Research on Saihanba Nature Reserve Based on Comprehensive Evaluation Method and Cluster Analysis

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Abstract. In this paper, we analyze the environmental impact of Saihanba Nature Reserve by constructing a comprehensive environmental assessment model. Specifically, we use the entropy weight method to determine the weight of each secondary index and quantitatively study the environmental changes before and after the construction of Saihanba. In addition, we established a mathematical model to evaluate the influence of Saihanba's ability to resist sand and dust storms and quantitatively evaluated the effect of Saihanba's ability to resist sand and dust storms. Finally, we investigated the scale of the constructed ecoregions using a clustering algorithm.

Keywords: Entropy method; correlation analysis; systematic cluster analysis.

1. Introduction

In the middle and early Qing Dynasty, Saihanba maintained its original ecology due to fewer human activities. After the Kangxi Dynasty, the Saihanba area was used as a royal garden, where many hunting and sacrificial activities were carried out, destroying Saihanba's ecological environment [1].

Since then, more human activities have led to Saihanba's ecological situation [2]. Historical records show that the Saihanba area has been flooded frequently. In the early days of the founding of New China, the Saihanba area had become a desert. In 1962. It can restore the ecological environment of Saihanba, and the Saihanba Forest Farm was established. From 1962 to 1983 was the stage of exploratory development and afforestation of the Saihanba Forest Farm. In May 1993, Saihanba was approved as a national forest park by the Ministry of Forestry, which marked the success of the Saihanba ecological restoration plan.

After consulting related literature, we selected three aspects of climatic conditions, maintaining ecological balance, and environmental protection as secondary indicators. It is supposed that the data selected for each year may be inaccurate due to various factors. As a result, we select one data every five years, and the data is the average of the five-year data. A comprehensive evaluation model is established to evaluate Saihanba s impact on the ecological environment [3]. Collect the corresponding data, use the entropy method to obtain the weight of each index, and construct a comprehensive evaluation model. This essay finally concluded that the value of Saihanba to the ecological environment changed over time and evaluated the impact of Saihanba on the local ecological environment by comparing the final results obtained from the evaluation model before and after the establishment of Saihanba.

2. Model Analysis

2.1. A Comprehensive Evaluation Model

If the data is smaller indicates that the indicator is better, which can be expressed as:

$$C - xi(i = 1,2, \dots, n) \tag{1}$$

This essay uses the entropy method to determine the weight of each indicator. The entropy method reflects the importance of the index according to the degree of difference between the sample values with the same index. Entropy is a measure of the degree of disorder in the system. If the information

entropy of an indicator is small, the amount of information provided by the indicator is great, and the more significant the role it plays in the comprehensive evaluation, the higher the weight.

Step 1: standardize the data of each indicator:

Assuming that k indicators are given:

$$\mathrm{X_1}, \mathrm{X_2}, \ldots, \mathrm{X_k} \tag{2}$$

Among which

$$\mathrm{X_i} = \{\mathrm{x_1}, \mathrm{x_2}, \ldots, \mathrm{x_n}\} \tag{3}$$

Assuming that the standardized value of each indicator data is $\mathrm{Y_1}, \mathrm{Y_2}, \ldots, \mathrm{Y_k}$, which can be expressed as:

$$Y_{ij} = \frac{X_{ij} - \min(X_i)}{\max(X_i) - \min(X_i)} \tag{4}$$

Step 2: Find the information entropy of each indicator

According to the definition of information entropy in information theory, the information entropy of a set of data is:

$$E_j = -\ln(\mathrm{n})^{-1} \sum_{i=1}^{n} p_{ij} ln\, p_{ij} \tag{5}$$

Where$p_{ij} = Y_{ij} / \sum_{i=1}^{n} Y_{ij}$.

If $p_{ij} = 0$, then define, $\lim_{p_{ij} \to 0} p_{ij} \ln p_{ij} = 0$

Step 3. Determine the weight of each indicator

According to the calculation formula of information entropy, the information entropy of each index is calculated as:

$$E_1, E_2, \ldots, E_k \tag{6}$$

Calculating the weight of each indicator through information entropy:

$$W_i = \frac{1 - E_i}{k - \sum E_i} (i = 1,2, \ldots k) \tag{7}$$

Find the score of each secondary index, which is shown in Table I.

Table I. The score of each secondary index.

Indicators of climatic conditions	Average Annual precipitation	The annual average temperature	Annual minimum temperature	Annual Maximum temperature
Weight	0.3275	0.2453	0.2311	0.1961

Obtain the complete evaluation result of Saihanba's environmental impact through secondary indicators, which are shown in Table II.

Table II. The comprehensive evaluation result.

Indicators	Environmental protection	Maintaining ecological balance	climatic conditions
Weight	0.2872	0.4848	0.228

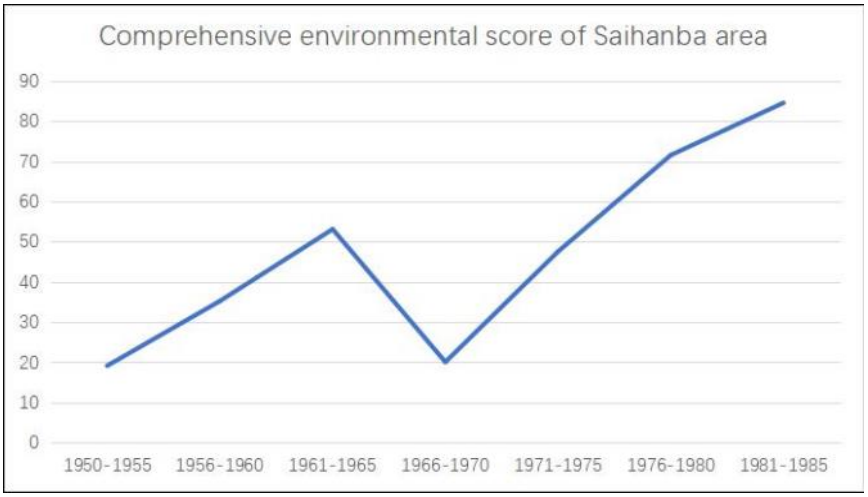


Figure1. Line chart of the comprehensive score of Saihanba's environmental impact.

Under this comprehensive evaluation model, with the establishment of the Saihanba Forest Farm, the overall environmental level of the Saihanba area showed an upward trend but declined from 1966 to 1970. We considered that this might be due to the large-scale insect pests and the decreased quality of air caused by pollution caused by extensive use of machines. In conclusion, the establishment of Saihanba Forest Farm has had a significant positive impact on improving the ecological environment.

2.2. Establishment of Correlation Analysis Model

It is necessary to establish a correlation analysis model to work out the correlation coefficients between the Saihanba forest index and Beijing air index to quantitatively evaluate the influence of Saihanba on Beijing's anti-dust ability.

In order to carry out correlation analysis, the specific forest index and air index should be determined, respectively. The forest index is determined to be the forest area and the actual forest coverage rate through literature review and research. The air index is air quality (average AQI value), the frequency of major pollution or above (per year), and the average windy days. We draw the scatter diagram between two forest indicators and three air indicators, which is shown in Fig. 2 to Fig.7.

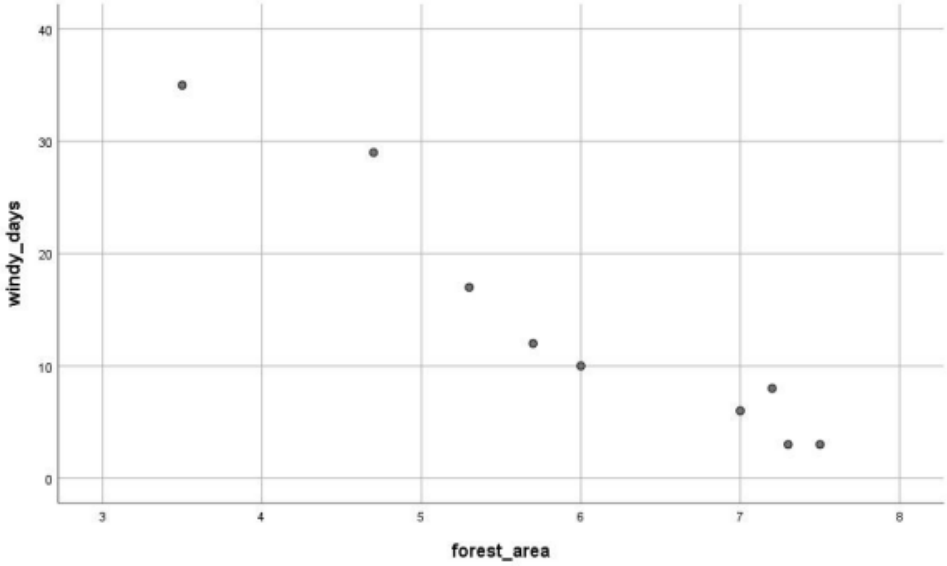


Figure 2. Scatter plot of windy days and forest area.

From Fig.2, we can see that there is a linear correlation between the forest area of Saihanba and the number of strong wind days in Beijing. In other words, the forest area of Saihanba impacts the number of windy days in Beijing. It can be seen that the forest area of Saihanba is negatively correlated with the number of gale days in Beijing.

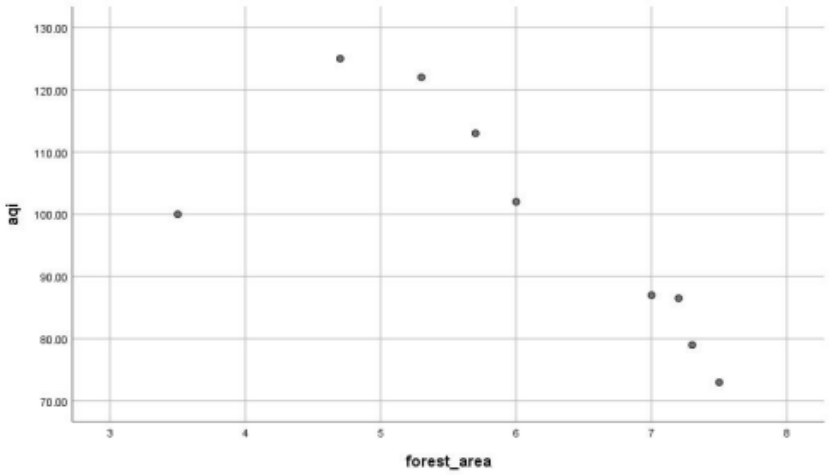


Figure 3. Scatter plot of AQI and forest area.

From Fig. 3, it can be seen that there is a linear correlation between the forest area of Saihanba and Beijing AQI. In other words, the forest area of Saihanba has an impact on Beijing AQI. It can be seen roughly that the forest area of Saihanba is negatively correlated with Beijing AQI.

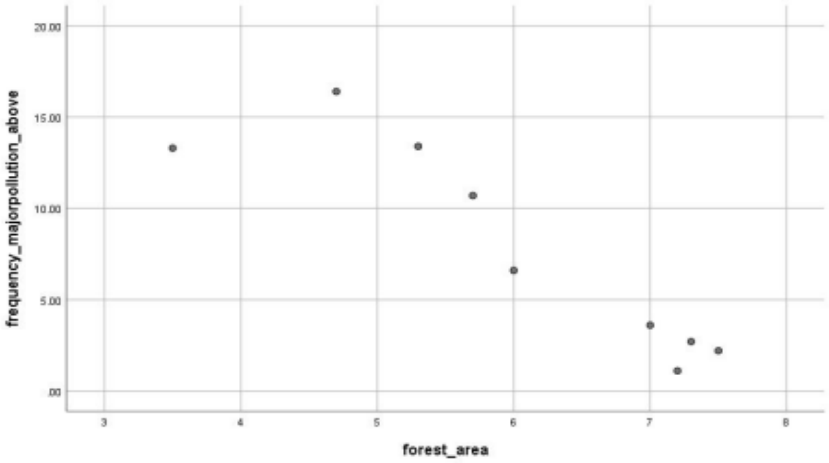


Figure 4. Scatter plot of the frequency of heavy pollution and above and forest area.

From Fig.4, it can be seen that there is a linear correlation between the forest area of Saihanba and the frequency of severe pollution or above in Beijing. In other words, the forest area of Saihanba has an impact on the frequency of severe pollution and above in Beijing. It can be seen that the forest area of Saihanba is negatively correlated with the frequency of severe pollution or above in Beijing.

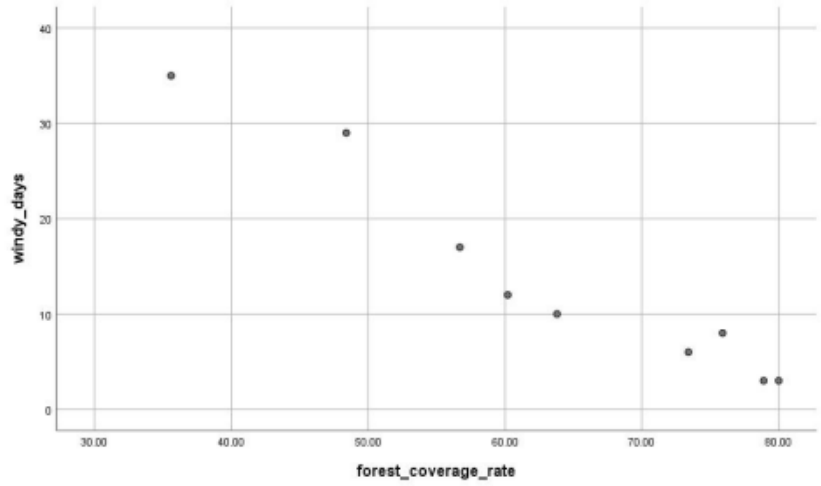


Figure 5. Scatter plot of windy days and forest coverage rate.

From Fig. 5, it can be seen that there is a linear correlation between the forest coverage rate of Saihanba and the number of strong wind days in Beijing. In other words, the forest coverage rate of Saihanba has an impact on the number of windy days in Beijing. It can be seen that the forest coverage rate of Saihanba is negatively correlated with the number of gale days in Beijing.

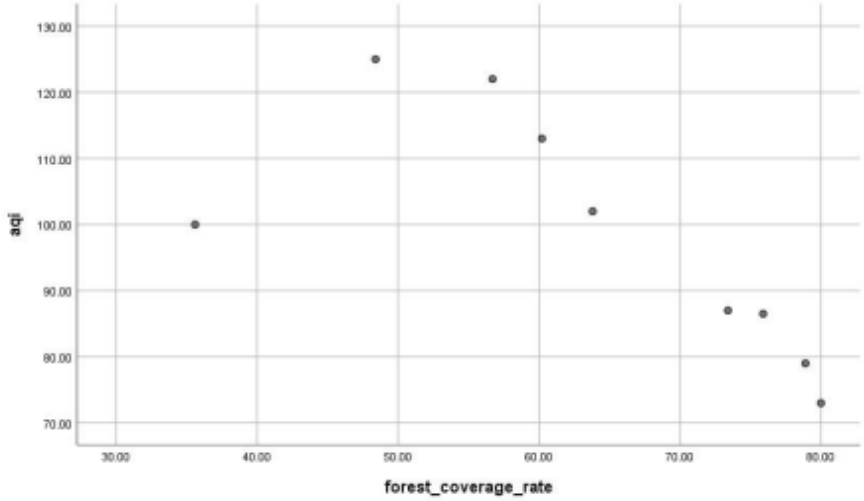


Figure 6. Scatter plot of AQI and forest coverage rate.

From Fig. 6, it can be seen that there is a linear correlation between the forest coverage rate of Saihanba and Beijing AQI. In other words, the forest coverage rate of Saihanba has an impact on Beijing AQI. It can be seen roughly that the forest coverage rate of Saihanba is negatively correlated with Beijing AQI.

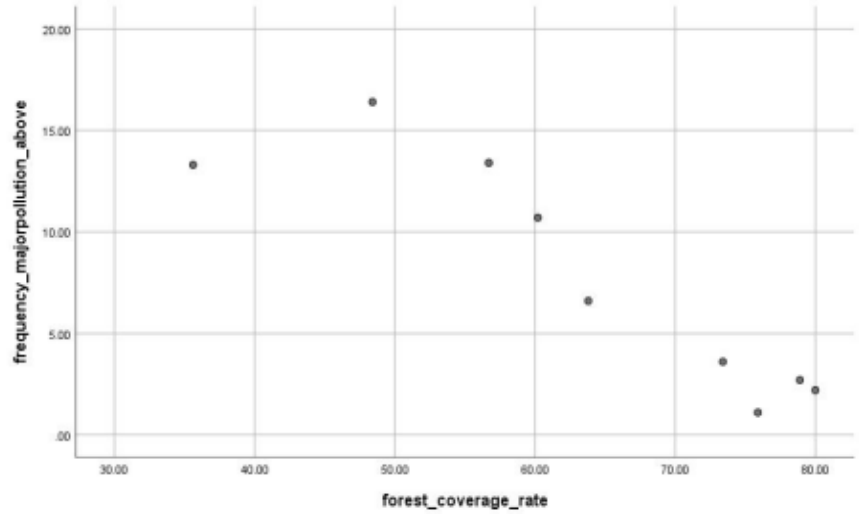


Figure 7. Scatter plot of the frequency of heavy pollution and above and forest coverage rate.

From Fig.7, it can be seen that there is a linear correlation between the forest coverage rate of Saihanba and the frequency of severe pollution or above in Beijing. In other words, the forest coverage rate of Saihanba has an impact on the frequency of severe pollution and above in Beijing. It can be seen that the forest coverage rate of Saihanba is negatively correlated with the frequency of severe pollution or above in Beijing.

2.3. Cluster Analysis

To promote the Saihanba Ecological Reserve to the whole country, we first need to determine which provinces are in a poor ecological environment. By collecting data, we can get the annual carbon emissions and forest area of all provinces in the country and then calculate each province's annual carbon dioxide conversion from the forest area. We set up an indicator h (the annual absorption

divided by the annual emissions), then use the cluster analysis to select the provinces with the lowest h value, and finally choose to establish ecological protection areas in these provinces, shown in Fig.8.

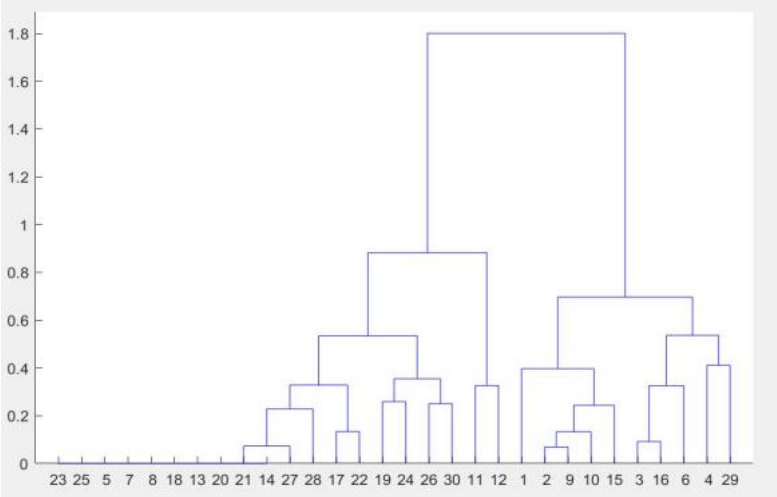


Figure 8. Annual emissions.

We determined the list of cities that need environmental protection and ecological construction [4]. Next, a cluster analysis model was established to perform cluster analysis on the geographic coordinates of the cities that need environmental protection. We got the geographic coordinates of the ecological protection zone to be built from this. According to the forest coverage rate, the area size of each ecological protection area is obtained. Through the quantitative analysis of the treatment of carbon dioxide after the completion of the above ecological protection zone, the impact of the ecological protection zone on the environment of Bangladesh is obtained.

In order to determine which cities need nature protection and environmental construction, we have conducted statistics on the AQI of all cities. Suppose the AQI of each city is $\emptyset_i$. There are n cities in Bangladesh, then$\overline{\emptyset} = \frac{1}{n}\sum_{i=1}^{n} \emptyset_i$. When $\emptyset_i > \emptyset$, we believe that the city's air quality is poor and needs ecological protection.

After calculation, we get $\emptyset$= 145, and it can be concluded that Dhaka, Rajshahi, and Sylhet have poor natural environments and need environmental protection and construction.

In order to determine the location of the ecological protection zone, we have counted the latitude and longitude coordinates of the city obtained in the previous step, and the results are shown in Table III.

Table III. The location of the ecological protection zone.

city_name	latitude	longitude
Dhaka	90.4125181	23.810332
Rajshahi	89.55	22.8166667
Sylhet	91.8123324	22.3475365

When formulating regional plans, the core management idea is to establish specific management goals, policies, and methods around "problems." The land-use division in regional planning is not based on the nature of land use as in traditional zoning but on the characteristics and importance of natural resources and artificial environments in different city areas and the protection levels to ensure their healthy development. Regional planning has created a "natural area" management system that covers the entire city and uses "natural area laws and regulations" to manage development activities that may have an impact on natural resources and the ecological environment. "Natural area" includes six types of districts. The natural resources and environmental characteristics of each district are different, while the problems of similar districts are relatively similar [5]. This method of thinking based on "problems" rather than traditional zoning "districts" as the basis for management and control enables urban resource and environmental issues to receive as much attention as possible so that

regional planning can formulate more targeted and effective control measures. According to the city's coordinates that need environmental protection, we can roughly determine the latitude and longitude of the environmental protection area (90.4125181, 23.810332).

Small-scale nature reserves are less than 10,000 hectares for forest-type nature reserves, medium-scale nature reserves are 10,000-50,000 hectares, large-scale nature reserves are 50,000--150,000 hectares and super-scale nature reserves are more than 150,000 hectares. The nature reserve needs at least 200,000 hectares, and the developed and alpine areas should have about 100,000 hectares. There should be 50,000-200,000 hectares in the undeveloped southern mountainous areas, and the developed southern mountainous areas should be between 10,000-50,000 hectares. According to the calculation of urban area and forest coverage rate, the natural ecological protection area needs to be about 3000 hectares.

3. Conclusion

In this paper, we mainly establish the evaluation model of Saihanba Ecological Reserve based on the collected data. On this basis, quantitatively analyze the effect of Saihanba on the ability to resist sand and dust storms. Finally, the above-mentioned ecological protection area evaluation model is extended to the whole country and even the Asia-Pacific region, and its impact is evaluated. Finally, planning and suggestions for constructing ecological protection areas are put forward.

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