add the weight of each secondary index corresponding to the pressure index C1, status index C2 and response index C3 of the primary index to obtain the weight corresponding to each primary index. They are respectively recorded as W1, W2, W3 .The calculation formula and results are as follows:

$$W_1 = \sum_{j}^{5} w_j = 0.5346$$

$$W_2 = \sum_{j}^{6} w_j = 0.2380$$

$$W_3 = \sum_{j}^{5} w_j = 0.2275$$

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The pressure layer represents the impact of human activities on the local environment, the state layer refers to the systematic change of ecological environment, and the response layer represents the state of ecological environment. It can be seen that the greatest impact on the evaluation system is human activities, the second is the change of ecological environment system, and the smallest is the ecological environment. The final scores for each year are shown in the Table 2 below:

Table 2. Model score

year	2005	2006	2007	2008	2009	2010	2011	2012
T0PSIS Method	0.1991	0.0.1835	0.2278	0.2644	0.2837	0.2092	0.2511	0.2765
year	2013	2014	2015	2016	2017	2018	2019	2020
T0PSIS Method	0.3153	0.4045	0.4489	0.5647	0.5098	0.6607	0.8012	0.4652

2.2.4 Spatial Autocorrelation Analysis

In this paper, the local Moran index[9] is used to establish the calculation equation as follows:

$$\mathrm{I_i} = \frac{\mathrm{Z_i}}{\mathrm{S^2}} \sum_{\mathrm{j \neq i}}^{\mathrm{n}} \mathrm{W_{ij}\, Z_j}$$

Among, $Z_i = y_i - \bar{y}$, $Z_j = y_j - \bar{y}$, $S^2 = \frac{1}{n}\sum(y_i - \bar{y})^2$, W_{ij} is the spatial weight value, n is the total number of all regions in the study area, and I_i represents the local Moran index of the region i. Finally, Moran's I significance is obtained as shown in Table 3.

Table 3. Moran index

Year	2020				2015			
	Moran's I	sd (Ii)	z	p	Moran's I	sd (Ii)	z	p
Shanxi	0.930	0.463	2.078	0.019	0.619	0.43	1.518	0.014
Shandong	2.408	0.463	5.269	0.001	0.543	0.43	1.34	0.009
Henan	1.351	0.364	3.800	0.000	0.417	0.341	1.322	0.003
Shaanxi	-0.055	0.303	-0.071	0.022	0.179	0.286	0.741	0
Gansu	0.395	0.364	1.176	0.000	0.028	0.341	0.181	0.008
Qinghai	0.496	0.463	1.143	0.027	-1.176	0.43	-2.658	0.024
Ningxia	0.396	0.545	0.788	0.015	-0.007	0.503	0.051	0.019
Year	2010				2005			
	Moran's I	sd (Ii)	z	p	Moran's I	sd (Ii)	z	p
Shanxi	0.469	0.405	1.241	0.007	0.136	0.282	0.602	0.004
Shandong	0.508	0.405	1.338	0.009	0.167	0.282	0.709	0.019
Henan	0.403	0.323	1.348	0	0.136	0.241	0.702	0.001
Shaanxi	0.117	0.274	0.548	0.002	0.064	0.218	0.444	0.008
Gansu	0.089	0.323	0.379	0.002	-0.008	0.241	0.104	0.005
Qinghai	-0.777	0.405	-1.839	0.03	-0.329	0.282	-1.049	0.04
Ningxia	-0.054	0.472	-0.043	0.03	-0.016	0.317	0.055	0.008

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From the significance of Moran's I[10] in Table 3, it can be seen that Shandong, Henan, Shanxi, Shaanxi, Ningxia, Gansu, Qinghai and other regions are extremely significant, that is, the carbon emissions[8] in these regions are highly correlated, that is, the changes in carbon emissions in these regions. It will greatly cause changes in carbon content in other regions, especially since 2015, the significance of Moran's I in these regions has gradually increased.

3. Conclusion

3.1 The Impact of Saihanba on the Surrounding Environment

According to the graph of the Figure 2, it can be seen that from 2005 to 2019, the evaluation score has gradually increased, that is, with the continuous improvement of Saihanba's construction, the surrounding ecological environment is constantly improving, and the data in 2020 has dropped significantly. , according to a certain data base, it is speculated that due to the impact of the global new crown pneumonia, a number of new medical production plants have been added in Chengde City and its surrounding areas, and the construction of Saihanba has also slowed down to a certain extent, resulting in a certain degree of decline in the quality of its surrounding environment.

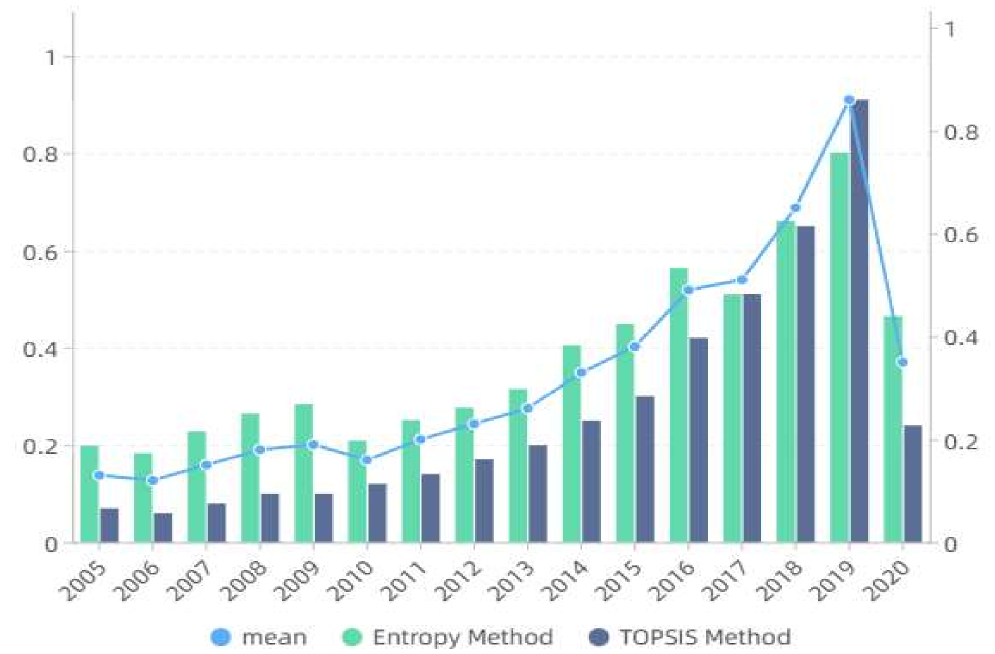

Figure 2. Impact assessment of Saihan dam repair on surrounding environment from 2005 to 2020

3.2 Promotion of Saihanba Model

The Geoda software was used to visualize the proportion of the panel data of carbon emissions in each province in the country's total carbon content in 2020, and the spatial distribution of carbon emissions as shown in the Figure 3 was obtained.

It can be seen from the figure 3 that Shandong, Henan, Shanxi, Shaanxi, Ningxia, Gansu and Qinghai are in the dark green part, and their carbon emission content has a direct impact on the light green part on the way, that is, ecological protection areas should be established in these seven areas to improve the ecological environment of the area on the one hand and prevent its erosion to the surrounding environment on the other hand.

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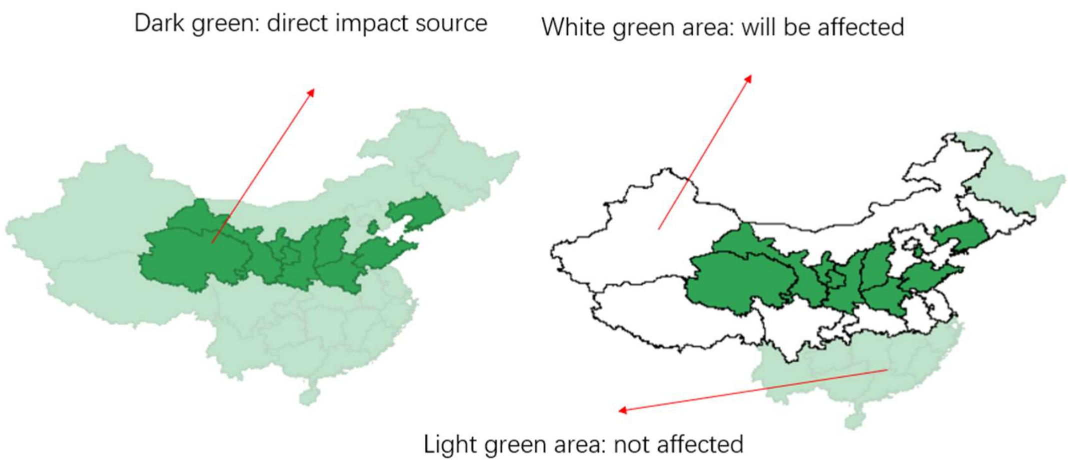

Figure 3. Proportion of national carbon emission space in 2020

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